TITLE: Palaeogene Foraminifera of the Central and Southern North Sea, and their Biostratigraphical application.

GAVIN KENNETH GILLMORE.

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ABSTRACT.

This thesis examines the Microfauna of the North Sea Palaeogene, particularly the foraminifera, and their biostratigraphical applications in the Central and Southern North Sea. A biostratigraphical scheme has been erected for calcareous benthic (CB Zones 1-15), agglutinated benthic (AB Zones 1-11b) and planktonic foraminifera (PK Zones 1a-13, utilising diatoms and radiolaria where necessary), which was then combined into one scheme using the previous 3 'groups'. The Shell Expro. U.K. computer was used to draw up rangecharts of these 'groups', and each well is described in the text and in 'Distribution charts' (See Enclosures Nos.1-10, plus Rangecharts in pocket). The foraminiferal biozonation of this thesis is correlated with NSP (North Sea planktonic) and NSB (North Sea benthonic) Zones of King (1983, 1989), the P Zones of Berggren et al. (1985), the sedimentological sequences of Stewart (1987) and the nannoplankton zones of L. Gallagher in his Ph.D. thesis. A combined biostratigraphic scheme, utilising both foraminifera and nannoplankton was proposed in Gallaghers thesis and is discussed here.

Figures. Page.

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This thesis was financially supported by a NERC/Case award with Shell Expro. U.K. General thanks are also due to all the staff at Shell, especially Mr W. Sikkema and to Mr. P. Osterloff. The calcareous nannoplankton from the same wells were examined by Dr. L. Gallagher in his Ph.D thesis.* Thanks also go to Mr. J. Davy for developing the S.E.M. prints.

I would like to express my gratitude to Miss S. Evans for her patient endurance.

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* GALLAGHER L.T.,1988. Tertiary Calcareous Nannofossils from the Central and Southern North Sea Basins, and their Biostratigraphical Application. Unpublished PhD thesis, University College London (University of London Library).

Chapter 1. INTRODUCTION.

1.1. General Comments.

This project examines the Palaeogene foraminifera that occurred in ditch-cuttings, side-wall samples, and core material from 7 Shell/Esso wells and one Esso Norway Inc. well in the North Sea. 5 were examined from the south-eastern part of the Central North Sea, 2 from the Southern North Sea, and one briefly studied from the Northern North Sea, Viking Graben (see fig.1). Comparative land sections were examined from the London Basin (Early Eocene, London Clay Formation, see figs.2 and 8), and Pegwell Bay (Palaeocene, Thanetian). This was done in order to construct a biostratigraphical zonation of North Sea Palaeogene deposits for both epibathyal/inner neritic faunas, and for deeper water agglutinated assemblages.

Some 130 species have been examined from the Palaeogene, although some 180 or more have been examined in total, which includes species from the Neogene. 80 + species of agglutinated benthonic foraminifera have been identified, 15 ± calcareous planktonic forms, with ± 35 useful calcareous benthonic ones.

The taxonomic classifications used in this study are from Loeblich and Tappan (1964, 1988), Banner (1982), Li Qianyu (1987), with reference to Haynes (1981).

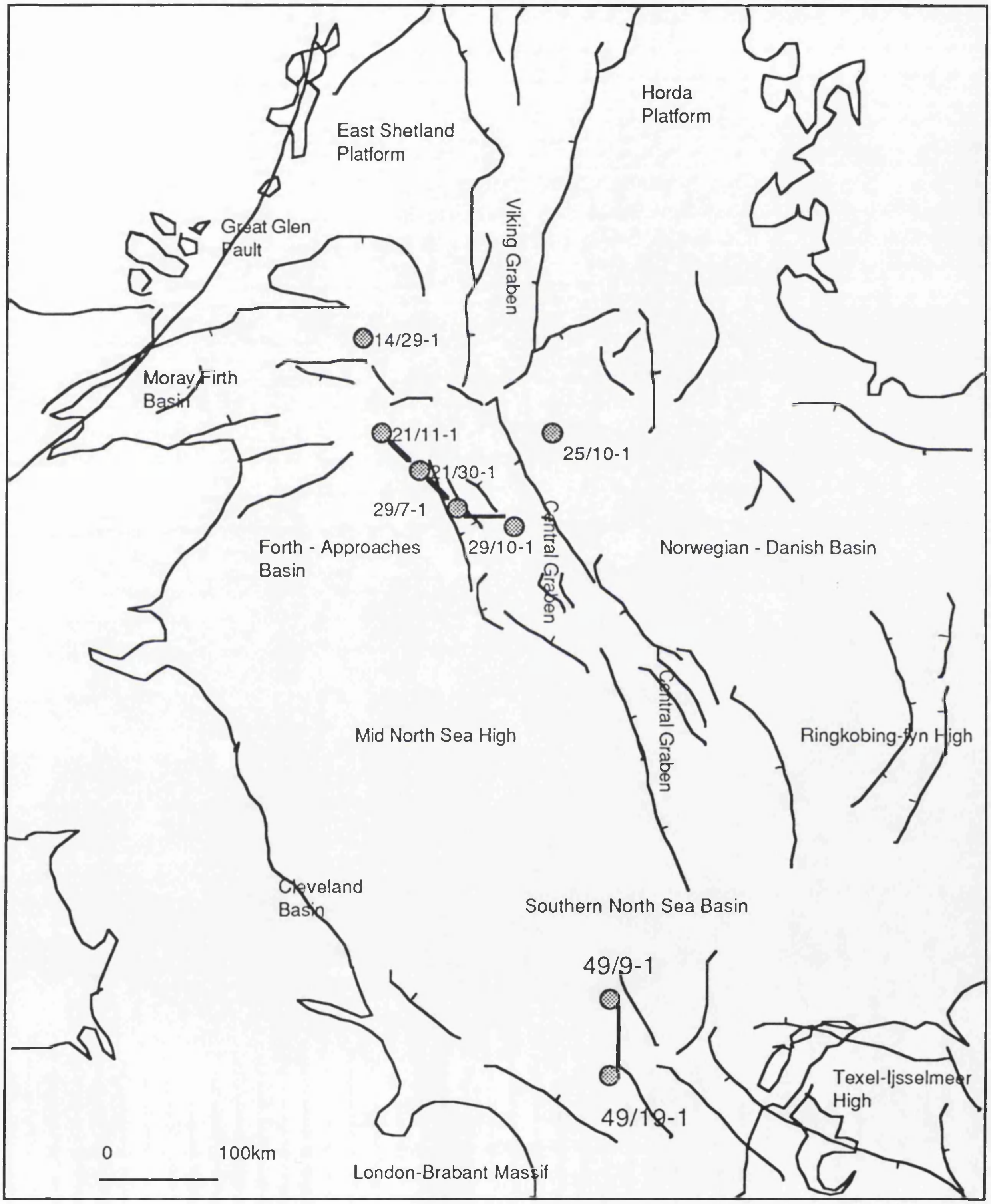


FIG.1. Location Map of North Sea Wells in this study, and their relationships to Structural Elements of the North Sea Basin.

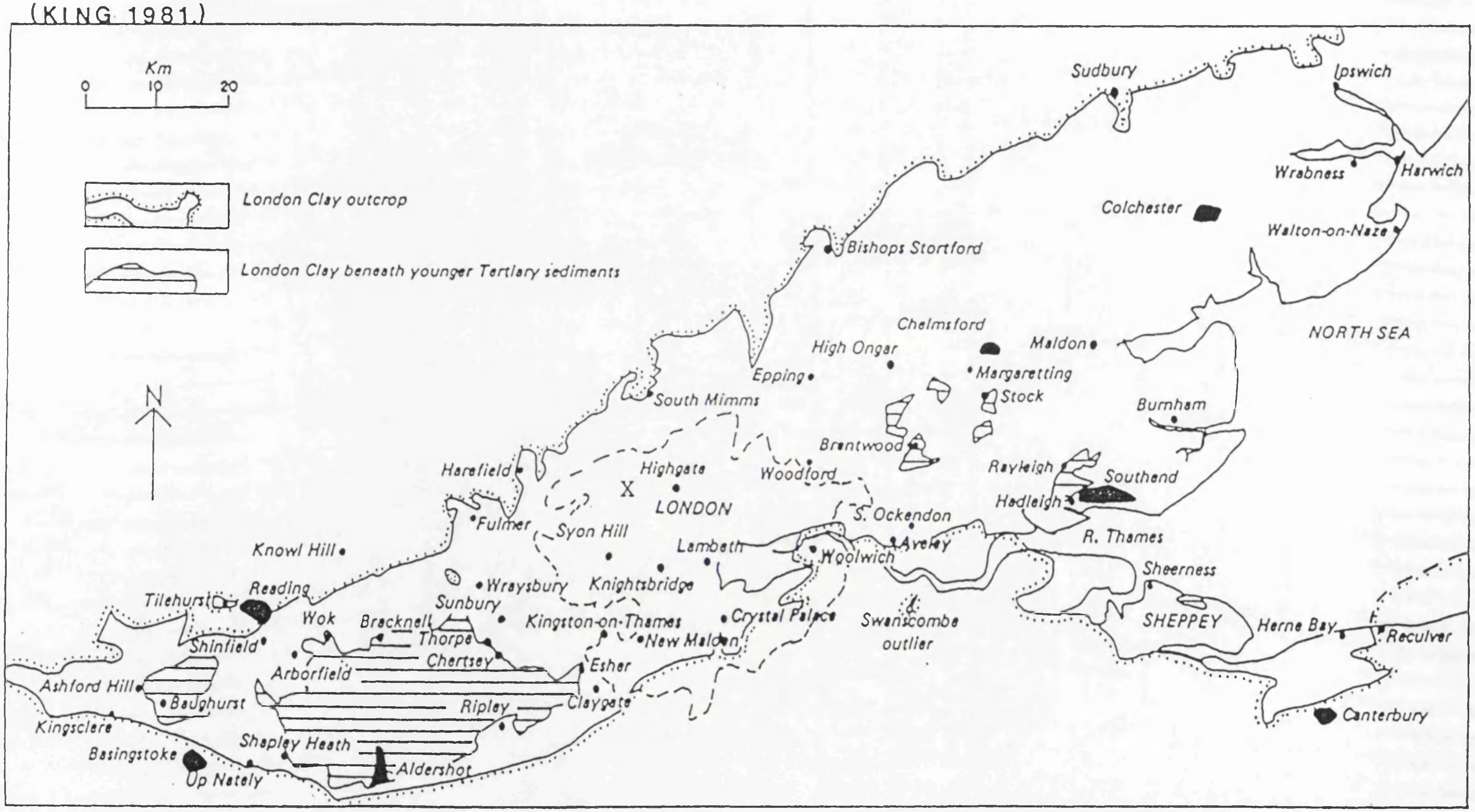

(KING 1981.)

FIG.2.
London Clay of the London Basin. Wok = Wockingham. The Tertiary sediments overlying the London Clay are the Bagshot Beds. X = Parliament Hill site, Hampstead Heath.

FIG.3.
PARTIAL LIST OF REFERENCES FOR NORTH SEA TERTIARY FORAMINIFERA, BIO- AND LITHOSTRATIGRAPHY, PLUS USEFUL COMPARATIVE SECTIONS.

Biostratigraphic/Foraminiferal.			
Northern North Sea	**Central North Sea**	**Southern N. Sea**	**Hatton-Rockall Bank**
Jones G.D., 1988	Gradstein and Berggren, 1981 King, 1983 Lott et al., 1983 Stewart, 1987 Charnock and Jones (in prep.) Gradstein et al., 1988 King, 1989.	Hughes, 1981 Crittenden, 1981, 1982 King, 1983	Murray, 1984

Labrador Sea	**Greenland Sea**	**Polish Carpathians**	**Alps**	**London Basin**
Berggren, 1972 Berggren and Aubert, 1976a Gradstein and Berggren, 1981 Gradstein, 1981 Miller et al. 1981	Gradstein and Berggren 1981 Gradstein, 1981 Verdenius and Van Hinte, 1983	Grzybowski (1896-1901) Geroch, 1960 Pozaryska, 1967 Ksiazkiewicz, 1975	Grun, 1969	Wetherell, 1838 Sherborn and Chapman 1886, 1889 Bowen, 1954 Ward, 1978 King, 1981

		Lithostratigraphic/Structural	
Netherlands	**Belgian Basin**	**Northern N. Sea**	**Central N. Sea**
Doppert and Neele, 1983	Batjes, 1958 Kaasschieter 1961 Willems, 1981 Hooyberghs, 1983, 1984	Mudge and Bliss, 1983	Parker, 1975 P.Ziegler, 1975 Deegan and Scull,1977. Lott et al., 1983 Lovell, 1984 Malm et al., 1984 Stewart, 1987.

Cenozoic of the North Sea

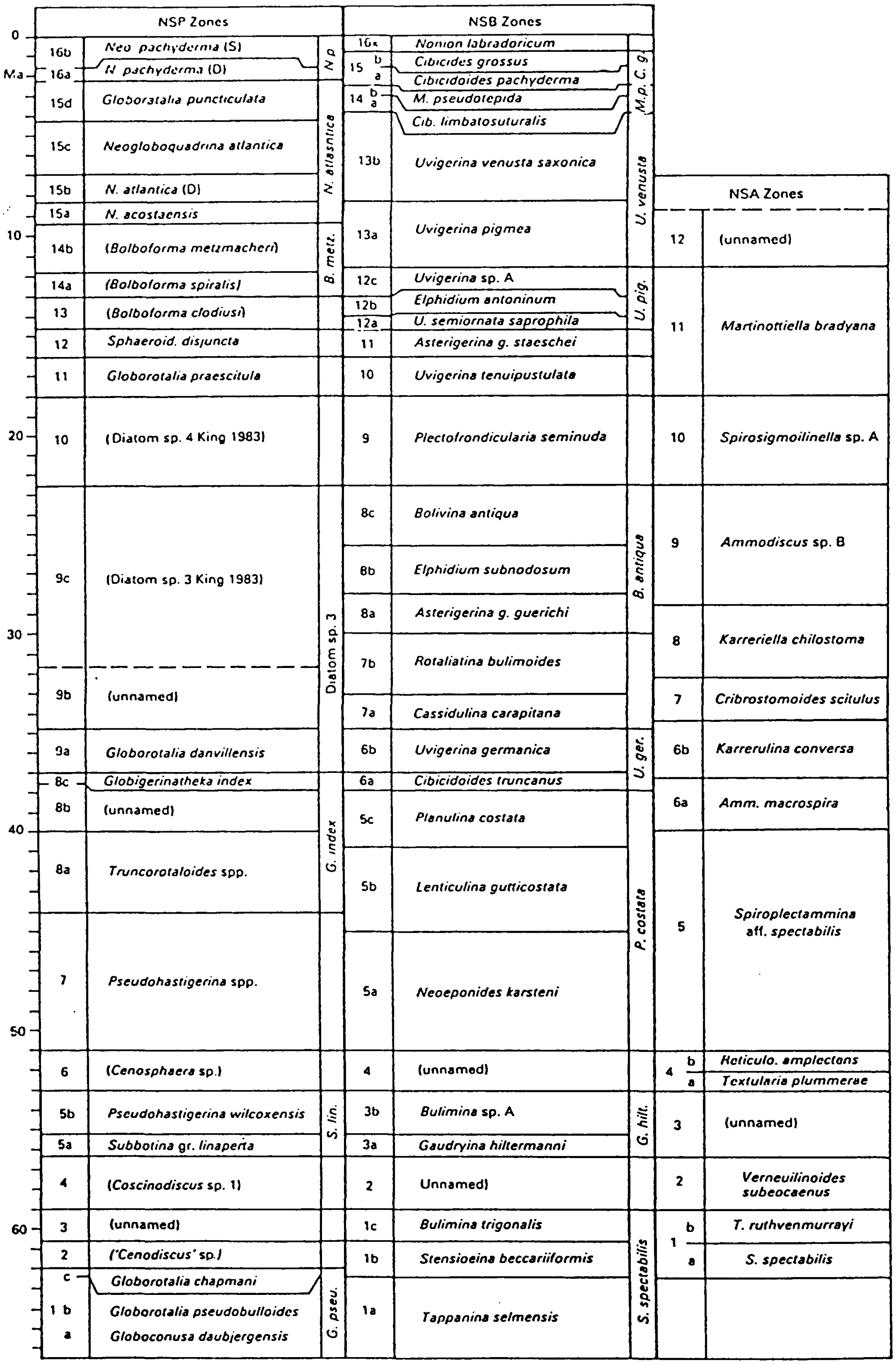


FIG.4.
Summary of King's (1989) NSB (North Sea Benthonic), NSP (North Sea Planktonic), and NSA (North Sea Agglutinants) Zonation of the North Sea Tertiary.

FIG.5a-b. King's (1989) North Sea Zonation, Early Palaeocene to Early Oligocene.

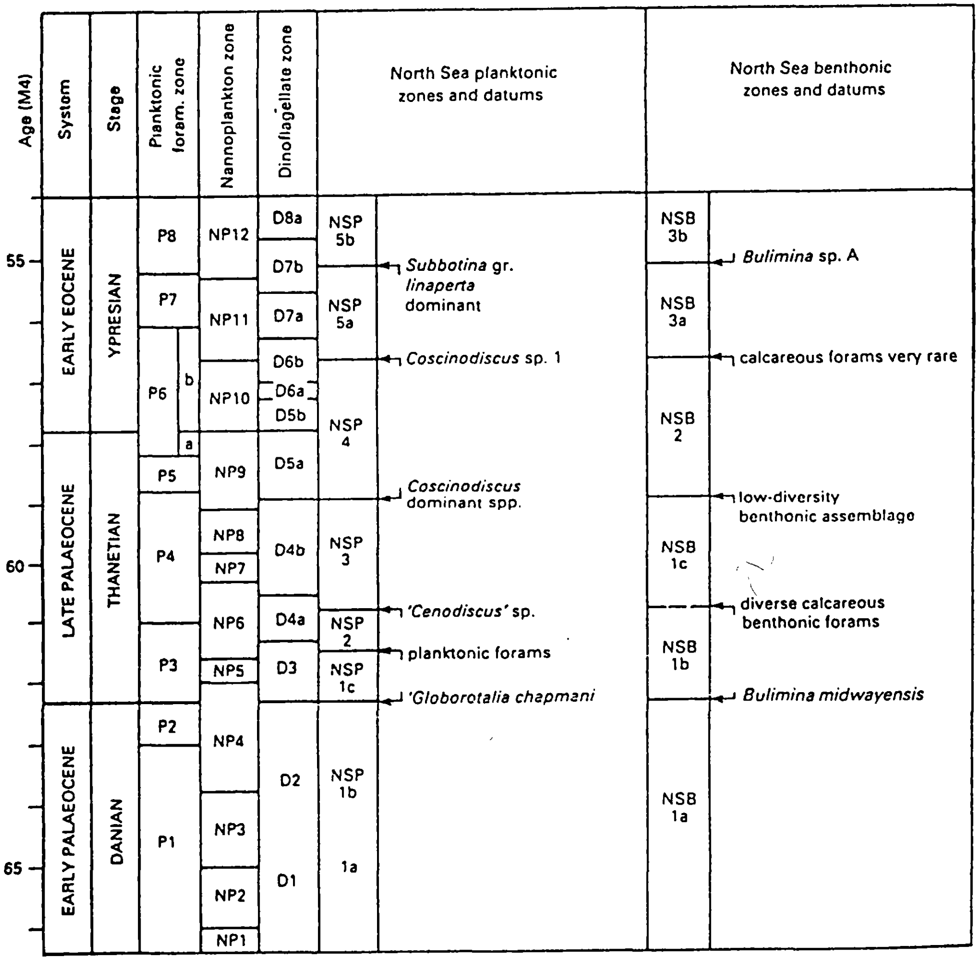


Fig.5a.— NSB and NSP zones and microfaunal marker events in the Palaeocene of the North Sea. Geochronology, stage nomenclature, nannoplankton (NP) and planktonic foraminiferid (P) zones are from Berggren *et al.* (1985). Dinoflagellate zones are from Costa and Manum (1988).

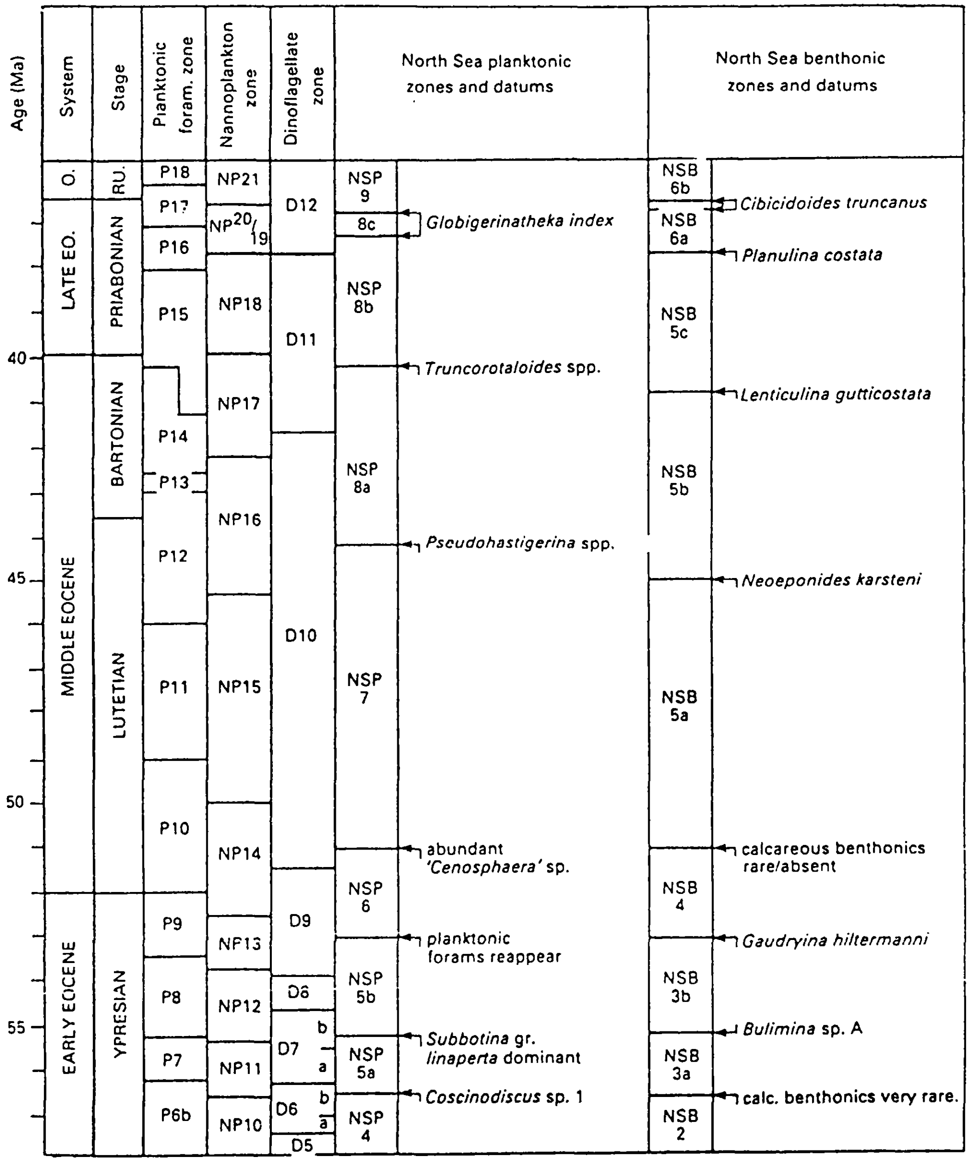


Fig.5b.— NSB and NSP zones microfaunal marker events and microfaunal marker events in the Eocene of the North Sea. Explanation as for Fig.5a.

FIG.6a-b. King's (1989) North Sea Zonation, Early Oligocene to Pleistocene.

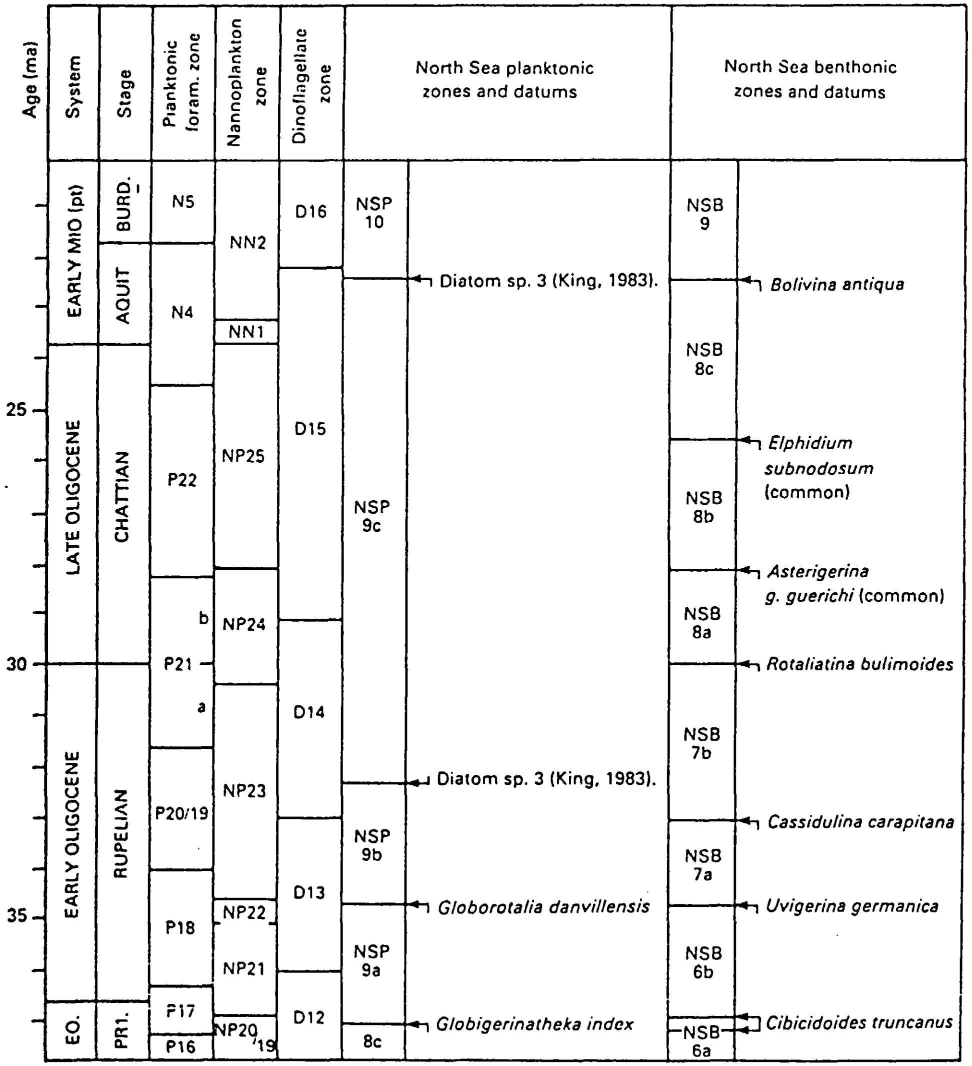


Fig.6a.— NSB and NSP zones and microfaunal marker events in the Oligocene and Early Miocene of the North Sea. Explanation as for Fig. 5a. AQUIT. = Aquitanian, BURD. = Burdigalian.

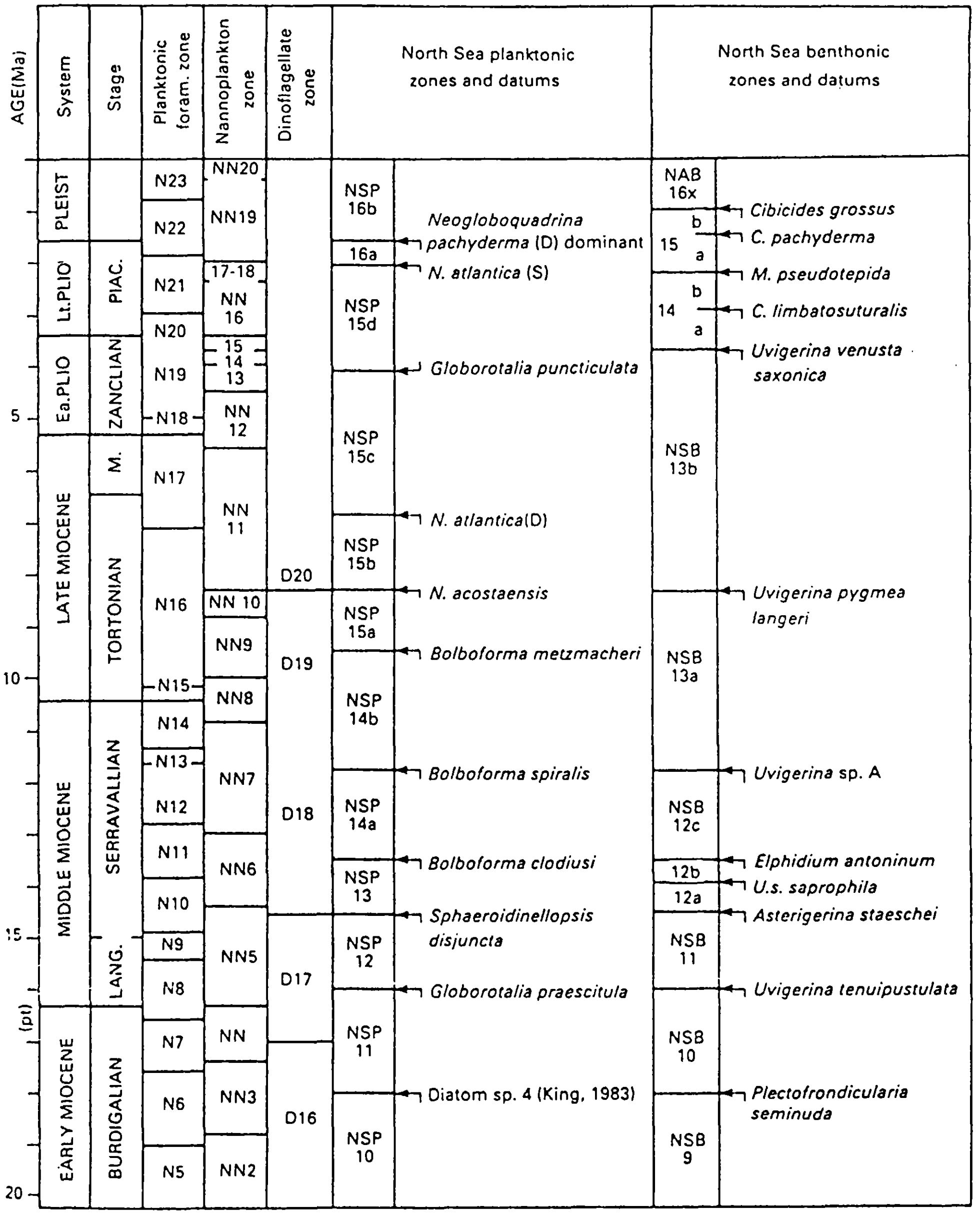


Fig. 6b.— NSB and NSP zones and microfaunal marker events in the Miocene, Pliocene and Pleistocene of the North Sea. Explanation as for Fig.5a. S = sinistral, D = dextral. LANG. = LANGHIAN, M. = MESSINIAN, PIAC. = PIACENZIAN.

1.2. Literature Survey.

Much of the previous micropalaeontological data collated in the analysis of the North Sea Palaeogene has remained unpublished. This was in order to protect the confidentiality and financial interests of the oil companies that were involved in drilling there. The few published accounts are shown in this diagram (fig.3), which also shows a number of lithostratigraphical and structural papers published, together with those from comparative areas. One of the most useful and well known of the biostratigraphical papers is by King (1983).

He presented a biostratigraphical breakdown of Tertiary deposits, both Neogene and Palaeogene, in the Central and Southern North Seas from some 200 wells. He recognized 8 benthonic (North Sea Benthonic or NSB, NSB1 to NSB7) and 9 planktonic (North Sea Planktonic or NSP, NSP1 to NSP9) zones in the Palaeogene. These are mostly interval zones, the top being defined by the highest occurrence of the zonal index species, while the base is automatically defined by the top of the underlying zone. The index species may only exist within its zone or may exist at deeper, older levels. These species have well defined tops. The zonation of King is based largely on species occurringin an outer sublittoral epibathyal biofacies. His work, therefore, was based mainly on calcareous benthics, (and or planktics where available), which are relatively rare or absent from the deepest part of the Central and Northern North Sea Basins, where a rich agglutinated foraminiferal fauna predominates. Most of the wells in this study come from such areas. King in 1989 redefined his zonation and changed some of the index species for his Zones (see figs.4-6b). He also introduced agglutinating foraminiferid zones (12 North Sea Agglutinants or NSA Zones). These Zones are based mostly on the non-calcareous agglutinants of the Rhabdammina-biofacies of King (1983), which characterise the assemblage found in the Central North Sea, Central Graben region (Gradstein and Berggren (1981)). Calibration of King's (1989) NSA Zones was established along the edges of the *Rhabdammina*-biofacies, where both calcareous and non-calcareous foraminifera occur together.

M.J. Hughes (1981) did some biostratigraphical work on top Oligocene/top Eocene material from an I.G.S. borehole in the Southern North Sea. However, he only published an informal zonation of Middle Oligocene material, so this is of limited stratigraphical use.

Crittenden has done some work on the planktonics of the Palaeogene (1981, 1982), but this again is very limited.

Gradstein, Kaminski and Berggren (1988) have recently published a short paper on the "Cenozoic foraminiferal Biostratigraphy of the Central North Sea". This was a stratigraphic analysis of mostly benthic taxa in 29 wells in the Central North Sea, using a ranking and scaling (R.A.S.C.) computer program. R.A.S.C. achieves an optimum or most likely sequence of events in a scale in wells and outcrop sections, that is, it presents an idealized sequence. They proposed 10 interval zones for the Tertiary (see below).

Cassidulina teretis Zone.	Middle Pliocene-Pleistocene.
Globorotalia praescitula-*Globorotalia zealandica* Zone.	Early-Middle Miocene.
Globigerina ex gr. *officinalis* Zone.	Late Oligocene-Early Miocene.
Rotaliatina bulimoides Zone.	Rupelian.
Globigerinatheka index Zone.	Late Eocene.
Reticulophragmium amplectens Zone.	Middle-Late Eocene.
Subbotina patagonica Zone.	Ypresian.
Coscinodiscus spp. Zone.	Late Selandian-Early Ypresian.
Trochammina ruthvenmurayi-*Reticulophragmium paupera* Zone.	Selandian.
Subbotina pseudobulloides Zone.	Danian.

This "optimum" sequence approximately matches the sequence given by King (1983). Geophysical markers were also used within Gradstein et al.'s (1988, fig.2) sequence. These markers are useful correlation tools. Log marker A marks the top Cretaceous, while log marker B marks the top Danian. C marks the base of the tuff (Balder Formation), and D the top. Log marker E sits at the base of the Late Eocene assemblage. F lies between the Eocene and the Oligocene and G marks the Miocene. Regional hiatuses were postulated in the Early Oligocene and Middle-Late Miocene time. Some 12 'unique events' were used within the optimum sequence, that is, those useful forms that occurred in less than 8 out of 29 wells. One must always bear in mind, when applying this sequence, that assemblages present change as you move from the Southern to the Central and Northern parts of the North Sea. Therefore, many of the forms within the optimum sequence will not occur in the South, and vice-versa. This sequence provides useful data on the deeper water Central basin assemblages, and establishes some previously unused agglutinated forms as zonal markers.

G. Charnock and R.W. Jones are also in the process of producing papers on the North Sea Tertiary agglutinated foraminifera, one on taxonomy and the other on Palaeogene biostratigraphy.

Kaminski et al. (1988) examined and compared the 'flysch-type' agglutinated foraminiferal assemblages from the Late Cretaceous and Palaeocene of Trinidad, with assemblages from southern California, western North Atlantic margin, Labrador Sea, Polish Carpathians, Atlantic DSDP sites, and the North Sea. Factor analysis was used to delineate some assemblages of the Danian sediments. This paper provides a very useful taxonomic section on these agglutinated foraminifera.

Gradstein and Berggren (1981) produced an important work on the agglutinated faunas from the Labrador, Greenland and Central North Seas. This work not only contains valuable taxonomic data but also some useful palaeobathymetric comments.

One of the few purely palaeobathymetric papers published on the the North Sea was by G.D. Jones (1988) on Lower Selandian (Palaeocene) 'flysch-type' agglutinated foraminifera from the Viking Graben. He suggests that the flysch-type faunas preferred living in deep waters, from below the shelf edge at about 200m, down to abyssal depths of approxomately 4kms. He points out though that depth alone is not an overiding factor influencing their occurrence, but that many flysch-type assemblages are associated with restricted basins that were filled with organic rich fine-grained sediment. These carbonate-poor conditions hindered the development of a calcareous fauna. Jones used the palaeoslope transect approach, and calculated water depth for his assemblages using trigonometric projection plus seismic and stratigraphic techniques. Samples from 6 wells were examined both in the U.K. and Norwegian sectors of the Viking Graben. This is an extremely useful paper, and poses some very interesting questions concerning the palaeobathymetry of agglutinated foraminiferal assemblages.

Work on comparative land sections has been done by King (1981) on the London Clay, Kaasschieter (1961) on the Belgian Eocene, and Batjes (1958) on the Belgian Oligocene. Doppert (1980) and Doppert and Neele (1983) developed a zonation scheme for the Palaeogene and Neogene of the Netherlands. Dopperts(and workers) 11-fold zonation uses over 90 species of mostly calcareous benthic forms typical of shallow to deep neritic environments. Many of the species referred to in these two papers occur in the Central and Southern North Sea in my Oligocene-Miocene sections. Some of the earliest and most useful papers were done by Grzybowski (1896-1901), largely taxonomic 'works' on Polish Carpathian agglutinated foraminifera, which compare well with Central North Sea forms.

Lithostratigraphic/structural work has been done by Ziegler (1975), Deegan and Scull (1977), Lott et al. (1983), Stewart (1987) on the Central North Sea, and Mudge and Bliss (1983) on the lithostratigraphy of material from the Northern North Sea.

Of all these papers only Berggren and Gradstein (1981), King (1983, 1989), and Gradstein et al. (1988), have published any detailed zonation scheme of the North Sea Region, although Stewart (1987) has also included a very useful biostratigraphical foraminiferal scheme for the Palaeocene and Early Eocene, and correlated these data with dinoflagellate zones.

2. THE STRUCTURE AND STRATIGRAPHY OF THE NORTH SEA TERTIARY.

The North Sea region is composed of a series of stratigraphically superimposed sedimentary basins of Late Palaeozoic through Tertiary age. The Permo-Triassic through Early Cretaceous history of the North Sea basin is a complex one, comprising a series of relative uplifts, rifting and differential subsidence in the Jurassic through Early Cretaceous time, while in the Late Cretaceous there was widespread subsidence. At this time a thick chalk 'blanket' was laid down covering the North Sea, originally much of Britain, and extending to Denmark, Belgium, Holland and Northern Germany. Figure 1 demonstrates the simple north-south form of the basin.

This relatively quiescent depositional 'regime' was ended by the Laramide tectonic phase when the North Sea became more restricted and Danian (Early Palaeocene) chalk (belonging to the Ekofisk Formation of Deegan and Scull, 1977, see figs.7 and 8) was deposited, from the Central Graben of the Central North Sea to Denmark. Uplift occurred elsewhere causing much erosion. This Laramide phase at the Cretaceous/Tertiary boundary was marked by wrench compressions, and the reactivation of old Mesozoic grabens.

The Laramide and Alpine movements which lasted from the latest Cretaceous to the middle of the Tertiary, are related to 2 separate major tectonic developments. By the early Tertiary, in the north west, the Northern Atlantic began to open up, reducing the lateral constraints on the "European plate mosaic" (P. Ziegler, 1975). From the Middle-Late Palaeocene to the present day there has been very little change in the extent of the North Sea basin. In the Central and Northern North Sea continuous sedimentation occured in the Tertiary where more than 3000m of terrigenous clastics were deposited.

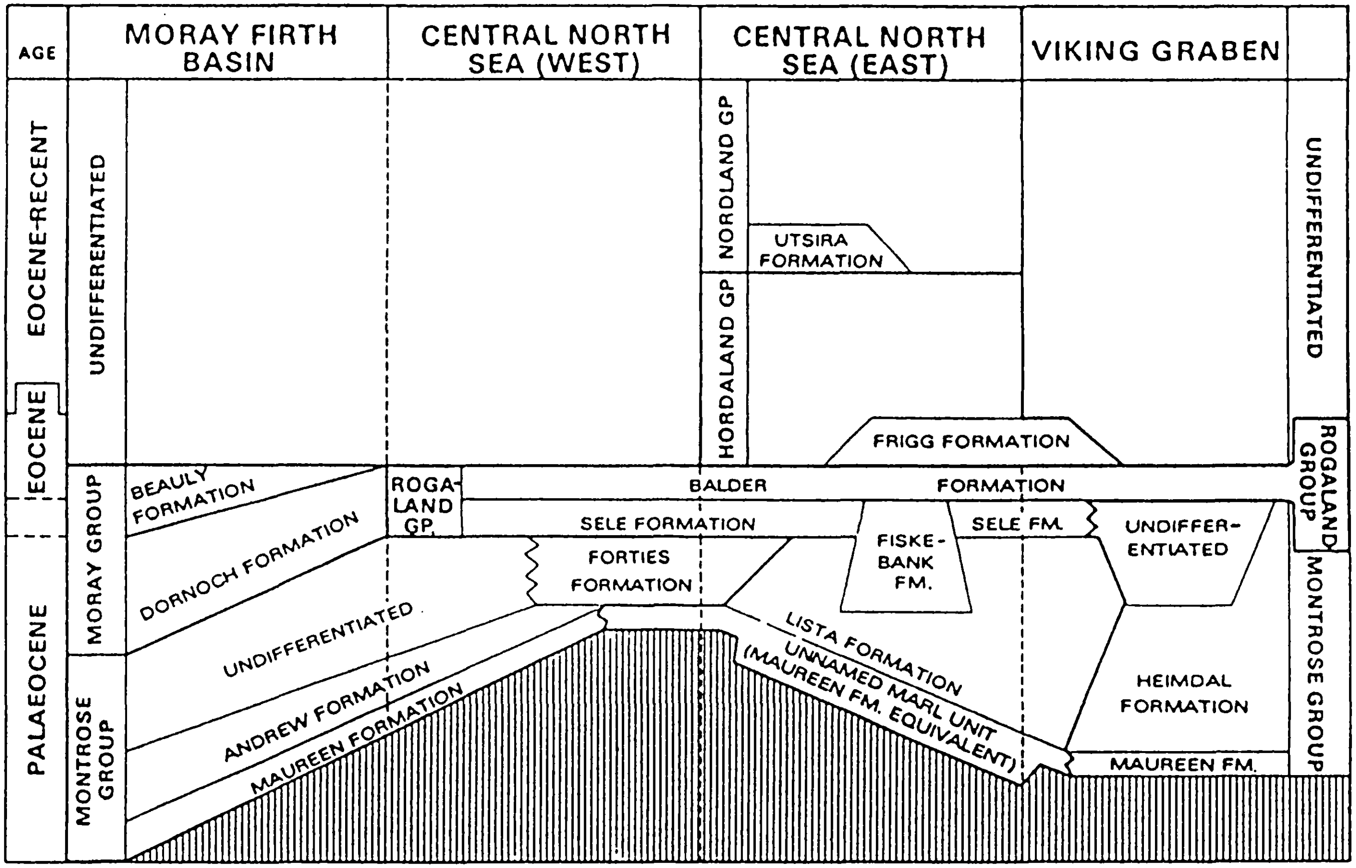
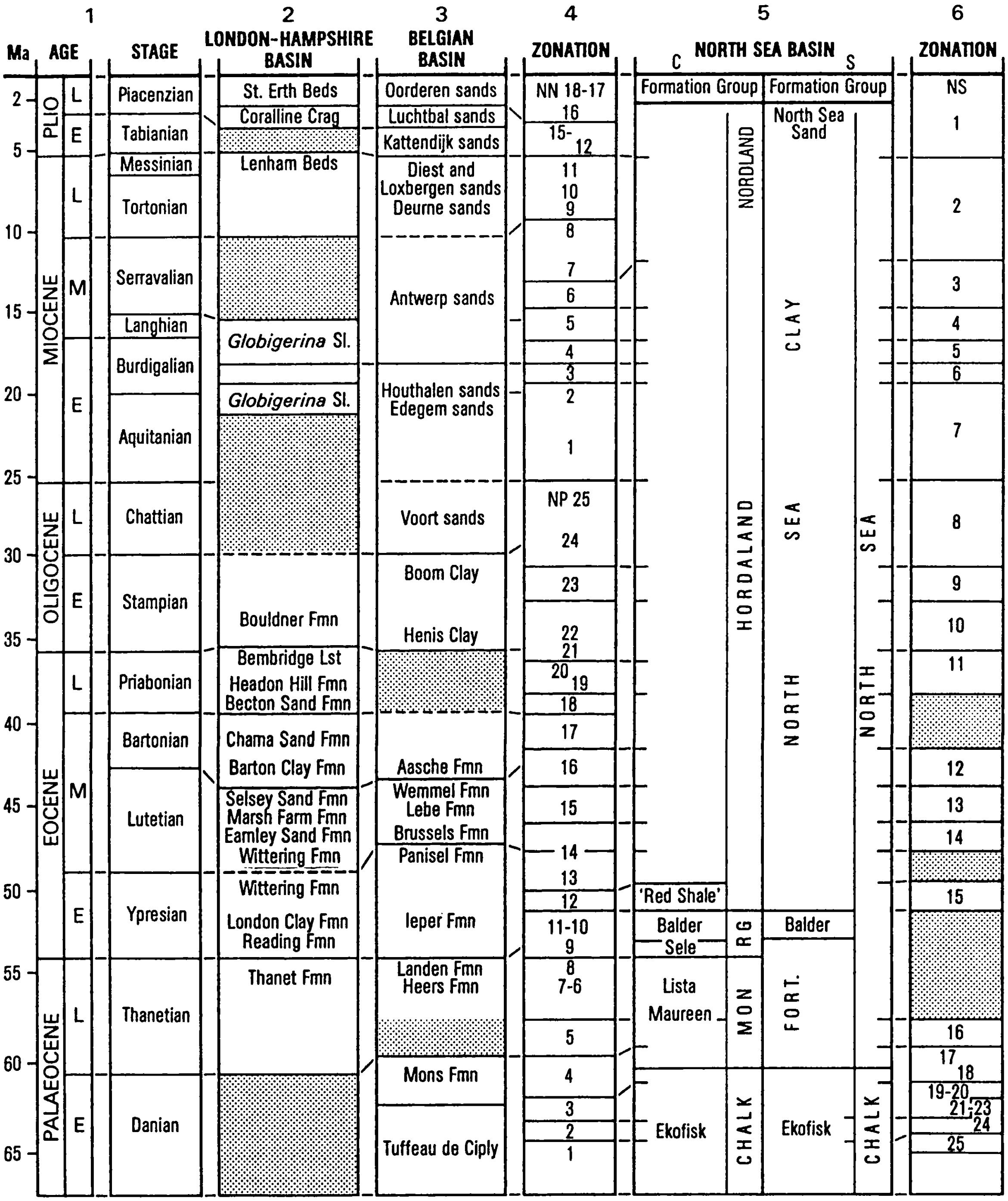


FIG.7.
Standard Tertiary lithostratigraphical nomenclature (after Deegan and Scull, 1977).



1 Haq *et al* (1987) and Cavalier and Pomerol (1986).

2 Curry *et al* (1978) and Jones (unpub.) and Murray *et al* (1987)

3 Curry *et al* and Jones (unpub.) and Pomerol (1982)

4 Martini (1971)

5 Deegan and Scull (1977)

6 This study

FIG.8.
A Correlation of onshore Sections with Standard North Sea Tertiary nomenclature and the NS Zonation of Gallagher (6), from his Ph.D thesis.

The Tertiary sequence in the Central North Sea is composed of 5 main Groups (see figs.7 and 8). These are the Montrose, Moray (the latter group is only observed in the Moray Firth Basin, and therefore not noted in fig.8), Rogaland, Hordaland and Nordland; with the top of the Chalk Group being represented by the Danian (Early Palaeocene) Ekofisk Formation, which is a continuation of the widespread Upper Cretaceous chalk sediments.

In the western part of the North Sea, in the Palaeocene/Lower Eocene in the outer Moray Firth-Forties area, a lower sedimentary fan sequence (Montrose Group) occurs, together with an upper shelf/deltaic sequence (Moray Group). To the east and north-east these dominantly arenaceous Groups pass into the more distal argillaceous sediments of the Rogaland Group.

The initial phase of Tertiary erosion, transport and deposition is represented by these 3 groups, between the top of the Chalk and the top of the Balder Formation (ash marker). These 3 groups contain much of the Tertiary oil accumulations.

On top of the Chalk succession was deposited the Montrose-Rogaland sequence, which consists at its base of the Maureen Formation, a transitional deposit between the chalk and the later Palaeocene clastics. This is a marl in which has been included many reworked fragments of chalk.

Overlying this formation in the Moray Firth Basin is the Andrew Formation, which is a sequence of overlapping sand fans coalesced into a sand sheet, and above this in the western part of the Central North Sea is the Forties Formation. This arenaceous unit was probably deposited within a submarine fan system. These major sand influxes in Late Palaeocene times are a result of uplift of the North Sea basin margins, the source areas being the Scottish mainland and East Shetland Platform. The Moray Group overlying the Montrose, consists of the Dornoch and Beauly Formations, deposited in shallow marine and paralic environments.

As previously mentioned the more extensive distal equivalent of the Moray and Montrose Groups is the Rogaland Group. This contains, at its base, an unnamed marl unit which is a Maureen Formation equivalent. Above this is the Lista Formation which interdigitates with the sand units of the Montrose Group. The Sele and Balder Formations occur above this. These are relatively thin units which have basin-wide distribution. The Sele is made up of a high amount of tuffaceous shale, while the Balder contains volcanic detritus and forms a distinctive "ash marker" (a very useful geophysical marker, see figures 7 and 8). The Sele Formation (together with the Forties Shale member) was deposited in a marginal marine to marine environment with restricted circulation. These deposits are of marine sands and silts with a deltaic influence, and pass basinwards into shales that are laminated. The Balder Formation occurs at the Palaeocene/Eocene boundary and marks a major volcanic episode. It was also deposited in a restricted marine environment.

Above the Moray and Rogaland Groups there is a largely monotonous series of fine-grained clastics, deposited when a more regular subsidence pattern was established from the Middle Eocene onwards. Erosion of the Scottish mainland, the East Shetland Platform, and parts of Scandinavia continued, and led to the deposition of deltaic and coastal barrier sand units in some marginal areas. These regressive units are often truncated by phases of marine transgression, and are marked in sublittoral sequences by thin beds rich in phosphatised faecal pellets or glauconite. The Hordaland and Nordaland Groups have been recognised in the Norwegian sector, but not differentiated on the U.K. side because of facies variations.

The Southern North Sea differs from the Central North Sea in various aspects. The Tertiary basin appears to have been shallower with fewer sediments being deposited, and with a greater number of hiatuses. Palaeocene sediments are often missing, and the Balder Formation equivalent is restricted to the eastern part of the basin (for example, in Block 49).

CHAPTER 3. FORAMINIFERAL CLASSIFICATION.

3.1. Criticisms of Loeblich and Tappan (1988).

The present writer agrees with Banner (1988, Newsletter of the Brit. Micropal. Soc. No.36), in doubting some of Loeblich and Tappan's concepts on which their classification is based (that is, it is not a phylogenetic approach), and the suprageneric (and generic) importance which has been given to some morphocharacters. The present writer, for example, finds it difficult to agree with Loeblich and Tappan (1988) concerning their updated classification of the calcareous benthic foraminifera, where much revision has taken place at both the generic and suprageneric level. In this study Loeblich and Tappan's earlier (1964) suprageneric classification was generally used, as it was found to be adequate for North Sea Tertiary biostratigraphy. However, the agglutinated benthic suprageneric and generic classification has undergone useful revisions in their 1988 publication, and these are included in this study, although some generic names in the agglutinated taxonomy are probably only of subgeneric status. For example, Meidamonella was used by Loeblich and Tappan (1988) to describe species of Karreriella possessing a slit-like aperture ten times as long as broad, with a lip or rim. Such a feature was not considered to be of generic status in this study (see section 3.2.2 for further comments). Forms possessing such an aperture were therefore referred to as Karreriella (Meidamonella). The strong emphasis on apertural characteristics used by Loeblich and Tappan (1988) to differentiate Karreriella-like taxa (as well as other genera) is unwise.

Loeblich and Tappan's (1988) classification of planktonic foraminifera is here regarded as inadequate, and a more phylogenetic approach was adopted based on Banner (1982).

The present writer also disagrees with Loeblich and Tappan (1988) regarding the use of subgenera resulting in an "unwieldy taxonomy". The rules of the ICZN Articles support the use of subgenera, and they can be useful in phylogenetic classifications in showing to the reader how different genus-group taxa are related.

3.2. Methodology employed in this thesis.

(i). The suprageneric classifications used are based upon those employed by Loeblich and Tappan (1964, 1988) and Banner (1982).

(ii). The generic diagnosis for benthic foraminifera are those published by Loeblich and Tappan (1988) and for planktonic foraminifera are those used by Banner (1982) and Li Qianyu (1987). Where the treatment here has had to differ from these, such differences are noted. In particular, descriptive diagnoses for genera of the Globigerinacea (which are not given satisfactorily by Loeblich and Tappan, 1988) are noted. Subgenera are employed to clarify close degrees of phylogenetic relationship and morphological similarity.

(iii). In order to minimise the morphological descriptions necessary for this work to be utilised stratigraphically, the species and subspecies which have been recognised and used are compared in tabular keys under each generic heading. These tabular keys are meant to clarify, for the reader, the morphocharacters which have actually been used for infrageneric (species, subspecies) distinctions. More morphocharacters (for each taxon) can be seen on the SEM images, and sketches, given here on the Plates.

3.3. Systematic Palaeontology.

3.3.1. Calcareous Benthic Foraminifera.

SUBORDER: MILIOLINA Delage and Herouard, 1896.

SUPERFAMILY: MILIOLACEA Ehrenberg, 1839.

FAMILY: MILIOLIDAE Ehrenberg, 1839.

SUBFAMILY: QUINQUELOCULININAE Cushman, 1917.

GENUS: *Quinqueloculina* d'Orbigny 1826.

i. *Q. imperialis porterensis* Rau. Inflated test, with oval outline.

ii. *Q. ludwigi* Reuss. Sutures depressed. Elongate oval test. Less inflated chambers than i.

iii. *Q. seminula* (Linnaeus). Similar to ii but with a shorter apertural neck, and more elongate test.

Quinqueloculina imperialis Hanna and Hanna
subsp. *porterensis* Rau 1948.
Pl.1, fig.1b.

Quinqueloculina imperialis Hanna and Hanna var. *porterensis* Rau 1948, p.159, pl.27, figs 9-11; Murray and Wright 1974, p.11 text-fig.5.

Notes.

Subangular chamber margins. Aperture a simple arch. Test outline oval to almost completely rounded.

Remarks.

Rare. Small, although some larger broken ones were picked from the London Clay Formation, Parliament Hill site. Noted by Wetherell (1838) and figured in his plate as Fig. 20 '*Miliola*'. *Q. imperialis* Hanna and Hanna (1924, p.58, pl.13, figs.7-8, 10) differs from *Q. imperialis porterensis* Rau in possessing a small bifid tooth, as can be seen in the example on

Pl.1, fig.1a from the North Sea Oligocene (reworked?). Rare in this study (2 specimens). Q. imperialis was described from the Eocene, U.S.A.

Quinqueloculina ludwigi Reuss.

Pl.1, fig.2.

Quinqueloculina ludwigi Reuss 1866, p.126, pl.1, fig.12; Batjes 1958, p.103, pl.1 fig.6; Kaasschieter 1961, p.148, pl.2, fig. 7,8.

Notes.

Test elongate oval. Chambers subrounded in section. Smooth wall. Aperture on a short neck, rounded with a small bifid(?) tooth.

Remarks.

Rare. Differs from Q. imperialis var. porterensis in being more elongate, with more sharply angled, less inflated chambers, and in having an apertural tooth. Similar to Q. seminula (Linnaeus), but has a more elongate test and apertural neck.

Quinqueloculina seminula (Linnaeus).

Serpula seminulum Linnaeus 1758, p.786.

Miliolina seminulum (Linnaeus), Nuttall 1927, p.107, Table 1 , no.29.

Quinqueloculina seminula (Linnaeus), Batjes 1958, pl.1, fig.15a-c.

Quinqueloculina seminulum (Linnaeus), Loeblich and Tappan 1964, p.458, fig.349, 1.

Remarks.

Nuttall (1927) noted this form in the Miocene and Upper Eocene Naparima region of Trinidad. It was noted in this study in, for example, well 14/29-1 (rare), Zone CB5, Middle Eocene (Zone NS12, late Middle Eocene, LTG.teste).

FAMILY: FISCHERINIDAE Millett, 1898.

SUBFAMILY: CYCLOGYRINAE Loeblich and Tappan, 1961.

Cornuspira Schultze 1854.

i. C. involvens (Reuss). Flattened compressed test, of a single planispiral tube. Porcelaneous wall.

Cornuspira involvens (Reuss).

Pl.1, fig.3.

Operculina involvens Reuss 1850, p370 pl.46 fig.20.

Cornuspira involvens (Reuss), Brady 1884, p200, pl.11 fig.1-3; Kaasschieter 1961, p137, pl.1 fig.3.

Notes.

Central part of test concave. Margin subrounded.

Remarks.

Very rare. Large. Test in this example (Pl.1, fig.3) has been compressed. Noted by Williams 1971 as Cyclogyra involvens (Reuss). Loeblich and Tappan 1964 correctly renamed Cornuspira Schultze 1854, as Cyclogyra Wood 1842, as the later was the older name. However, by this time the former was so commonly used that Ponder (1974), proposed that the senior name Cyclogyra be suppressed (Bull. Zool. Nomen. 31 (1) p54-58). Following his proposal the ICZN ruled that Cornuspira is the valid generic name.

Similar to C. bournemanni Reuss, 1863, but lacks the carina and more distinct growth lines of the latter.

SUBORDER: ROTALIINA Delage and Herouard, 1896.

SUPERFAMILY: CASSIDULINACEA D'Orbigny, 1839.

FAMILY: OSANGULARIIDAE Loeblich and Tappan, 1964.

GENUS: Osangularia Brotzen 1940.

i. *O. plummerae* Brotzen. Raised and thickened sutures on spiral side. Very thick spiral suture. Very sharp peripheral keel.

ii. *O. expansa* (Toulmin). Less raised sutures on spiral side than i. Thinner? and less angular peripheral keel.

iii. *O.* [illegible] *corderiana* (d'Orbigny). Large, clear umbilical boss on umbilical side. Sutures distinct, although almost flush.

iv. *O. navarroana* (Cushman). Small boss on the umbilical side. Keeled margin.

Osangularia plummerae Brotzen.

Pl.1, fig.4.

Truncatulina culter (Parker and Jones), Plummer 1926 (1927), Taf.10, fig.147 (1a-c; pl.15, fig.2a-b).

Osangularia plummerae Brotzen 1940, p30, pl.10 fig.1, p.15 fig.2..

Notes.

Test is sharply convex ventrally and gently rounded dorsally. Finely perforate. Test has a sharply acute, peripheral margin which is bordered by a broad thin imperforate flange. 8 to 9 chambers in the final whorl. The dorsal sutures occur as broad, dense, imperforate bands that are elevated, curved and oblique. Ventral ones generally limbate between the early chambers of the final whorl, but depressed between the last two or three. They are almost radiate from a small elevated umbilical filling.

Remarks.

Common in the London Clay where it is well preserved in the 250μm to 125μm fractions. *O. plummerae* s.str. often has only slightly elevated or flat sutures on the dorsal side. However, in the present material, the sutures were quite strongly elevated. Also not noted in the type description was the presence of numerous pores between the raised sutures.

O. plummerae according to Brotzen, occurs in large numbers in the London Clay. It is surprising, therefore, that Wetherell (1838) did not figure this species, as it is quite a distinctive and prominent form in samples studied from Parliament Hill. Sherborn and Chapman (1886) observed a similar form from the London Clay at Piccadilly, which they referred to as Pulvulina boueana (d'Orbigny, 1846). King (1981, Text-fig.44, p.114) noted Osangularia plummerae (as Osangularia sp.) at the base of his Division C in the London Clay Formation.

Osangularia expansa (Toulmin, 1941).

Parrella expansa Toulmin 1941, p.604, Text-figs 3,4F,4G.

Osangularia expansa (Toulmin), King 1983, p.35, pl.5, figs.21-22.

Remarks.

Similar to O. plummerae, but differs in having less distinct sutures on the spiral side, with a less well developed peripheral 'keel'. This species ranges in the North Sea Tertiary from the Early to early Late Palaeocene (King, 1983), and occurs in Zone CB2.

Osangularia cordieriana (d'Orbigny).

Rotalina (Rotalina) cordieriana d'Orbigny 1840, p.33, pl.3, figs.9-11.

Osangularia cordieriana (d'Orbigny), Hart et al. 1981, p.212, pl.7.20, figs. 4-6.

Notes.

Test with acute periphery. 8-10 chambers in the final whorl. Raised distinct umbilical boss of clear calcite on umbilical side. Sutures distinct.

Remarks.

Range according to Hart et al. (op. cit.) from the Campanian to the Early Maastrichtian (Late Cretaceous). This species was commonly encountered in the Early to early Late Palaeocene Zone CB2 in the North Sea.

Osangularia navarroana (Cushman).

Pulvinulinella navarroana Cushman 1938,p.66, pl.11, fig.5.

Osangularia navarroana (Cushman), Hart et al. 1981, p.212, pl.7.20, figs. 7,8.

Notes.

Keeled margin. Umbilical side has only a moderately raised boss. 10-12 chambers on umbilical side.

Remarks.

Differs from O. cordieriana (d'Orbigny) by having a more distinctively keeled margin. This species was noted in the Early-early Late Palaeocene in Zone CB2 in the North Sea Tertiary. Hart et al. (op. cit.) recorded this species from the Upper Chalk, Early Maastrichtian.

GENUS: Gyroidinoides Brotzen 1942.

i. Gyroidinoides sp. Flattish form.

ii. Gyroidinoides nitida (Reuss). Inflated globose form.

Gyroidinoides sp.

Pl.1, fig.5.

Remarks.

Small. Test not elevated so much in umbilical view as one would expect in Gyroidinoides. Only found in British Library samples, London Clay. Poorly preserved.

Gyroidinoides nitida (Reuss).

Rotalina nitida Reuss 1844, p.214 (type figure not given), Reuss 1845, pl.8, fig.52, pl.12, figs.8, 20.

Gyroidinoides nitidus (Reuss), Hofker 1966, pl.3, fig.62, pl.11, figs.112a-113c; Sliter 1974, pl.12, figs.7-8.

Remarks.

This species was noted in the Late Cretaceous, in the Southern North Sea. Rare. Hofker (1966) noted this species in the Maastrichtian. Sliter (1974) recorded this species in the Late Cretaceous of DSDP Leg 39, Site 356, Santonian-Maastrichtian. This species, like all others referred here to Gyroidinoides, possesses a flattened apertural face (depressed into a concavity near the periphery) and an interiomarginal aperture which runs from this concavity to the open umbilicus which is furnished with broadened apertural flap or flaps. These characters distinguish the genus from Gyroidina.

FAMILY: LOXOSTOMIDAE Loeblich and Tappan 1962.

GENUS: Loxostomum Ehrenberg 1854.

i. L. lammersi Cushman & ten Dam. Elongate, slender test, sides parallel for much of its length. Broadly rounded periphery. Chambers numerous, inflated, sutures depressed.

ii. L. teretum (Cushman). Test slender, very slightly tapering and slightly compressed. Less elongate than i. Chambers slightly inflated. Sutures distinct, not depressed.With thin costae towards the initial stages.

Loxostomum lammersi Cushman and ten Dam.

Loxostomum lammersi Cushman and ten Dam 1947, p.58, pl.14, fig.6; Doppert 1980, pl.6, figs.3a-b; King 1983, p.23, pl.2, fig.26; King 1989, p.479, pl.9.7, fig.19.

Remarks.

Doppert (1980) recorded L. lammersi in his FB Zone, Early Pliocene. King (1983) recorded this species in the Early Pliocene, NSB13b-NSB15a, and he later (King, 1989) recorded this species from the Late Miocene-Late Pliocene.

Loxostomum teretum (Cushman).

Loxostoma teretum Cushman 1937, p.179, pl.21, figs.1-2; ten Dam 1944, p.114.

Loxostomum teretum (Cushman), Doppert and Neele 1983, pl.9, fig.4a-b.

Remarks.

This species was noted by ten Dam (1944) in the Bartonian (late Middle Eocene) of the Netherlands. Doppert and Neele (1983) noted this form in their FH Zone, ?Early-Late Eocene.

GENUS: Aragonia Finlay 1939.

i. A. aragonensis (Nuttall). Very compressed test. Thin limbate sutures with fine raised projections extending backwards along the chamber surfaces.

Aragonia aragonensis (Nuttall).

Pl.1, figs.6a-b.

Textularia aragonensis Nuttall 1930, p.280, pl.23, fig.6.

Aragonia aragonensis (Nuttall), Tjalsma and Lohmann 1983, p.23, pl.11, figs.2a-b; van Morkhoven et al. 1986, p.308-314, chart no.101, pl.101A-C.

Remarks.

This species is rare to abundant in the Early Eocene (Zone P8 of

Berggren, 1972) to Middle Eocene (Zone P14 of Berggren, op. cit.), and it has a wide bathymetric range (see Tjalsma and Lohmann, 1983). Van Morkhoven et al. (1986) recorded this species in the Late Palaeocene (P5 of Berggren, op. cit.) through late Middle Eocene (P14). They also state that A. aragonensis (Nuttall) was primarily a bathyal and abyssal form. It was noted in this study in Zone CB3, Early Eocene in the Southern North Sea.

FAMILY: CASSIDULINIDAE d'Orbigny 1839.

GENUS: Cassidulina d'Orbigny 1826.

i. C. laevigata d'Orbigny. Large flattened form. Sutures distinct, slightly depressed. Angular periphery, sharp.

ii. C. crassa d'Orbigny. Relatively small species. Subrounded periphery. Chambers more inflated than i.

iii. C. pliocarinata Voorthuysen. Similar to i, but with a thin distinct peripheral keel. Juveniles with strongly 'milled' keels.

iv. C. carapitana Hedberg. Sharp peripheral margin, without keel. Broader test in apertural view than i and iii.

Cassidulina laevigata d'Orbigny.

Cassidulina laevigata d'Orbigny 1826,p.282, pl.15, figs.4-5; Doppert 1980, pl.1, fig.4a-b, pl.9, fig.1a-b; King 1983, p.33, pl.5, figs.3-4.

Remarks.

This species was recorded by King (1983) in the Late Miocene (Zone NSB13) to Pleistocene (Zone NSB17). Doppert (1980) recorded C. laevigata d'Orbigny in his FA to FD Zones, Late Pliocene to Middle Miocene. It was commonly found as a caved element of the faunal assemblage in samples examined in this study from the Miocene, from the North Sea Basin.

Cassidulina crassa d'Orbigny.

Cassidulina crassa d'Orbigny 1839,p.56, pl.7, figs.18-20; King 1983, p.33. pl.5, figs.1-2.

Remarks.

King (1983) recorded C. crassa d'Orbigny in the Early Pliocene (Zone NSB14) to Pleistocene (Zone NSB17). This species is only found caved in this study.

Cassidulina pliocarinata Voorthuysen.

Cassidulina laevigata var. pliocarinata van Voorthuysen 1950, p.62, text-figs.4a-c, pl.3, fig.4.

Cassidulina pliocarinata Voorthuysen, King 1983, p.33, pl.5, fig.5.

Remarks.

This species was recorded by King (1983) from the Late Miocene (Zone NSB13a) to the Early Pliocene (NSB14). This species was often noted as being caved in this study.

Cassidulina carapitana Hedberg.

Pl.1, fig.7.

Cassidulina carapitana Hedberg 1937,p.680, pl.92, fig.6a-b; Batjes 1958, p.137, pl.6, fig.7; King 1983, p.33, pl.4, Figs.24-25.

Remarks.

This species was used in this study to mark Zone CB7A, Early Oligocene. King (1983) used it to mark his Zone NSB7a, Early Oligocene-Late Eocene.

GENUS: *Globocassidulina* Voloshinova 1960.

i. *G. subglobosa* (Brady). Subglobular test. Broadly rounded peripheral margin. Chambers inflated.

Globocassidulina subglobosa (Brady).

Cassidulina subglobosa Brady 1884, p.430, pl.54, figs.17a-c.

Globocassidulina subglobosa (Brady), Tjalsma and Lohmann 1983, p.31, pl.16, fig.9.

Remarks.

G. subglobosa is rare to abundant from the Late Palaeocene (Zone P4 of Berggren, 1972) upward, and it has a wide bathymetric distribution (Tjalsma and Lohmann, 1983).

FAMILY: NONIONIDAE Schultze, 1854.

SUBFAMILY: NONIONINAE Schultze, 1854.

GENUS: *Pullenia* Parker and Jones 1862.

i. *P. quinqueloba* (Reuss). Subrounded peripheral margin. Less inflated than iii, 5 chambers in final whorl.

ii. *P. quaternaria* (Reuss). Only 4 chambers in final whorl. Rounded peripheral margin. Less lobulate periphery than i.

iii. *P. bulloides* (d'Orbigny). Inflated chambers. Very broadly rounded peripheral margin. Globose test.

Pullenia quinqueloba (Reuss).

Pl.1, fig.8.

Nonionina quinqueloba Reuss 1851, p.71, pl.5 fig.31a-b.

Pullenia quinqueloba (Reuss), Cushman and Todd 1943, p.10, pl.2 fig.5, pl.3 fig.8; Kaasschieter 1961, p.202, pl.11 fig.1-2.

Description.

5 to 6 chambers in final whorl. Compressed with a subrounded periphery.

Remarks.

Recorded by Bowen (1954) from the London Clay Formation, Early Eocene. Small, often broken. A four chambered form of P. quinqueloba was also seen, possibly P. quinqueloba var. quadriloba (Reuss).

Pullenia quaternaria (Reuss).

Nonionina quaternaria Reuss 1851, p.34, pl.3, fig.13a-b.

Pullenia quaternaria (Reuss), ten Dam 1944, p.127, pl.5, fig.1; Doppert 1980 p.118; Doppert and Neele 1983, p.9, pl.23, fig.1a-b.

Remarks.

This species was recorded by Doppert and Neele (1983) in their FJ Bulimina trigonalis-Cibicides proprius Zone, Late Palaeocene. In this study P. quaternaria was noted in Zone CB2, early Late Palaeocene-Early Palaeocene.

Pullenia bulloides (d'Orbigny)

Nonionina bulloides d'Orbigny 1826, p.293, no.2; d'Orbigny 1846, p.107, pl.5, figs.9-10..

Pullenia bulloides (d'Orbigny), Batjes 1958, p.139, pl.6, fig.9; Ulleberg 1974, p.281, pl.7, fig.5; Doppert 1980, p.263, pl.13, fig.2a-b.

Remarks.

This species was recorded by Ulleberg (1974) from the Middle Oligocene, Viborg Formation, Denmark. It was originally described by d'Orbigny (1826) from the Tertiary of the Vienna Basin, Austria. Doppert (1980) recorded this species in his FC Zone, Late Miocene.

GENUS: *Nonion* de Montfort 1808.

i. *N. compressum* di Napoli. Flattened compressed test in apertural view. Sutures depressed with approximately 12 chambers visible.

ii. *N. granosum* (d'Orbigny). Test less compressed than i. Approximately 8 chambers in final whorl. Inflated, lobulate periphery. 'Granules' covering the umbilical region.

iii. *N. orbiculare* (Brady). Inflated form. Broadly rounded peripheral margin. 9-10 chambers in final whorl. 'Granules' cover umbilical region, and extend along slightly depressed sutures.

Nonion compressum di Napoli.

Nonion compressum di Napoli 1952, p.96, pl.5, figs.2, 2a; van Voorthuysen 1957, p.30, Taf.23, fig.5.

Remarks.

Shell Expro. U.K. record this species in the Miocene-Quaternary, it was originally recorded from the Pleistocene.

Nonion granosum (d'Orbigny).

Nonionina granosa d'Orbigny 1846, p.110, pl.15, figs.19-20.

Nonion granosum (d'Orbigny), Batjes 1958, p.142, pl.7, figs.1-3; Doppert 1980, p.265-266, pl.20, figs.1a-b.

Remarks.

Doppert (1980) recorded this species in his *Stainforthia schriebersiana*-*Sigmomorphina regularis* FE Zone, Late Oligocene-Early Miocene.

Nonion orbiculare (Brady).

Nonionina orbicularis Brady 1881, p.415, pl.21, fig.5; Brady 1884, pl.109, figs.21a-21.

Nonion orbiculare (Brady), Hansen and Andersen 1976, p.22, pl.20, figs.10-13, pl.21, fig.1.

Protelphidium orbiculare (Brady), Doppert 1980, p.260, pl.4, fig.2a-b.

Haynesina orbiculare (Brady), King 1983, p.31, pl.4, figs.13-14.

Remarks.

Doppert (1980) noted this form in his FA Zone, Late Pliocene-Early Pleistocene. King (1983) recorded this species in his NSB14 (Early Pliocene) to NSB17 (Pleistocene) Zones.

GENUS: Pseudononion Asano 1936.

i. P. boueanus (d'Orbigny). Lenticular test when viewed from the apertural face. Sutures slightly depressed. High and broad apertural face.

Pseudononion boueanus (d'Orbigny).

Pl.1, fig.10.

Nonionina boueana d'Orbigny 1846, p.108, pl.5, figs.11-12.

Nonion boueanum (d'Orbigny), ten Dam and Reinhold, 1942, p.77, pl.5, fig.4; Batjes 1958, p.143, pl.7, figs.6-7.

Florilus boueanus (d'Orbigny), Doppert 1980, p.263, pl.9, figs.7a-b, pl.16, figs.1a-b; King 1983, p.33, pl.5, figs.9-10.

Remarks.

This species was recorded by Doppert (1980) in his FD and FC Zones, Middle-Late Miocene. King (1983) noted this form in his NSB8 to NSB14 Zones, Late Oligocene-Early Pliocene.

SUBFAMILY: CHILOSTOMELLINAE Brady, 1881.

GENUS: Chilostomelloides Cushman, 1926.

i. C. oviformis (Sherborn & Chapman). Ovate shape. Circular aperture with rim.

Chilostomelloides oviformis (Sherborn and Chapman).

Pl.1, fig.11.

Lagena (Obliquina) oviformis Sherborn and Chapman 1886, pl.14, fig.19 a-d.

Chilostomelloides oviformis (Sherborn and Chapman), Loeblich and Tappan 1964, p.743 fig.611, 4a-b.

Remarks.

Rare, found in Parliament Hill sample no.4, London Clay Formation. Test fragile, length approximately 0.5mm. Similar to C. eocenica Cushman 1926 (p.78, pl.11 fig.20a-c), the type drawing of which shows the penultimate chamber as being much larger than in the above. The test also does not taper so much towards the ends. The overall outline of the Parliament Hill form is that of C. oviformis.

GENUS: Quadrimorphina Finlay 1939.

i. Q. allomorphinoides (Reuss). Comparatively large final chamber. Subangular peripheral margin, lobulate. Sutures depressed, distinct. Aperture with distinct flap.

Quadrimorphina allomorphinoides (Reuss).

Valvulina allomorphinoides Reuss 1860, p.223, pl.11, fig.6.

Allomorphina allomorphinoides (Reuss), White 1928, p.304, pl.41, fig.8.

Quadrimorphina allomorphinoides (Reuss), Sliter 1974, pl.7, fig.12.

Remarks.

White (1928) recorded this species in the Velasco Formation (Palaeocene), from the Tampico area of Mexico. Sliter (1974) recorded this species in the Cretaceous (Albian- Maastrichtian), DSDP Leg 39 Site 356.

This species was recorded in the Early-early Late Palaeocene in this study, Zone CB2.

FAMILY: ANOMALINIDAE Cushman, 1927.

SUBFAMILY: ANOMALININAE Cushman, 1927.

GENUS: Anomalinoides Brotzen, 1942.

i. A. dorri (Cole). Broadly rounded periphery. Coarsely perforate. Sutures broad and thickened in earlier stages on the umbilical side.

ii. A. capitatus (Gümbel). Differs from i in having more strongly raised sutures throughout the test.

iii. A. danica (Brotzen). Perforations medium to coarse. Surface smooth in initial stages on spiral side which is flattened. Deep, open umbilicus on umbilical side. Broadly rounded to subangular periphery.

iv. A. semicribratus (Gümbel). Compact test, coarsely perforated for size. Sutures distinct, slightly depressed.

v. A. acuta Plummer. Distinct umbilical boss on both sides. More strongly curved sutures than vii. Umilical side non-perforate.

vi. A. acuta anomalinoides (ten Dam). More acute periphery than v, often with a raised spiral suture and more distinct peripheral band. Perforations on both sides.

vii. A. ypresiensis (ten Dam). Distinct boss on spiral side. Smaller boss on umbilical. Sutures on spiral side almost flush to slightly depressed, smooth. Spiral side strongly perforated. Umbilical side almost non-perforate. Distinct peripheral band.

Anomalinoides dorri (Cole).

Pl.1, figs.12a-b, Pl.2, fig.1.

Anomalina dorri Cole 1928, p.218 (18) pl.34 (3), fig.1-2.

Anomalinoides dorri (Cole), Berggren and Aubert 1976, p.338 pl.4 fig.14-15.

Notes.

Coarsely perforate. Depressed umbilicus on the convex dorsal (spiral) side. Curved sutures, flush to slightly raised. Ventral side flattened with sutures raised and thickened to form distinct ridges in the earlier parts. Chambers inflated, 8 in the last whorl. Periphery broadly rounded. Aperture at base of final chamber extending onto dorsal side, not onto the ventral.

Remarks.

Anomalina d'Orbigny (1846), is no longer a valid generic name as the original type on which his drawings were based have been lost. This species fits into the description of *Anomalinoides* Brotzen (1942).

Hagn (1956) suggested that *A. dorri* is the same as *A. dorri* var. *aragonensis* Nuttall (1930), and *A. capitatus* (Gümbel 1868). If this is so, the senior name is *A. capitatus*. Van Morkhoven *et al*. 1986 place *A. dorri* var *aragonensis* into synonymy of *A. capitatus*, (but do not include *A. dorri* s.str.) and state that Berggren and Aubert's (1976) illustration of *A. aragonensis* is the same as *A. capitatus*. Van Morkhoven *et al*. (*op. cit*.) seem to suggest that *A. dorri* and *A. aragonensis* are the same species as *A. capitatus*, but they do not commit themselves. This species was noted from the Early Eocene London Clay Formation.

Anomalinoides capitatus (Gümbel).

Pl.2, fig.2a-d.

Rotalia capitata Gümbel 1868, (1870), P.653, pl.2 fig.92.

?*Rosalina calymene* Gümbel 1868 (1870), P.658, pl.2 fig.100a-c.

Anomalina dorri Cole var. *aragonensis* Nuttall 1930, p.291, pl.24 fig.18, pl.25 fig.1.

Anomalinoides captitatus (Gumbel). Van Morkhoven *et al*. 1986, p.276-278, pl.92 fig.1a-2b.

Notes.

Compact coarsely perforate test. Sutures often thick and raised, more pronounced on the umbilical than on the spiral side. The periphery of the first chambers in the final whorl is imperforate, later chambers perforate.

Remarks.

Ranges from the Late Palaeocene to the Early Oligocene (Van Morkhoven *et al*., 1986). This species was recorded in the Southern and Central North Sea Eocene in this study.

Anomalinoides danica (Brotzen).

Cibicides danica Brotzen 1940, p.31, tf.7:2.

Gavelinella danica (Brotzen). Hofker 1966, p.41, pl.6, fig.51, pl.84 figs.218, 220-222; King 1983, p.32, pl.5 figs.16-17; Tjalsma and Lohmann, 1983, pl.5 fig.7a-c; Doppert and Neele 1983, p.9 pl.27 fig.3a-c.

Remarks.

Tjalsma and Lohmann (1983) recorded *G. danica* from the Palaeocene, Zones P1-P5 of Berggren 1972. Doppert and Neele (1983) recorded this species from the Netherlands, in their FK Zone, Early Palaeocene (Montian and Danian). Van Morkhoven *et al*. (1986) regarded *Anomalinoides danicus* (Brotzen) and *A. rubiginosus* (Cushman) as "depth-related ecophenotypes" (p.368). As *A. rubiginosus* is the senior name they therefore place *A. danicus* into synonymy. However, *A. rubiginosus* differs from *A. danicus* in having a smoother dorsal (spiral) side, with less depressed sutures. The periphery of the former is also more rounded than the latter, and it possesses a slightly concave ventral (umbilical) side. The early portion on the ventral side of *A. rubiginosus* (Cushman) is also more irregularly pitted.

Anomalinoides semicribratus (Beckmann).

Pl.2, fig.3.

Anomalina pompiloides Galloway and Heminway var. *semicribrata* Beckmann 1953, p.400, pl.27, fig.3, text-figs.24-25.

Gavelinella semicribrata (Beckmann), Tjalsma and Lohmann 1983, p.31, pl.16, fig.6a-b.

Anomalinoides semicribratus (Beckmann), Berggren and Aubert 1976, pl.4, figs.12-13; van Morkhoven *et al*. 1986, p.147-149, Chart No.48, pl.48.

Linaresia semicribratus (Beckmann), Loeblich and Tappan 1988, p.640-641, pl.722, figs.1-7.

Remarks.

This species ranges from P12 (of Berggren, 1972) upwards, and has a wide bathymetric range, according to Tjalsma and Lohmann (1983). Van Morkhoven *et al*. (1986) noted this species in middle bathyal to abyssal depths; while its' stratigraphic range was from the Middle Eocene (P12 of Berggren, *op. cit*.) through Middle Miocene (N12). Transitional forms between *A. semicribratus* (Beckmann) and *A. capitatus* (Gümbel) occur commonly in Zones P9-P11 of Berggren (1972). *A. semicribratus* was noted in this study in the Eocene, and often associated with *A. capitatus*. Van Morkhoven *et al*. (op. cit.) suggest that *A. danica* (Brotzen) (=*A. rubiginosus* Cushman of van Morkhoven *et al*., *op. cit*.), *A, capitatus*, *A. semicribratus* and *A. globulosus* (Chapman and Parr) form a chronocline ranging from the Upper Cretaceous (Maastrichtian) through to the Pleistocene (Zone N23 of Berggren, *op. cit.*). The examples of *A. semicribratus* in this thesis have less depressed sutures, are smaller, and have less lobulate peripheries than the topotypes shown by Loeblich and Tappan (1988). The example on plate 2 figure 3 may be a juvenile. Loeblich and Tappan (op. cit.) place *A. semicribratus* into·the genus *Linaresia* Gonzalez-Donoso 1968. In *Anomalinoides* the aperture extends from the umbilicus of the more involute side to the spiral suture of the last 1 or 2 or 3 chambers of the more evolute side (Loeblich and Tappan 1988, pl.708, figs.18-20, topotype). In *Linaresia* the aperture appears to extend almost to the umbilicus of the more involute side but not to extend in the spiral suture of the more evolute side (Loeblich and Tappan 1988, fig.1-3, 6, topotypes from the Oligocene). The examples of '*semicribratus*' from the North Sea belonged to *Anomalinoides*.

Anomalinoides acuta Plummer.

Pl.2, fig.4a-b.

Anomalina ammonoides (Reuss) var. *acuta* Plummer 1926, p.149, pl.10, fig.2a-c.

Anomalina acuta Plummer, Doppert 1980, p.6, pl.10, fig.3a-c.

Remarks.

Doppert (1980) recorded this species in his FH Zone, ?Early-Late Eocene. This species was noted in Zones CB3-6 in the Southern North Sea in this study, Early-Late Eocene.

Anomalinoides acuta Plummer *anomalinoides* (ten Dam).

Pl.2, fig.5a-c.

Cibicides anomalinoides ten Dam 1944,

Anomalinoides acuta (Plummer) var. *anomalinoides* (ten Dam), Kaaschieter 1961, pl.13, fig.4a-c; Murray and Wright 1974, pl.19, figs.5-6, 8.

Remarks.

This sub-species was recorded in this study in the Southern North Sea, well 49/9-1, Middle-Late Eocene. Murray and Wright (1974) recorded it in the Cuisian (Early Eocene) of the Paris Basin.

Anomalinoides ypresiensis (ten Dam).

Cibicides ypresiensis ten Dam 1944, p.136, Taf.6, fig.2a-c.

Anomalinoides ypresiensis (ten Dam), Murray and Wright 1974, pl.19, fig.15, pl.20, figs.1-2.

Anomalina ypresiensis (ten Dam), Doppert 1983, p.9, pl.16, fig.1a-c.

Remarks.

Murray and Wright (1974) noted this species in the "Cuisian" and Lutetian (Early-Middle Eocene) of the Paris Basin. Doppert (1983) recorded it in his *Anomalina ypresiensis*-*Gaudryina hiltermanni* FI Zone, Early Eocene. *A. ypresiensis* was recorded in this study in the Southern North Sea, *Gaudryina hiltermanni* Zone, AB4. Shell Expro. U.K. record this species in the Middle-Late Eocene, mainly in the Southern North Sea.

GENUS: *Cibicidoides* Thalmann 1939, emend. Loeblich and Tappan 1955.

i. *C. alleni* subsp.A. Thickened, raised spiral suture common. Has small umbilical boss in a depression. Periphery subacute. More compressed than ii.

ii. C. alleni subsp.B. More inflated than i. Umbilical side without small central boss. Spiral suture distinctly incised.

iii. C. eocaenus (Gumbel). Slightly depressed, distinct spiral suture. Perforated on spiral side, only relatively rare perforations on umbilical. Sutures slightly depressed on spiral side. Chambers taper sharply towards angular periphery.

iv. C. velascoensis (Cushman). Flattened umbilical side. Broadly rounded periphery. Thickened areas between sutures on the umbilical side. Smooth wall, punctate.

v. C. hyaphalus (Fisher). Differs from iv in often being biconvex. Subacute periphery. Transparent umbo on spiral side, smooth. Umbilical side slightly convex, with poorly developed umbilical plug. Also differs from iv in lacking distinct depressions between the sutures on the umbilical side.

vi. C. dayi (White). Differs from iv and v in possessing well developed, distinct umbos on both sides, large spiral one. Subacute periphery, more compressed test in apertural view than v. Sutures indistinct, flush.

Cibicidoides alleni (Plummer) sub.sp.A.

Pl.2, fig.6a-c.

Truncatulina alleni Plummer 1927, p.155 pl.10 fig.4a-c.

? Cibicides hilgardi Garret 1941, p.155 pl.26 fig.13-14.

Cibicides proprius Brotzen 1948 (in part), p.78, pl.12 fig. 3a-c; Kaaschieter 1961, pl.13, fig.9a-c.

Cibicidoides alleni (Plummer), Berggren and Aubert 1975, p.151-153, pl.5, 1a-d, pl.7, 1a-3d: Murray et al. 1981, p.250 pl.8.5 fig. 13-15.

Notes.

Biconvex. Heavily limbate, thickened and raised spiral sutures.

Remarks.

The thickening of the sutures, mainly the spiral one, on some forms, (NB. pl.7 fig.1a-3d, Berggren and Aubert 1975), could be the result of eco-phenotypy (the Midway environment, where Berggren and Aubert's examples came from, could have produced this), but it seems to be a consistent feature.

Cibicidoides alleni (Plummer) sub.sp.B.

Pl.3, fig.1a-b.

? Rotalia mortoni Reuss 1862, p.337 pl.8 fig.1.

? Cibicides cryptomphalus (Reuss), Ten Dam 1944, p.132 pl.1 fig.4 (non Reuss).

Cibicides proprius Brotzen 1948, (in part, see above synonymy), fig.4a-c.

? Cibicides (Cibicidoides) breslesensis Rouvillois 1960, p.75 pl.4 fig.56.

Notes.

With very deeply incised spiral sutures.

Remarks.

C. alleni sub.sp.A. and C. alleni sub.sp.B. may be geographic subspecies with overlap in space and time. They may also be ecophenotypes, but I distinguish them because they might have different environmental preference that may indicate some form of palaeoenvironmental distinction. Until this is proven it is worthwhile keeping these seperate, but as forms of one species. The term 'sub-species' is therefore being used in this case as a possible phenotypic label. Degree of inflation of test varies within species 'group', as does size and number of its perforations.

Cibicidoides eocaenus (Gümbel).

Pl.3, fig.2a-b.

Rotalia *eocaena* Gümbel 1868 (1870), p.650, pl.2, fig.87a,b.

Cibicides *tuxpamensis* Cole 1928, p.219(19), pl.32(1), figs.2-3, pl.3, figs.5-6.

Cibicides *perlucida* Nuttall 1932, p.33, pl.8, figs.10-12.

Cibicdoides *eocaenus* (Gümbel), van Morkhoven *et* *al*. 1986, p.256-263, pl.86A-C.

Remarks.

The known stratigraphic range of this species is from the Early Eocene (P6b of Berggren) through Late Oligocene (P22), according to van Morkhoven *et* *al*. (1986). The latter authors state that *C.* *eocaenus* was primarily a bathyal species, although it ranged from outer neritic to abyssal depths.

Cibicidoides *velascoensis* (Cushman).

Anomalina *velascoensis* Cushman 1925, p.21, pl.3, figs.3a-c.

Gavelinella *velascoensis* (Cushman), Tjalsma and Lohmann 1983, p.14, pl.5, figs.8a-d.

Cibicidoides *velascoensis* (Cushman), van Morkhoven *et* *al*. 1986, p.371-373, pl.121; King 1989, p.474, pl.9.6, figs.10-11..

Remarks.

This species was recorded by Tjalsma and Lohmann (1983) in Berggren's (1972) Zones P1-P5. It occurs in Zone CB2 in this study, Early-early Late Palaeocene. Van Morkhoven *et* *al*. (1986) recorded this species range as Late Cretaceous (Campanian) through Late Palaeocene (P5 of Berggren, *op.* *cit*.). *C.* *velascoensis* occurs in upper bathyal to abyssal depths (van Morkhoven *et* *al*., *op.cit*.). King (1989) records this species in his NSB1b Zone, early Late Palaeocene, with Stensioina beccariformis (White) and Cibicidoides dayi (White).

Cibicidoides hyaphalus (Fisher).

Anomalinoides hyaphalus Fisher 1969, p.197, test-figs. 3a-c.

Gavelinella hyaphalus (Fisher), Tjalsma and Lohmann 1983, p.13, pl.4, figs.8-9, pl.7, figs.11a-b.

Cibicidoides hyaphalus (Fisher), van Morkhoven et al. 1986, p.359-361, pl.116.

Remarks.

Recorded in the Palaeocene, Zones P1-P5 of Berggren (1972), by Tjalsma and Lohmann (1983). This species was recorded in Zone CB2 in this study. Van Morkhoven et al. (1986) note that this species known stratigraphic range is from the Late Cretaceous (Late Maastrichtian) through Late Palaeocene (P5 of Berggren, 1972), and that its bathymetric range was from outer neritic to bathyal depths. Occurs in this study in Zone CB2, Early-early Late Palaeocene.

Cibicidoides dayi (White)

Planulina dayi White 1928, p.300, pl.41, figs.3a-c (not figs.4a-5c).

Cibicidoides dayi (White), Tjalsma and Lohmann 1983, p.9, pl.6, figs.6-7; Van Morkhoven et al. 1986, p.353-356, pl.114; King 1989, p.471, pl.9.5, fig.25-26.

Remarks.

Tjalsma and Lohmann (1983) recorded C. dayi from the Palaeocene, Zones P1-P3 of Berggren (1972). Van Morkhoven et al. (1986) noted this species in Late Cretaceous (Campanian) through Late Palaeocene (P5 of

Berggren, op. cit.) material. The latter authors also noted that C. dayi was primarily a bathyal and abyssal form. King (1989) recorded this species in his NSB1b Zone, early Late Palaeocene, with Stensioina beccariformis (White). Occurs in this study in Zone CB2, Early-early Late Palaeocene.

GENUS: Gavelinella Brotzen 1942.

i. G. complanata (Reuss). Very compressed test in apertural view. Acute to subacute periphery. Approximately 12 chambers in the final whorl. Perforate wall. Sutures flush to slightly depressed.

Gavelinella complanata (Reuss).

Anomalina complanata Reuss 1851, p.36, p.14, fig.3a-c.

Cibicides complanata (Reuss), Brotzen 1945, p.55, pl.2, fig.4.

Gavelinopsis complanata Hofker 1957, p.324-329, Abb.372-379; Hofker 1966, p.29, pl.3, fig.58, pl.14, fig.72.

Remarks.

G. complanata forms noted in the North Sea in this study were 'intermediates', between the latter species and Gavelinella bartensteini (Hofker, 1956, see Hofker 1957, p.329-330, Abb.375, 376). G. bartensteini evolved from G. complanata according to Hofker (1957). The North Sea forms are closer to G. complanata in that they are more evolute on the spiral side, although they have a slightly lobulate peripheral margin as in G. bartensteini (compare Hofker 1957, Abb.Abb.375 and 376 with Abb.374). G. complanata was noted in this study in well 49/9-1, Late Cretaceous. Brotzen (1945) noted this form in the Late Cretaceous, Late Campanian-Early Maastrichtian. Hofker (1966) recorded G. complanata as a common species in the Late Campanian, although it was also found in the Early Maastrichtian.

GENUS: Heterolepa Franzenau 1884.

i. H. mexicanus (Nuttal). Flattened spiral side with depressed spiral suture. Sutures imperforate, strongly curved on spiral side. Earlier whorls on this side often obscurred by glassy material. Convex umbilical side, with thickened and raised sutures. Wall perforate.

ii. H. dutemplei peelensis (ten Dam & Reinhold). Generally almost equally biconvex. Subacute peripheral margin. Coarse-medium perforations.

iii. H. dutemplei praecincta (Karrer). Unequally biconvex, more convex umbilical side than ii. Acute peripheral margin. Coarsely perforated.

Heterolepa mexicanus (Nuttall).

Pl.3, fig.3a-c.

Cibicides mexicana Nuttall 1932, p.33, pl.9, figs.7-9..

Cibicidoides mexicanus (Nuttall), van Morkhoven et al. 1986, p.222-227, pl.76A-C.

Remarks.

This species was placed into the genus Heterolepa because of its apertural restriction. The aperture is not continuous along the spiral suture of the evolute side. The umbilical side in forms in this thesis from the North Sea may be less strongly convex than is typical for this species (see fig.3a, plate 3). The known stratigraphic range of this species is from the Late Eocene (Zone P16 of Berggren) to the Early Miocene (Zone N5), according to van Morkhoven et al. (1986). The latter authors also state that H. mexicanus was a middle and lower bathyal species.

Heterolepa dutemplei peelensis (ten Dam and Reinhold).

Pl.3, fig.4a-b.

Cibicides peelensis ten Dam and Reinhold 1942, p.100, pl.8, fig.8, pl.10,

fig.1.

Cibicides dutemplei (d'Orbigny) var. *peelensis* ten Dam and Reinhold, Batjes 1958, p.151, pl.9, fig.11

Heterolepa dutemplei peelensis (ten Dam and Reinhold), King 1983, p.35, pl.5, figs.23-24.

Cibicidoides dutemplei peelensis (ten Dam and Reinhold), King 1989, p.472, pl.9.6, figs.3-4.

Remarks.

King (1989) records this species from the Early-Middle Eocene. It is often reworked in wells examined in this study.

Heterolepa dutemplei praecincta (Karrer)

Rotalia praecincta Karrer 1868, p.189, pl.5, fig.7.

Cibicides dutemplei (d'Orbigny) var. *praecinctus* (Karrer), Batjes 1958, p.151, pl.9, fig.10.

Heterolepa dutemplei praecincta (Karrer), King 1983, p.32, pl.5, figs.25-26.

Remarks.

Recorded by King (1983) from his Zone NSB5 (Middle Eocene) to Zone NSB7 (Early Oligocene). This species was described by Karrer (1868) from the Miocene, Rumania. King (1989) placed *H. dutemplei praecincta* into the synonymy of *Cibicidoides mexicanus* (Nuttall). However, *H. dutemplei praecinata* of King (1983) has a more conical appearance to its umbilical side than *C. mexicanus*, which has a more inflated convex umbilical side.

GENUS: *Melonis* De Montfort, 1808.

i. *M. affinis* (Reuss). Smooth walled, almost flush, slightly depressed sutures, glassy. 'Biumbilcate'.

Melonis affinis (Reuss).

Pl.3, fig.5.

Nonionina affinis Reuss 1851, p72, pl.5 fig.32a-b

Nonion affine (Reuss), Cushman 1939, p9, pl.2 fig.13; Kaasschieter 1961, p.203, pl.11 fig.3-4.

Melonis affine (Reuss), Murray et al. 1981, p.254, pl.8.7, fig.12-13.

Remarks.

Often appears worn. Ranges to Recent. Noted by Kaasschieter (1961) from the Eocene of Belgium.

GENUS: Pulsiphonina Brotzen, 1948.

i. P. prima (Plummer). Small test, with semilunate chambers on the spiral side. 'sub'-lobulate periphery.

Pulsiphonina prima (Plummer).

Pl.3, fig.6a-b.

Siphonina prima Plummer 1927, p.148 pl.12 fig.4; Kaasschieter 1961, p.230, pl.15, fig.2.

Pulsiphonina prima (Plummer), Haynes 1956, p.96, pl.17 fig.9-9b; Murray et al. 1981, p.258 pl.8.9 fig.5-7.

Remarks.

Very small (occurs in 63µm sieve fraction). Similar to Sherborn and Chapman's (1889) Discorbina rosacea (d'Orbigny, 1826). However, unlike Discorbina s.s. this example (and probably Sherborn and Chapman's, op. cit.) is biconvex. Preservation of figured specimens very poor which is atypical of the London Clay Formation, Parliament Hill site.

GENUS: *Stensioina* Brotzen 1936.

i. *S. beccariiformis* (White). Slightly convex spiral side, sutures flush to slightly depressed. Smooth, no perforations. Broadly rounded peripheral margin. Umbilical side convex to almost concave, and sutures may be divided into 'beads' or be 'open'. Apertural face often large and rounded.

ii. *S. pommerana* Brotzen. Flat spiral side, more strongly convex umbilical side than i. Ornamentation on spiral side more pronounced than in i. Subacute-acute peripheral margin.

Stensioina beccariiformis (White). Pl.3, figs.7a-b.

Rotalia beccariiformis White 1928, p.287, pl.39, figs.2a-4c.

Rotalia parvula ten Dam 1944, p.121, Taf.4, fig.1

Gavelinella beccariiformis (White), Tjalsma and Lohmann 1983, p.12, pl.6, figs.1a-3b; King 1983, p.33, 35, pl.5, figs.13-15.

Stensioina beccariiformis (White), van Morkhoven *et al*. 1986, p.346-353, chart no.113, pl.113A-D.

Stensioeina beccariformis (White), King 1989, p.482, pl.9.8, figs.18-19.

Remarks.

Gradstein and Kaminski (1981, p.234) noted this species in palaeoenvironmentally deep-water Palaeocene sediments, in the Central North Sea, central basin. It was recorded by the latter authors in sediments that were transitional between Danian limestones and clastic mud and sands with flysch-type agglutinated foraminferal faunas. This, according to van Morkhoven *et al*. (1986), suggests that abrupt subsidence took place in the latest Danian. *S. beccariiformis* was a bathyal and abyssal species, although a neritic morphotype (*S. parvula* (ten Dam)) was noted by van Morkhoven *et al*. (*op. cit*.) in Palaeocene deposits of northwestern Europe; who also noted *S. beccariiformis* from the Late Cretaceous (Santonian) through Late Palaeocene (P5 of Berggren, 1972). Tjalsma and Lohmann (1983) recorded this species in the Palaeocene, from Berggren's (1972) Zone P1 to P5. In this thesis, S. beccariiformis was the marker species for Zone CB2, Early-early Late Palaeocene. King (1989) recorded this species in his NSB1 Zone (P3 to base of P5 of Berggren et al. 1985, early Late-Late Palaeocene), although in 1983 King had recorded this species in the Early to early Late Palaeocene, Zones P1-P5 of Berggren 1972. Preservation of photographed material very poor, which is typical of the North Sea Palaeocene.

Stensioina pommerana Brotzen.

Stensioina pommerana Brotzen 1936 p.166; Brotzen 1945, p.51, pl.1, fig.14; Hofker 1966, p.30, pl.11, fig.125a-c; Koch 1977, p.51, pl.11, figs.1-4; Hart et al. 1981, p.220, pl.7.24, figs.10-12.

Remarks.

S. pommerana Brotzen differs from S. exsculpta exsculpta (Reuss) in having a more strongly convex umbilical side, and the ornamentation on the spiral side is also less pronounced. S. exsculpta exsculpta sensu Koch (1977) is a low trochospiral form, almost flat in apertural view. S. pommerana is strongly plano-convex. S. exsculpta gracilis Brotzen (see Koch, op. cit., p.44, pl.11, figs.5-8) differs from S. pommerana in having a convex spiral side, with a distinctively raised spiral suture. Hofker (1966) noted the latter species in the Maastrichtian (his Zone C). Koch (op. cit., Table 2, p.13) noted S. pommerana in the late Early Campanian, Bolivinoides decoratus decoratus Zone to the Late Maastrichtian Pseudotextularia elegans Zone. This species was noted in this thesis in the Late Cretaceous, and it was occasionally reworked into the Palaeocene. Hart et al. (1981) recorded this species in the Early Campanian (rare) to the Middle Campanian and Maastrichtian. Van Morkhoven et al. (1986) regard S. pommerana as a synonym of S. excolata (Cushman 1926), even though S. pommerana is the senior name. S. pommerana generally has a more strongly convex ventral side than S. excolata, and a has a more distinctively raised spiral suture on the flat dorsal side.

SUPERFAMILY: ROBERTINACEA Reuss 1850.

FAMILY: CERATOBULIMINIDAE Cushman 1927.

SUBFAMILY: CERATOBULIMININAE Cushman 1927.

GENUS: Ceratobulimina Toula 1915.

i. C. contraria (Reuss). Periphery rounded. Sutures more depressed near the umbilicus. Inflated form.

ii. C. aff woodi Khan. Flatter more compressed form than i. Length much greater than breadth, generally with a higher apertural face than i. More open umbilicus than i.

Ceratobulimina contraria (Reuss). Pl.3, fig.8.

Rotalina contraria Reuss 1851, p.76, pl.5, fig.37.

Ceratobulimina contraria Reuss, Batjes 1958, p.160, pl.10, fig.4; Kiessel 1970, p.318, pl.21, fig.3; Ulleberg 1974, p.284-285, pl.8, fig.7, pl.9, fig.6; Doppert 1980, p.266, pl.18, fig.3a-c.

Remarks.

Doppert (1980) recorded this species in his FE Zone, Late Oligocene-Early Miocene. Ulleberg (1974) recorded this species from the Middle Oligocene Viborg Formation, Denmark. It was described by Reuss (1851) from the Eocene, Germany.

Ceratobulimina sp. aff. woodi Khan 1950.

see. Ceratobulimina woodi Khan 1950, p.276, pl.2, figs.15 (holotype)-16, 20-21 (paratypes).

Remarks.

C. woodi Khan s.s. was a Cretaceous (Aptian) species. It has been placed by Shell Expro. U.K. into the genus Ceratolamarckina (Loeblich and Tappan 1964, p.769). The species noted in this study was a ceratobuliminid. C. aff. woodi was noted in this study in wells 21/11-1 (few) Zone CB6, Late Eocene (Zone NS11 Late Eocene, LTG.teste), and 14/29-1, Zones PK10-AB11, Late Oligocene-Early Miocene.

SUBFAMILY: EPISTOMININAE Wedekind 1937.

GENUS: Hoeglundina Brotzen 1948.

i. H. elegans (d'Orbigny). Biconvex test with subacute periphery. Sutures only very slightly depressed, curved gently. Distinctive latero-marginal aperture.

Hoeglundina elegans (d'Orbigny).

Rotalia (Turbinuline) elegans d'Orbigny 1826, p.276 (type figure not given); Parker, Jones and Brady 1871, pl.12, fig.142..

Hoeglundina elegans (d'Orbigny), van Morkhoven et al. 1986, p.97-99, chart no.29, pl.29.

Remarks.

H. elegans (d'Orbigny) was recorded by van Morkhoven et al. (1986) from the Late Eocene (P16 of Berggren, 1972) through Pleistocene (N23). Van Morkhoven et al. (op. cit.) pointed out that this species has a wide bathymetric range, from depths of 42m to 4,330m.

SUPERFAMILY: DISCORBACEA Ehrenberg 1838.

FAMILY: DISCORBIDAE Ehrenberg 1838.

SUBFAMILY: DISCORBINAE Ehrenberg 1838.

GENUS: Buccella Andersen 1952.

i. Buccella frigida (Cushman). Smooth spiral side flattened. Slightly depressed spiral suture. Subrounded peripheral margin. Convex umbilical side with radial sutures, and distinctively granulose around the umbilicus and along the sutures.

Buccella frigida (Cushman).

Pl.3, fig.9a-b.

Pulvinulina frigida Cushman 1922, p.144 (type figure not given).

Buccella frigida (Cushman), Doppert 1980, p.260, pl.1, fig.3a-c; King (1983), p.23, 29, pl.3, figs.7-8.

Remarks.

Doppert (1980) noted this species in his FA Zone, Late Pliocene-Early Pleistocene. King (1983) noted it in his NSB13a (Late Miocene) to NSB17 (Pleistocene) Zones. Letsch and Sissingh (1983) recorded this species in their FT8 (Late Miocene) to FT9 (Miocene-Pliocene) Zones, and also in the Pleistocene. Commonly caved in this study.

SUBFAMILY: BAGGININAE Cushman 1927.

GENUS: Cancris de Montfort 1808.

i. C. auriculus primitivus Cushman and Todd. Compressed test when viewed from the apertural face. Sutures slightly depressed. Convex umbilical side. Open umbilicus.

Cancris auriculus primitivus Cushman and Todd.

Cancris auriculus (Fichtel and Moll) primitivus Cushman and Todd 1942, p.77, pl.19, figs.1a-2c; Kaaschieter 1961, p.214, pl.12, figs.9-10; King 1983, p.29, pl.3, figs.9-10.

Remarks.

King (1983) noted this species in his NSB3 Zone, Early Eocene. Rare in wells in this study. It was described by Cushman and Todd (1942) from the Oligocene, Germany.

FAMILY: SIPHONINIDAE Cushman 1927.

GENUS: Siphonina Reuss 1850.

i. S. reticulata (Czjzek). Biconvex test with crenulated peripheral keel. Smooth wall, with aperture on neck with distinct broad rim.

Siphonina reticulata (Czjzek).

Pl.4, fig.1a-c.

Rotalina reticulata Czjzek 1848, p.145, pl.13, figs.7-9.

Siphonina reticulata (Czjzek). King 1983, p.28, pl.3, figs.11-12.

Remarks.

North Sea examples of this species were usually smooth, rather than 'hispid' as shown in Czjzek (1848, pl.13, fig.8) on the umbilical side. It was recorded by King (1983) as common in his NSB12 Zone, Middle-early Late Miocene (the species FDO); it was also noted in Oligocene to Miocene sediments. It is used in this study to mark Zone CB14, early Late Miocene.

FAMILY: ASTERIGERINIDAE d'Orbigny 1839.

GENUS: Asterigerina d'Orbigny in de la Sagra 1839.

i. A. staeschi ten Dam and Reinhold. Slightly convex spiral side, with imperforate, slightly raised sutures. Acute periphery with keel. Sutures depressed on umbilical side, which is strongly convex. Pustules around aperture often extend onto the apertural face, and umbilicus.

ii. A. bartoniana (ten Dam). Biconvex form. More distinct peripheral keel than i or iii. Pustulose around the aperture and first formed chambers in the last whorl.

iii. A guerichi (Franke). Larger, broader, more flattened form than i, with a less 'domed' umbilical side. Pustules more restricted to the apertural region than i, with a smaller apertural face.

Asterigerina staeschei ten Dam and Reinhold.

Pl.4, fig.2a-b.

Asterigerina guerichi (Franke) var. staeschei ten Dam and Reinhold 1941, Taf.7, fig.2; Batjes 1958, p.159, pl.10, fig.6.

Asterigerina staeschi (ten Dam and Reinhold), Bartenstein et al. 1962, p.375, Tab.21, pl.54, fig.22, 23a-b; Doppert 1980, p.263-266, pl.15, fig.1a-c, pl.17, fig.3a-c.

Asterigerinina guerichi staeschi ten Dam and Reinhold, King 1989, p.467, pl.9.4, figs.24-25.

Remarks.

King (1989) recorded this species in his NSB9-11 Zones, Early-Middle Miocene. Letsch and Sissingh (1983) recorded this species in their FT6 A. staeschi Zone. Doppert (1975) used this species to mark his A. staeschi-Uvigerina tenuipustulata assemblage FD Zone, Middle Miocene. It was also noted in his FE Zone, Late Oligocene-Early Miocene.

Asterigerina bartoniana (ten Dam).

Rotalia granulosa ten Dam 1944, p.121, Taf.4, fig.2, renamed Rotalia bartoniana ten Dam 1947.

Asterigerina bartoniana (ten Dam 1944), Murray and Wright 1974, pl.10, figs.4-6; Murray et al. 1981, p.246, pl.8.3, figs.12-14; Doppert and Neele 1983, p.6-9, pl.9, fig.1a-c.

Remarks.

Murray and Wright (1974) noted this species in the Barton Clay, Eocene, Barton-on-Sea, England. Murray et al. (1981) noted this species range as Middle-Late Eocene. Doppert and Neele (1983) recorded this species in their Vaginulinopsis decorata-Pseudohasterigerina micra FH Zone, ?Early-Late Eocene. It was described by ten Dam (1944) from the Eocene, 'Bartonian', of the Netherlands.

Asterigerina guerichi (Franke).

Pl.4, fig.3a-b.

Discorbina guerichi Franke 1912, p.29, p.30, textfig.8.

Asterigerina guerichi (Franke), Batjes 1958, p.159, pl.10, fig.7; Bartenstein et al. 1962, p.374, Tab.21, pl.54, figs.20a-b, 21; Doppert 1980, pl.17, fig.2a-c; King 1983, pl.3, figs.1-3.

Asterigerina guerichi guerichi (Franke), King 1989, p.467, pl.9.4, figs.30-31.

Remarks.

Differs from A. staeschi in having a more equally biconvex test, a less convex umbilical side and in having less widespread granulation over the umbilical region. Generally a larger and more flattened form. Doppert (1980) recorded this species in their FE Zone, Late Oligocene-Early Miocene. The last (LAD) A. guerichi was recorded by Letsch and Sissingh (1983) at the top of their FT5b Zone, Late Oligocene. Stratigraphical range is from the Late Oligocene to Early Miocene (King, 1989). King (1983) used this species acme to mark his NSB8a Zone, it was used in this study to mark

Zone CB8, early Late Oligocene. The preservation of the figured specimens is poor, but this is typical of material available from North Sea wells.

FAMILY: EPISTOMARIIDAE Hofker 1954.

GENUS: Nuttallides Finlay 1939.

i. N. truempyi (Nuttal). Strongly convex umbilical side, with sutures that are 'kinked'. Umbilical boss. Spiral side low. Has a peripheral band.

Nuttallides truempyi (Nuttall).

Eponides truempyi Nuttall 1930, p.287, pl.24, figs.9, 13-14.

Nuttallides trumpyi (Nuttall), Loeblich and Tappan 1964, p.595, fig.473, 7-8.

Nuttallides truempyi (Nuttall), Tjalsma and Lohmann 1983, p.17, pl.6, figs.4a-b, pl.21, figs.1a-4c; van Morkhoven et al. 1986, p.288-295, chart no.96, pl.96A-D.

Remarks.

Loeblich and Tappan (1964) recorded this species in the Eocene of Mexico and New Zealand. Recorded by Tjalsma and Lohmann (1983) as frequent to abundant in Palaeocene sediments, and rare to abundant in the Eocene. LAD in the Middle-Late Eocene. Van Morkhoven et al. (1986) record this species ranges as being from the Late Cretaceous (Campanian) through Late Eocene (P17 of Berggren, 1972). N. truempyi (Nuttall) was predominantly a lower bathyal and abyssal taxon (Tjalsma and Lohmann, 1983). Rare in this study in Zone CB2, Early-early Late Palaeocene.

FAMILY: ALABAMINIDAE Hofker, 1951.

GENUS: Gyroidina d'Orbigny 1846.

i. G. octocamerata Cushman and Hanna. Low spiral side, slightly convex. Incised spiral suture. Umbilcal side more convex. Broadly rounded periphery. Sutures on the umbilical side radial. Fine, smooth, polished wall.

ii. G. angustiumbilicata ten Dam. More compressed species than ii, less convex on the umbilical and spiral sides. Slightly incised spiral suture. Sutures on the umbilical side are slightly curved. The spire may be 'raised' slightly.

iii. G. soldanii mamillata (Andreae). Broadly 'domed' or convex spiral side, with a very rounded periphery. Convex umbilical side. High spired test, although not as high as Rotaliatina bulimoides (Reuss).

iv. G. soldanii girardana (Reuss). Very convex umbilical side. Flat to slightly convex spiral side. Spiral suture more excavated than i. Broad apertural face that may protrude from the flat spiral side. Much larger than i-iii. Central ?boss on spiral side.

Gyroidina octocamerata Cushman and Hanna.

Pl.4, fig.4.

Gyroidina soldanii d'Orbigny var. octocamerata Cushman and Hanna, 1927, p.233, pl.14 fig.16-18.

Gyroidinoides soldanii (d'Orbigny) var. octocamerata (Cushman and Hanna), Brotzen 1948, p.76 pl.11 fig.3.

Valvulineria octocamerata (Cushman and Hanna), Bandy 1949, p.84 pl.13 fig.1.

Gyroidina cf. obicularis d'Orbigny, Ten Dam 1944, p.118.

Gyroidina octocamerata Cushman and Hanna, Kaasschieter 1961, p.212, pl.13 fig.2.

Notes.

Sutures on the spiral side oblique. Strongly convex umbilical.

Finely perforate. Periphery subrounded.

Remarks.

Rare, small. Differs from *G. octocamerata* s. str. in having a slightly more convex spiral side. However, the last chambers of these examples are broken. This species, like all those referred here to the genus *Gyroidina* has a flattened apertural face and an aperture which runs interiomarginally from near the periphery to the closed umbilicus. It is these characters which distinguish them from *Gyroidinoides*.

Gyroidina angustiumbilcata Ten Dam.

Pl.4, fig.5.

Gyroidina angustiumbilicata Ten Dam 1944, p.117 pl.4 fig.7; Kaasschieter 1961, p.212 pl.12 fig.4; Murray and Wright 1974, pl.20 fig..8-10.

Notes.

Slightly convex to flattened spiral side. Convex umbilical. Finely perforate, small compressed test. Umbilicus nearly closed, periphery rounded. 8 chambers in the final whorl.

Remarks.

Rare. Noted by Williams (1971) in the London Clay Formation. Differs from *G. octocamerata* in the orientation of sutures. Differs from *G. angustiumbilicata* s.s. in only rarely having a 'raised' spire.

Gyroidina soldanii mamillata (Andreae).

Pl.4, fig.6.

Rotalia girardana Reuss var. *mamillata* Andreae 1884, p.142, pl.9, fig.4.
Gyroidina soldanii var. *mamillata* (Andreae), Batjes 1958, P.147, pl.17, fig.15.

Gyroidina mamillata (Andreae), Hughes 1981, pl.15.3, fig.2.

Gyroidina soldanii mamillata (Andreae), King 1983, p.32, pl.5, fig.18; King 1989, p.478, pl.9.7, fig.17.

Remarks.

North Sea examples of this species have a more broadly rounded periphery than that shown in Andreaes (1884) type figure. *G. soldanii mamillata* was recorded by King (1983) from the early Late Oligocene to the Late Eocene. It commonly occurs in his NSB7 Zone, Early Oligocene, CB7 in this study, with *Rotaliatina bulimoides* (Reuss).

Gyroidina soldanii girardana (Reuss).

Pl.4, fig.7.

Rotalina girardana Reuss, 1851, p.73, pl.5, fig.34a-c.

Gyroidina soldanii d'Orbigny var. *girardana* (Reuss), Batjes 1958, p.147, pl.7, fig.12.

Gyroidinoides girardanus (Reuss), Kiessel 1970, p.288, pl.16, fig.2; Tjalsma and Lohmann 1983, p.14.

Gyroidinoides soldanii forma *girardanus* (Reuss), Ulleberg 1974, p.282, pl.5, figs.1-5, pl.7, figs.8-9.

Gyroidina soldanii girardana (Reuss), King 1989, p.478, pl.9.7, figs.15-16.

Notes.

G. soldanii girardana differs from *G. soldanii soldanii*, according to King (1989), in having a more conical profile, and a depressed spiral suture in the last whorl.

Remarks.

King (*op. cit.*) records *G. soldanii girardana* from the Early Miocene to the Early Oligocene. Ulleberg (1974) recorded the latter species from the Viborg Formation in Denmark (Middle Oligocene). This species was noted by Tjalsma and Lohmann (1983) as rare to frequent from Zone P1-P5 of Berggren 1972. It was originally described from the Eocene, Germany (Reuss, 1851).

GENUS: Oridorsalis Andersen 1961.

i. O. umbonatus (Reuss). Biconvex test. Smooth wall. Sutures radial on the spiral side, depressed in later stages, flush and obscu-red in the earlier part. Central part of spire 'domed'. Sutures radial on the umbilical side.

Oridorsalis umbonatus (Reuss).

Pl.4, fig.8a-b.

Rotalina umbonata Reuss 1851, p.75, pl.5, fig.35.

Eponides umbonatus (Reuss), ten Dam 1944, p.120.

Oridorsalis umbonatus (Reuss), Tjalsma and Lohmann 1983, p.18, pl.6, figs.8a-c.

Remarks.

According to Tjalsma and Lohmann (1983) this species has a wide bathymetric range. They noted that it was rare in most of the Palaeocene, and more common in the latest Palaeocene and Eocene.

GENUS: Rotaliatina Cushman 1925.

i. R. bulimoides (Reuss). Similar to G. soldanii mamillata (Andrae) but with a much higher spire.

Rotaliatina bulimoides (Reuss).

Pl.4, fig.9.

Rotalina bulimoides Reuss 1851, p.77, pl.5, fig.38a-c.

Rotaliatina bulimoides (Reuss), Batjes 1958, p.148, pl.8, figs.3-4; Hughes

1981, pl.15.3, fig.3; King 1983, p.35, pl.5, fig.28.

Remarks.

North Sea examples of this species differ from Reuss (1851) illustration in being slightly lower spired, with less depressed sutures. It was described from the Eocene, Germany. King (1983) recorded this species in his NSB7 Zone, Early Oligocene. It was used in this study to mark Zone CB7, Early Oligocene. The extraordinarily poor preservation of the figured specimen is typical of North Sea Oligocene calcareous species.

GENUS: Alabamina Toulmin, 1941.

i. A. wilcoxensis Toulmin. Angular periphery. Almost flat to slightly convex spiral side.

ii. A. obtusa (Burrows & Holland). Subangular periphery. Raised, strongly convex spiral side. A more inflated form than i.

iii. A. solnasensis Brotzen. Much smaller than i-ii. Differs from ii in its more depressed sutures on the spiral side, more elongate chambers, and more lobulate peripheral margin. Slightly convex spiral side. Less convex umbilical side than i, with a subangular periphery.

Alabamina wilcoxensis Toulmin.

Pl.4, fig.10a-b, Pl.5, fig.1.

Alabamina wilcoxensis Toulmin, 1941, p.603, pl.81 fig.10-14, tf.4a-c; Kaasschieter 1961, p.228 pl.13 fig.14; Murray 1984, p.532 pl.3, fig.22-24.

Notes.

Test almost plano-convex.

Remarks.

Noted by Williams 1971 from the London Clay together with A. obtusa (Burrows and Holland). The above tends to be larger than the later.

Alabamina obtusa (Burrows and Holland).

Pl.5, fig.2.

Pulvinulina exigua (Brady) var. *obtusa* Burrows and Holland 1897, p.49 pl.2, fig.25.

Alabamina obtusa (Burrows and Holland), Haynes 1956, p.89, pl.17 fig.3-3L; Kaaschieter 1961, p.227 pl.13 fig.15; Murray 1984, p.532 pl.3, fig.19-21.

Description.

Usually 5 chambers in final whorl, nearly biconvex.

Remarks.

Less common in the Eocene London Clay than *A. wilcoxensis* (Toulmin), with a more rounded periphery. Test more equally biconvex. The present writer disagrees with Toulmin (1941) who placed *Alabamina obtusa* (Burrows and Holland) into synonymy with his *A. wilcoxensis*, as *A. obtusa* is a more inflated species. The latter species was described by Burrows and Holland (1897), from the Thanet Beds, Pegwell Bay.

Alabamina solnasensis Brotzen.

Alabamina solnasensis Brotzen 1948, p.102, pl.16, fig.4a-c.

Remarks.

This species was described by Brotzen (1948) from the Early Palaeocene, "Zealandian" of southern Sweden. It was noted in this study (as rare) in Zone CB2, Early-early Late Palaeocene.

GENUS: *Svratkina* Pokorny 1956.

i. *S. perlata* (Andreae). Distinctly, and coarsely perforated species. Slightly convex spiral side with curved sutures. More convex umbilical with almost radial sutures. Sutures on both sides only slightly depressed.

Svratkina perlata (Andreae).

Pulvinulina perlata Andreae 1884, p.124, pl.8, fig.12a-c.

Svratkina perlata (Andreae), Berggren and Aubert 1976, p.318, pl.4, figs.21-22; Hughes 1981, pl.15.2, figs.16-18; King 1989, p.482, pl.9.8, fig.20.

Remarks.

Hughes (1981) recorded this form in the Middle Oligocene of the Southern North Sea. King (1989) recorded this species in the Early Oligocene Zone NSB7 to early Late Oligocene Zone NSB8a. Andreae (1884) described this species from the Middle Oligocene, France.

SUPERFAMILY: ROTALIACEA Ehrenberg 1839.

FAMILY: ROTALIIDAE Ehrenberg 1839.

SUBFAMILY ROTALIIMAE Ehrenberg 1839.

GENUS: Rotalia Lamarck 1804.

i. R. canui Cushman. Compressed test, with a slightly convex spiral side. Distinctly elongated chambers which become slightly pointed at the peripheral margin. Very depressed sutures.

Rotalia canui Cushman

Rotalia canui Cushman 1928 p.55, pl.3, fig.2a-c; Batjes 1958, p.168, pl.12, figs.5-7; Doppert 1980, p.266, pl.20, fig.3a-b; Doppert and Neele 1983, p.4-6, pl.6, fig.4a-b.

Pararotalia canui (Cushman), King 1983, p.31, pl.4, figs.9-10.

Remarks.

Doppert (1975) noted this species in his FG Zone, Early Oligocene, while Doppert (1980) noted this species in his FE Zone, Late Oligocene-Early Miocene. Doppert and Neele (1983) recorded this species in their FG-

FF Zones, Early-Middle Oligocene. King (1983) noted this form in his NSB6a (late Middle Eocene) to NSB9 (Early Miocene) Zones.

FAMILY: ELPHIDIIDAE Galloway 1933.

SUBFAMILY: ELPHIDIINAE Galloway 1933.

GENUS: Haynesina Banner and Culver 1978.

Haynesina sp.

Pl.1, fig.9.

Remarks.

The specimen on plate 1, figure 9 shows bridged intraseptal lacunae. It is analogous to the species figured by Banner and Culver (1978) which was of a character, chamber shape and number close to H. germanica (Ehrenberg), but it had septal bridges, and believed to be an intermediate to very simple forms of Elphidium. Haynesina sp. was noted in this thesis in the Early Pliocene, for example in Well 21/11-1, 2130'DC.

GENUS: Elphidium de Montfort 1808.

i. E. excavatum (Terquem). Lobulate, rounded peripheral margin. Flattened compressed test. Sutures depressed, with distinct retral processes. Pustulose only around the aperture, umbilicus, and sutures.

ii. E. inflatum (Reuss). More inflated form than i. Coarsely 'pustulose' surface. Much longer retral processes than i. Very broadly rounded peripheral margin.

Elphidium excavatum (Terquem).

Pl.5, fig.3.

Polystomella excavata Terquem 1876, p.429, pl.2, fig.2a-d.

Elphidium excavatum (Terquem), Hansen and Andersen 1976, p.10, pl.6, fig.1-

6; King 1983, p.29, pl.3, figs.28-29.

Remarks.

King (1983) noted this species from his NSB13b Zone (Late Miocene-Early Pliocene) to his NSB17 Zone (Pleistocene).

Elphidium inflatum (Reuss).

Pl.5, fig.4.

Polystomella inflata Reuss 1861, p.358, pl.3, fig.10a-b.

Elphidium inflatum (Reuss), Batjes 1958, p.164, pl.12, fig.2; King 1983, p.29, pl.4, figs.1-2.

Cribrononion inflatum (Reuss), Doppert 1980, p.263, pl.15, fig.4a-b.

Remarks.

Doppert (1980) recorded this species in his FD Zone, Middle Miocene. King (1983) recorded this species in his NSB10 (Early-Middle Miocene) to NSB11 (Middle Miocene) Zones. Letsch and Sissingh (1983) recorded this species in his FT7 Zone, Middle Miocene.

GENUS: *Cribrononion* Thalmann 1947.

i. *C. subnodosum* (Roemer). Lenticular test, with peripheral band. Pustulose around the aperture. Numerous chambers (approximately 13) in the final whorl. Sutures curved.

Cribrononion subnodosum (Roemer).

Robulina subnodosum Roemer 1838, p.391, pl.3, fig.61a-b.

Elphidium subnodosum (Roemer), Batjes 1958, p.163, pl.8, figs.12-13; King 1983, p.31, pl.4, figs.5, 11.

Cribrononion subnodosum (Roemer), Doppert 1980, p.266, pl.19, figs.1a-c.

Remarks.

Batjes (1958) noted this species in the Early Oligocene. Doppert (1980) recorded this form in his FE Zone, Late Oligocene-Early Miocene. King (1983) recorded this species in his NSB6a (Middle Eocene) to NSB8c (Late Oligocene) Zones.

SUPERFAMILY: ORBITOIDACEA Schwager, 1876.

FAMILY: EPONIDIDAE Hofker 1951.

GENUS: Eponides de Montfort 1808.

i. *E. lunata* Brotzen. Small test. Very acute peripheral margin, lobulate. Sutures curved and depressed on the umbilical side, strongly curved on the spiral side. Has a peripheral band.

ii. *E. plummerae* Cushman. Differs from i in having a subacute peripheral margin. Chambers also not as inflated as i on the umbilical side, with less depressed and curved sutures. No peripheral band. Less lobulate periphery than i. Does not have the crescent shaped chambers on the spiral side which i has.

iii. *E. karsteni* (Reuss). Very convex spiral side. Distinctly imperforate, and thickened spiral suture common, with slightly raised and strongly curved sutures on the spiral side. Broad peripheral band, imperforate. Sutures depressed and radial on the umbilical side, which also has a depressed umbilical area.

Eponides lunata Brotzen.

Eponides lunata Brotzen 1948, p.77, pl.10, figs.17-18; Hofker 1966, p.140, pl.20, fig.39, pl.38, fig.205; Doppert and Neele 1983, p.9, pl.24, fig.2a-c.

Remarks.

E. lunata was described by Brotzen (1948) from the Early Palaeocene of Sweden. Noted in this study In Early-early Late Palaeocene sediments, Zone CB2. Hofker (1966) noted this species in Palaeocene Clays and Greensand overlying Danske Kalk. Doppert and Neele (1983) record this species in their FJ Zone, Late Palaeocene. Loeblich and Tappan (1988, p.642-643, pl.721, figs.1-7) regarded E. lunata as the type species for the genus Paralabamina Hansen 1970 (see Appendix C for discussion).

Eponides plummerae Cushman.

Eponides plummerae Cushman 1948, p.44, pl.8, fig.9; Cushman 1951, p.52, pl.14, figs.20, 22.

Remarks.

This species was noted in this study in wells 29/7-1 (Zone CB2, Early-early Late Palaeocene), and 29/10-1 (Zone CB2, Early-early Late Palaeocene, and Zone PK1B, Early Palaeocene). Cushman (1951) noted this form in the Palaeocene of the Gulf Coastal region of the U.S.A. and surrounding area. Rare in this study.

Eponides karsteni (Reuss).

Pl.5, fig.5a-d.

Rotalia karsteni Reuss 1855, p.273, pl.9, fig.6a-c.

Eponides schriebersi (d'Orbigny), non d'Orbigny, Kaaschieter 1961, p.210, pl.11, figs.14-15; Hughes 1981, pl.15.4, figs.9-10, 12.

Neoeponides karsteni (Reuss), King 1983, p.30, pl.4, figs.21, 26-27; King 1989, p.479, pl.9.7, figs.27-28..

Remarks.

Recorded by King (1983, 1989) in the Middle Eocene, marker species for Zone CB4 in this study, in the Southern North Sea. This species was described by Reuss (1855) from the Cretaceous, Turonian of Germany according to Ellis and Messina (1940 et. seq.). King (1983) placed this species into Neoeponides, but the type Neoeponides (Loeblich and Tappan 1988, p.558, pl.605) possesses large foliar chamberlets on the umbilical side forming a stellate pattern around the umbilicus; these do not appear to be present in this species which is here referred to Eponides.

FAMILY: CIBICIDIDAE Cushman, 1927.

SUBFAMILY: PLANULININAE Bérmudez, 1952.

GENUS: Planulina d'Orbigny 1826.

i. P. costata (Hantken). Very flattened form. Chambers numerous with strongly curved sutures. Distinct peripheral keel. Wall ?finely perforate. Subacute periphery.

Planulina costata (Hantken).

Pl.5, fig.6a-b.

Truncatulina costata Hantken 1875, p.73, pl.9, fig.2a-c.

Planulina palmerae van Bellen, in van Bellen et al. 1941, p.1144, figs.7-9; King 1983, p.33, pl.4, figs.17-18, 23.

Planulina costata (Hantken), van Morkhoven et al. 1986, p.212-214, chart no.72, pl.72.

Remarks.

King (1983) records this species (as P. palmerae Bellen) in his NSB5 Zone, Middle Eocene. Van Morkhoven et al. (1986) noted this species stratigraphic range as being Late Eocene (P15 of Berggren) through Early Miocene (N5); it was recorded in this study in Zone CB5. It was described by Hantken (1875) from the Late Oligocene, Hungary. P. costata was primarily an upper and middle bathyal species, although it has been recorded in outer neritic to lower bathyal depths (van Morkhoven et al., op. cit.).

GENUS: Cibicidina Bandy, 1949.

i. C. cunobelini Haynes. Sutures depressed on the umbilical side. Depressed and 'open' umbilicus. Rounded peripheral margin.

Cibicidina cunobelini Haynes, 1957.

Pl.5, fig.7.

Cibicides praecursorius (Schwager), Ten Dam 1944, p.134, pl.5 fig.2.

Cibicides (Cibicidina) cunobelini Haynes in Wood & Haynes 1957, p.51, pl.5 fig.16-18.

Notes.

7 to 8 chambers in the final whorl on the umbilical side.

Remarks.

The forms were mostly megalospheric, having up to 8 chambers visible ventrally. The chambers appear to have developed lappets on the umbilical side, a characteristic 'accelerated' in this species in megalospheric forms. The involution on the ventral side in this species is variable with part of the first whorl sometimes being seen.

This species was described from the Late Palaeocene by Haynes (in Wood and Haynes, 1957), but was also recorded from the London Clay by Williams (1971). He stated that C. cunobelini was most common in the lower and upper parts of the London Clay. Noted by King (1981) in his Division C.

SUBFAMILY: CIBICIDINAE Cushman, 1927.

GENUS: Cibicides De Montfort, 1808.

i. C. lobatulus (Walker and Jacob) s.l. Flat spiral side, with coarse perforations between broad, imperforate sutures, depressed. Lobulate peripheral margin. Coarsely perforate. Slightly depressed umbilicus, angular periphery.

ii. *C. grossus* (Dam and Reinhold). Globose, large, coarsely perforate test. Coarsely perforate between sutures on both sides. Broadly rounded peripheral margin. Sutures slightly depressed.

iii. *C. sulzensis* (Herrmann). Distinctly 'open' spire with many chambers visible on the spiral side. Subacute periphery.

iv. *C. westi* (Howe). Convex spiral side, flat spiral. Thick peripheral band. Differs from i in having more curved and less depressed sutures on the umbilical side, and in having fewer perforations.

v. *C. ekblomi* Brotzen. Small test. Slightly convex spiral side, almost flat umbilical. Acute peripheral margin. Numerous chambers with strongly curved, broad, not depressed sutures. Small central plug on the spiral side. Small. depressed umbilicus on the umbilical side.

vi. *C. voltziana* (d'Orbigny). Subacute peripheral margin. One umbo on the low convex spiral side. Convex umbilical.

vii. *C. anglica* (Bowen). Biconvex test, witha slightly less convex spiral side. Subacute periphery. Smooth umbilical side with strongly curved sutures that are more depressed in the later chambers. Spiral side coarsely perforate. Sutures thickened. Also differs from vi in its very rough spiral boss.

viii. *C. tenellus* (Reuss). Plano-convex test. Sutures on umbilical side slightly depressed in later chambers, smooth and flush in earlier ones, finely perforate. Spiral side finely perforate, less smooth than the umbilical, sutures are depressed in later parts.

ix. *C. pseudoungerianus* (Cushman). Biconvex. Larger test than x with a more compressed peripheral margin. Smooth umbilical side, and a spiral side that has only a few scattered coarse pores. Strongly curved sutures on both sides. Distinctive, thick, marginal peripheral band.

x. *C. ungerianus* (d'Orbigny). Spiral side with very distint umbilical 'additions', similar to those of vii. Sutures less curved than ix, and also has a less acute peripheral margin without such a distinctive marginal band. The umbilical side is more inflated than ix, and with a flatter spiral side.

xi. *C. disjunctus* (Terquem). Plano-convex test. Flat to almost concave spiral side. Acute periphery. Distinct, sharp, peripheral band. Strongly convex umbilical side.

xii. *C. pygmeus* (Hantken). Relatively small test. Distinctly raised spiral suture. Very coarsely perforated on the spiral side for the size of the test. Peripheral margin slightly lobulate. Wth spiral ?boss.

xiii. *C. acutimargo* ten Dam. Similar to *C. "proprius"* Brotzen, but with a more rounded peripheral margin, and more lobulate peripheral margin.

xiv. *C. succedens* (Brotzen). Similar to *Cibicidoides alleni* but differs in possessing a larger conoidal (cone-shaped) umbilical plug. Distinct, curved sutures on both sides, only very slightly depressed.

Cibicides lobatulus (Walker and Jacob) sensu lato.

Pl.5, fig.8a-b.

Nautilus lobatulus Walker and Jacob 1798, p.642, pl.14 fig.36.

Truncatulina lobatula (Walker and Jacob), Cushman 1918, p.16, pl.1 fig.10, p.60, pl.17 fig.1-3.

Cibicides lobatulus (Walker and Jacob), Y. Le Calvez 1949, p.46; Kaasschieter 1961, p.221 pl.14 fig.5.

Description.

7-8 chambers in final whorl. Aperture extends onto spiral side for 1-2 chambers, with thin lip. Coarsely perforate. Convex umbilical, flat spiral. Periphery acute.

Remarks.

Figured by Wetherell (1838) as No.16 on his plate. *C. lobatulus* s. str. has finer pores on the umbilical side.

Cibicides grossus (Dam and Reinhold).

Cibicides lobatulus (Walker and Jacob) var. *grossa* nov var. Dam and Reinhold 1941, p.62, pl.5, figs.5a-c, pl.6, figs.1a-c.

Cibicides lobatulus f. *grossa* ten Dam and Reinhold 1941, 1980, pl.5, figs.3a-c.

Cibicides grossus (Dam and Reinhold) King 1983, p.30, pl.4, fig.6.

Remarks.

King (1983) recorded this species in Zone NSB15, Early-Late Pliocene. Often caved in this study.

Cibicides sulzensis (Herrmann).

Discorbina sulzensis Herrmann 1917, p.290, pl.3, fig.26.

Cibicides sulzensis (Herrmann), Kaaschieter 1961, pl.13, fig.11a-c; Kiesel 1970, pl.19, figs.7a-b, 10a-b; Doppert and Neele 1983, p.4-6, pl.3, fig.2a-c.

Remarks.

Doppert and Neele (1983) record this species from their FF/FG Zone, Early-Middle Oligocene. It was noted in this study in Eocene material.

Cibicides westi (Howe). Pl.5, fig.9a-b.

Cibicides westi Howe 1939, p.88, pl.13, figs.20-22; Kiesel 1970, pl.20, fig.5a-c.

Cibicidoides westi (Howe), Tjalsma and Lohmann 1983, p.29.

Remarks.

C. westi was noted in the London Clay, Ypresian, Early Eocene, and in Zones CB5-6 Middle-Late Eocene in the North Sea (well 21/11-1), in this study. It differs from C westi s.s. in generally having a less conical umbilical side. A form similar in morphology to this species, and noted as C. aff. westi was noted in the Palaeocene of the North Sea (Zones AB3, Late Palaeocene, and CB2, Early-early Late Palaeocene, well 21/11-1). C. aff. westi had a more acute margin, and a less convex umbilical side.

Cibicides ekblomi Brotzen.

Cibicides ekblomi Brotzen 1948, p.82, pl.13, fig.2a-c.

Remarks.

Brotzen (1948) described C. ekblomi from Early Palaeocene ("Zealandian") sediments in southern Sweden; it was rare, in this study, in Zone CB2, Early-early Late Paleocene.

Cibicides voltziana (d'Orbigny).

Rotalina (Rotalina) voltziana d'Orbigny 1840, p.31, pl.2, figs.32-34.

Cibicides voltziana (d'Orbigny), Schijfsma 1946, pl.5, fig.6a-c.

Gavelinopsis voltziana (d'Orbigny), Hofker 1966, p.29, pl.3, fig.63, pl.11, fig.124a-c.

Remarks.

According to Schijfsma (1946) this species has been recorded from the Upper Cretaceous (Senonian and Maastrichtian). Shell Expro. U.K. record this species in Upper Cretaceous to Late Palaeocene sediments. According to Schijfsma (op. cit.) this species differs from Cibicidoides dayi (White) in possessing only one umbo, on the spiral side, whereas C. dayi has an umbo on both sides. Anomalinoides rubiginosa (Cushman) differs from Cibicides voltziana (d'Orbigny) by having a biconvex test and in not having an umbo; C. voltziana is almost plano-convex. Hofker (1966) recorded C. voltziana in his Zone C, and noted its range as being from the late Early Campanian to the Late Maastrichtian and Danian. The latter species was recorded in Zone CB2 in this study, Early-early Late Palaeocene.

Cibicides anglica (Bowen).

Pl.6, fig.1a-b.

Planulina anglica Bowen 1954, p.133-134, fig.A, 1-3.

Anomalinoides acuta (Plummer), sensu Murray et al. 1981, p.246, pl.8.3, figs.1-3.

Remarks.

This species was described by Bowen (1954) from the upper part of the London Clay Formation, Whitecliff Bay, Isle of Wight. Murray et al. (1981) figure this species (as Anomalinoides acuta (Plummer) sic!) also from the London Clay of Whitecliff Bay. It was noted in this study in the London Clay Formation in the London Basin (Zone CB3, AB4, PK4), and rarely from the Early Eocene in the Southern North Sea.

Cibicides tenellus (Reuss).

Pl.6, fig.2a-c.

Truncatulina tenella Reuss 1865, S.43, Taf.5, fig.6.

Cibicides tenellus (Reuss), Murray and Wright 1974, p.17, pl.16, figs.12-14; Doppert 1980, p.266, pl.18, fig.4a-c; Murray *et al*. 1981, p.250, pl.8.5, figs.4-6.

Remarks.

Murray and Wright (1974) noted this species in the Eocene, Bracklesham Beds, Sussex, England. Murray *et al*. (1981) noted this species total range in the U.K. as being Early-Late Eocene. However, Doppert (1980) noted this species in his FE Zone, Early Miocene-Late Oligocene. *C. tenellus* (Reuss) was recorded in this study in Zone CB14, early Late Miocene in well 21/30-1, and Zone PK10, Late Oligocene (-?Early Miocene), well 21/11-1.

Cibicides pseudoungerianus (Cushman).

Pl.6, fig.3a-b.

Truncatulina pseudoungerianus Cushman 1922, p.97, pl.20, fig.9.

Cibicides pseudoungerianus (Cushman), ten Dam and Reinhold 1941, p.62, pl.5, fig.4a-c; King 1983, p.30, pl.4, figs.15-16, 22.

Heterolepa pseudoungerianus (Cushman), Doppert 1980, p.11, figs.1a-c.

Remarks.

This species was recorded by King (1983) in Middle Eocene (NSB5) to Late Pliocene (NSB15a) sediments.

Cibicides ungerianus (d'Orbigny).

Pl.6, fig.4a-b.

Rotalina ungeriana d'Orbigny 1846, p.157, pl.8, figs.16-18.

Cibicidoides ungerianus (d'Orbigny), Tjalsma and Lohmann 1983, p.28, pl.18, figs.1a-c, pl.21, figs.5-6.

Cibicides ungerianus (d'Orbigny), Doppert and Neele 1983, p.4-6, pl.3, fig.3a-c.

Remarks.

C. ungerianus' FAD is in the Early Eocene (P6b of Berggren, 1972). This species ranges into the Oligocene, and has a wide bathymetric range (Tjalsma and Lohmann, 1983). Doppert and Neele (1983) recorded this species in their FF/FG Zone Early-Middle Oligocene.

Cibicides disjunctus (Terquem).

Truncatulina disjuncta Terquem 1882, p.95, pl.10, fig.3.

Cibicides disjunctus (Terquem), ten Dam 1944, p.134, pl.5, fig.8.

Remarks.

Letsch and Sissingh (1983) recorded this species in their FT2 Zone, Ypresian, Early Eocene. Ten Dam (1944) also noted this species in the Early Eocene, Ypresian (Netherlands). Described by Terquem (1882) from the Eocene, France. Rare in wells in this study.

Cibicides pygmeus (Hantken).

Pl.6, fig.5.

Truncatulina pygmea Hantken 1875, p.78, pl.10, fig.8.

Cibicides pygmeus (Hantken), Kaaschieter 1961, pl.14, fig.1a-c; Kiesel 1970, pl.20, fig.2a-b; Doppert and Neele 1983, p.6, pl.8, fig.1a-c.

Cibicidoides pygmeus (Hantken), Murray *et al*. 1981, p.250, pl.8.5, figs.16-18.

Remarks.

Total range from the Early-Middle Eocene, according to Murray *et* *al*. (1981). Doppert and Neele (1983) record this species in their FH Zone, Eocene. Rare in the London Clay, Early Eocene in this study.

Cibicides acutimargo ten Dam.

Cibicides cryptomphalus (Reuss) var. *acutimargo* ten Dam 1944, p.133, pl.5, fig.4.

Cibicides proprius var. *acutimargo* ten Dam, Kaaschieter 1961, p.222, pl.13, fig.10a-c, pl.14, fig.7a-c.

Remarks.

This species was noted (as *C. proprius acutimargo* in the distribution chart, enclosure no.7) in well 49/19-1, Southern North Sea. Rare. This species was left in the genus *Cibicides* as it does not possess the necessary diagnostic characteristics of *Cibicidoides* (unlike *Cibicides proprius*=*Cibicidoides alleni*). Kaaschieter (1961) noted this species in the Eocene of Belgium and in the London Clay. Ten Dam (1944) described it from the Eocene of the Netherlands.

Cibicides succedens (Brotzen).

Cibicides succedens Brotzen 1948, p.80, pl.12, figs.1-2; Murray *et al*. 1981, p.250, pl.8.5, figs.1-3.

Remarks.

C. succedens (Brotzen) was described from the Early Palaeocene ("Zealandian") of Sweden. Murray *et al*. (1981) record this species from the Thanet Formation, Late Palaeocene. Noted in this study in Zone CB2, Early-early Late Palaeocene.

FAMILY: HOMOTREMATIDAE Cushman 1927.

SUBFAMILY: VICTORIELLININAE Chapman and Crespin 1930.

GENUS: *Korobkovella* Hagn and Ohmert 1971.

i. *K. grosserugosa* (Gümbel). Flattened spiral side, inflated, involute umbilical side. Narrow, excavated umbilicus. Sutures radial, slightly depressed. Rounded peripheral margin, slightly lobulate. Coarsely perforate. Sutures in initial chambers of the last whorl on the umbilical side are not depressed often with a smooth surface.

Korobkovella grosserugosa (Gümbel).

Truncatulina grosserugosa Gümbel 1868, p.660, pl.2, fig.104a-c.

Anomalina grosserugosa (Gümbel), Kaaschieter 1961, p.217, pl.12, fig.14a-c; Murray *et al*. 1981, p.244, pl.8.2, figs.22-24.

Korobkovella grosserugosa grosserugosa (Gümbel), Hagn and Ohmert 1971, p.136-140, pl.1, fig.1a-c, pl.2, fig.1a-b, pl.5, fig.3a-c.

?*Gavelinella danica* (Brotzen), non Brotzen, *sensu* Koch 1977, p.64, pl.6, fig.5.

Korobkovella grosserugasa (Gümbel), Loeblich and Tappan 1988, p.596, pl.658.

Remarks.

The specimen figured by Koch (1977) as '*G*'. *danica*, is probably *K. grossrerugosa*; it has smooth non-punctate early chambers, and it does not possess the limbate sutures of *A. danica*. Loeblich and Tappan (1988) noted the genus *Korobkovella* in the Middle Eocene of Germany, Hungary and Poland. Murray *et al*. (1981) recorded this species in the London Clay Formation, Early Eocene. It was noted in this study in well 14/29-1, Zone CB5, Middle Eocene (Zone NS12, late Middle Eocene, LTG.*teste*). *K. grosserugosa* was described by Gumbel (1868) from the Eocene of Germany, while Kaaschieter (1961) described it from the Eocene of Belgium.

SUPERFAMILY: BULIMINACEA Jones, 1875.

FAMILY: BULIMINIDAE Jones, 1875.

SUBFAMILY: BULIMININAE Jones, 1875.

GENUS: Praeglobobulimina Hofker, 1951.

i. P. ovata (d'Orbigny). Cylindrical test tapering at both ends, for the most part almost parallel sided. Chambers globular, with slightly depressed sutures.

Praeglobobulimina ovata (d'Orbigny).

Pl.6, fig.6.

Bulimina ovata d'Orbigny 1846, p.185, pl.11 fig.13-14; Marks 1951, p.57; Kaasschieter 1961, p.191, pl.9 fig.6.

Praeglobobulimina ovata (d'Orbigny), Murray et al. 1981, fig.8.10a-b.

Notes.

Aperture an elongate sub-terminal 'slit', extending from the base of the final chamber towards its apex. Strongly overlapping chambers, triserial. Found in the 75μm or 125μm fractions.

Remarks.

Kaaschieter (1961) noted this species in the Eocene of Belgium. It was noted in this thesis in the London Clay Formation, Early Eocene, Ypresian, Zones AB4, PK4.

GENUS: Bulimina d'Orbigny 1826.

i. B. aculeata d'Orbigny. Globular later chambers, usually spinose earlier ones. Flaring test.

ii. *B. marginata* d'Orbigny. Flaring test. Base of chambers distinctly spinose throughout. Chambers less globular than i.

iii. *B. elongata subulata* Cushman and Parker. Similar to i, but chambers similar to v, although even less inflated, close to iv. Early chambers spinose, later ones smooth.

iv. *B. elongata* d'Orbigny. Less rapidly enlarging, and less globular chambers than i and iii. Non-spinose, later chambers increasing only slowly in size as added. Non flaring test.

v. *B. gibba* Fornasini. Non-spinose or only very fine spines in earlier part. Chambers less inflated than i, and less rapidly enlarging. Flaring test.

vi. *B. trigonalis* ten Dam. Slowly enlarging chambers as added, but more flaring test than iv. Subrounded periphery.

vii. *B. alsatica* Cushman and Parker. Relatively small and short, rapidly flaring test. Most of the test of 'plate-like' costae with very short spines. Last two chambers inflated, smooth.

viii. *Bulimina* sp. of King (1983). Distinctly ornamented flaring test with broken vertical ridges standing proud from the main test wall. Non globose chambers.

ix. *B. denticulata* Cushman and Parker. Test larger than vii. Rapidly enlarging chambers as added. Chambers more distinct throughout than vii. Flutted earlier chambers.

Bulimina aculeata d'Orbigny.

Bulimina aculeata d'Orbigny 1826, p.269; Brady 1873-1876, pl.51, figs.7-9; van Morkhoven *et al*. 1986, p.31-33, pl.7.

Remarks.

This form is very variable in its ornamentation. Some examples are almost non-spinose. *B. aculeata* d'Orbigny has more globular chambers in the later part of the test, and more rapidly enlarging chambers, than *B. gibba* Fornasini. Occurs in the upper bathyal to abyssal depths (see van Morkhoven *et al*. 1986, p.32). Van Morkhoven *et al*. (*op. cit*.) regarded *B. aculeata* as a deeper-water ecophenotype of *B. marginata* d'Orbigny. The stratigraphic range of this species is from the Late Miocene (N16 of Berggren) to the Pleistocene (N23).

Bulimina marginata d'Orbigny.

Bulimina marginata d'Orbigny 1826, p.269, pl.12, fig.10-12; van Morkhoven *et al*. 1986, p.18-21, pl.2.

Bulimina submarginata Parr 1950, p.336, pl.12, fig.13.

Bulimina tenuis Phleger and Parker 1951, p.16, pl.7, figs.33-34.

NOT *Bulimina marginata* d'Orbigny *sensu* King 1983, pl2, figs.17-18.

Remarks.

King's (1983) interpretation of *B. marginata* includes *B. aculeata* d'Orbigny. *B. marginata* differs from *B. aculeata* in having crenulated chamber margins. *B. marginata* occurs in stenohaline conditions, in a fine-grained substrate between less tham 30m to approximately 480m, with greatest abundances in outer shelf and upper slope depths (van Morkhoven *et al*. 1986). Van Morkhoven *et al*. (*op. cit*.) recorded *B. marginata* in the Late Pliocene (N21 of Berggren) through Pleistocene. Usually recorded as a caved species in this study.

Bulimina elongata subulata Cushman and Parker.

Bulimina elongata d'Orbigny var *subulata* Cushman and Parker 1937, p.51, pl.7, figs.6-7; van Voorthuysen 1950, pl.2, fig.7; Haynes 1973, pl.10, figs.10. 15.

Remarks.

This species was described by Cushman and Parker (1937) from the Miocene of the Vienna Basin, Austria, and was noted by Shell Expro U.K. in Pliocene-Pleistocene material. It was often caved in this study.

Bulimina elongata d'Orbigny.

Pl.6, fig.7.

Bulimina elongata d'Orbigny 1846, Taf.11, Fig.19-20; Batjes 1958, p.126, pl.4, figs.16-17; Doppert 1980 pl.15, fig.2a-b; King 1983, p.22, pl.2, fig.16.

Remarks.

King (1983) recorded this species in the Late Miocene (Zone NSB13a) to the Late Oligocene (NSB8a). It was used in this study to mark Zone CB15, Late Miocene.

Bulimina gibba Fornasini.

Bulimina gibba Fornasini 1902, p.378, pl.O, figs.32, 34; Barker 1960, pl.50, fig.1-4.

Remarks.

This species was noted in Middle Miocene sediments in the North Sea in this study.

Bulimina trigonalis ten Dam.

Pl.6, fig.8a-c.

Bulimina trigonalis ten Dam 1944, p.112, Tf.52, fig.1-2; King 1983, p.22, pl.2, fig.20; Doppert and Neele 1983, p.9, pl.24, figs.3-4.

Bulimina thanetensis Cushman and Parker 1947; Murray *et al*. 1981 pl.8.3, figs.24-25.

Remarks.

This species was common in material from the Late Palaeocene Thanet Formation, Pegwell Bay, England, in this study. Murray *et al*. (1981) also noted *B. trigonalis* (as *B. thanetensis* Cushman and Parker) in the Thanet Formation, from the Lower Pegwell Marls, Pegwell. King (1983) noted this species in his NSB1 Zone, Early-early Late Palaeocene, in the North Sea; while Doppert and Neele (1983) recorded *B. trigonalis* in their FJ Zone, Late Palaeocene.

Bulimina alsatica Cushman and Parker.

Bulimina alsatica Cushman and Parker 1937, p.39, pl.4, figs.6-7c; Doppert and Neele 1983, p.4-6, pl.6, fig.5.

Remarks.

Doppert and Neele (1983) recorded this species in their FF/FG Zone, Early-Middle Olgocene. Rare in the Oligocene in wells in this study. This species was described by Cushman and Parker (1937) from the Oligocene of France.

Bulimina sp. of King.

Bulimina sp. nov. King 1983, p.22, pl.2, fig.22.

Remarks.

This species was described by King (1983) from the Early Eocene of the North Sea, Zone NSB3. Noted in this study in Zone CB3, Early Eocene, Southern North Sea.

Bulimina denticulata Cushman and Parker.

Bulimina denticulata Cushman and Parker 1936, p.42, pl.7, figs.7-8.

Remarks.

Rare in wells in this study. Noted in well 14/29-1 in the Early-early Late Palaeocene, Zone CB2. This is an Early Palaeocene species according to Shell Expro. U.K., although it was described by Cushman and Parker (1936) from the Eocene of California, U.S.A. According to Ellis and Messina (1940 et. seq.) B. denticulata Cushman and Parker 1936 is a homonym of B. truncana Gumbel var. denticulata Protescu 1932, the new name being B. macilenta Cushman and Parker 1939.

GENUS: Stainforthia Hofker 1956.

i. S. schriebersiana (Czjzek). Elongate, gradually tapering test, slightly compressed with a subrounded periphery. Chambers at least twice as long as broad.

Stainforthia schriebersiana (Czjzek).

Virgulina schriebersiana Czjzek 1848, p.147, pl.13, figs.18-21; ten Dam and Reinhold 1942, p.82, pl.5, fig.14; Bartenstein et al. 1962, p.369, Tab. 21, Taf.54, fig.26.

Stainforthia schriebersiana (Czjzek), Doppert 1980, p.266, pl.21, fig.1a-b.

Fursenkoina schriebersiana (Czjzek), King 1983, p.22, pl.2, fig.23.

Remarks.

Bartenstein et al. (1962) recorded this species in the Late Oligocene and Early Miocene. Doppert (1975, 1980) noted this species in his S. schriebersiana-Sigmomorphina regularis FE Zone, Late Oligocene-Early Miocene. King (1983) noted S. schriebersiana (Czjzek) in the Early Oligocene (Zone NSB7) to Late Oligocene (Zone NSB8c). Letsch and Sissingh

(1983) noted the LAD of S. schriebersiana in the Late Oligocene (FT5b Zone). The FDO of this species was used in this study to indicate Zone CB12, Early Miocene. This species was described by Czjzek (1848) from the Tertiary of Austria. Rare in this study.

FAMILY: ISLANDIELLIDAE Leoblich and Tappan 1964.

GENUS: Cassidulinoides Cushman 1927.

i. C. bradyi (Norman). Small, smooth test. Subrounded peripheral margin. Slightly depressed sutures, distinct biserial part as high as the enrolled part.

Cassidulinoides bradyi (Norman).

Pl.7, fig.1.

Cassidulina bradyi Norman 1881, in Brady 1881, p.59, type figure in Brady 1884, pl.54, figs.6-10.

Cassidulinoides bradyi (Norman), Doppert 1980, p.263, pl.9, fig.2.

Remarks.

C. bradyi (Norman) was recorded by Doppert (1980) in his Late Miocene Siphotextularia-Uvigerina hosiusi FC Zone.

FAMILY: UVIGERINIDAE Haeckel, 1894.

GENUS: Uvigerina d'Orbigny, 1826.

i. U. batjesi Kaasschieter. Hispid test, hardly flaring. Globular chambers. Depressed sutures.

ii. U. acuminata Hosius. Globular chambers. Test covered in regular costae.

iii. Uvigerina pygmaea langeri Daniels and Spiegler. Test relatively small, with ridges in the initial part, later part with spines.

iv. U. oligocaenica Andreae. Almost smooth test, globular chamber arrangement similar to i.

v. Uvigerina sp.1. Relatively large test, more flaring than i. Initial chambers strongly fluted to bladed. Aperture on long neck with lip.

vi. U. jacksonensis Cushman. Similar to ix, but with less continuous costae and less inflated chambers, test shorter.

vii. U. tenuipustulata Voorthuysen. Similar to iv but with 'pustules'. Not as distinctly hispid as i.

viii. U. venusta deurnensis (Meuter and Laga). Chambers less globular, and and more subovate than ii. Wall covered by regular longitudinal costae, with some small pustules. Less hispid than iii, and chambers more compressed.

ix. U. macrocarinata Papp and Turnovsky. Relatively large, inflated test, with depressed sutures. Chambers less inflated and sutures less distinct than in ii. Also much larger than ii, and covered by more irregular costae.

Uvigerina batjesi. (Var. A and B). Kaasschieter.

Pl.7, fig.2a-b.

Uvigerina rugosa Ten Dam (not Terquem), 1944, p.115, pl.3 fig.13.

Uvigerina batjesi Kaasschieter 1961, p.197, pl.8 fig. 27-28, pl.9 fig.23,27.

Notes.

Sutures of inflated chambers more depressed in later part. Test covered by many small nodes giving it a hispid appearance.

Remarks.

Var. A was thinner and longer than var. B. This could be a case of juveniles and adults of the same species. According to Kaasschieter (1961) the microspheric form is tapering, while the macrospheric tends to be broader. Var.A, therefore, could be a microspheric form, and var.B a macrospheric one. Common in the 75µm fraction. Usually well preserved.

Uvigerina acuminata Hosius.

Uvigerina aculeata Hosius 1893 (non d'Orbigny 1846), Taf.2, fig.9.

Uvigerina acuminata Hosius 1895, p.167; King 1983, p.23, pl.2, fig.28.

Remarks.

King (1983) recorded this species in the Early-Middle Miocene, Zones NSB10-11.

Uvigerina pygmaea langeri Daniels and Spiegler.

Pl.7, fig.3.

Uvigerina pygmaea d'Orbigny langeri Daniels and Spiegler 1977, p.28, pl.4, figs.8-10, pl.8, fig.4; King 1983, p.23, pl.2, fig.33.

Remarks.

King (1983) recorded this species his NSB12b and NSB13a Zones, Late Miocene. Rare in wells in this study.

Uvigerina oligocaenica Andreae.

Uvigerina oligocaenica Andreae 1894, p.50, textfig.1.

Angulogerina gracilis (Reuss) var. oligocaenica (Andreae), Batjes 1958, p.134, pl.6, fig.3.

Remarks.

This species, considered by Batjes (1958) to be a subspecies of A. gracilis (Reuss), is a Miocene-Oligocene form (according to Shell Expro. U.K.).

Uvigerina sp.1.

Pl.7, fig.4.

Remarks.

This species is typically found in the Eocene in this study, in the Southern North Sea. It was recognised by Shell U.K. Expro. as an Eocene species.

Uvigerina jacksonensis Cushman.

Uvigerina jacksonensis Cushman 1925 p.67, pl.10, fig.13; King 1983, p.23, pl.2, fig.31.

Remarks.

U. jacksonensis was recorded by King (1983) in his NSB6, and NSB5 Zones, Middle-Late Eocene. It occurred in this study in Zones CB6 and CB5, Middle-Late Eocene in the Southern North Sea only.

Uvigerina tenuipustulata Voorthuysen.

Uvigerina tenuipustulata van Voorthuysen 1950, p.60, pl.2, fig.35; Batjes 1958, p.134, pl.5, fig.20; Doppert 1980, p.263, pl.16, fig.4a-b; King 1983, p.23, pl.2, fig.35.

Remarks.

Doppert (1980) recorded this species in his FD Zone, Middle Miocene. King (1983) recorded U. tenuipustulata Voorthuysen in his NSB10 Zone, Early-early Middle Miocene. Rare in wells in this study, and often caved.

Uvigerina venusta deurnensis (Meuter and Laga).

Uvigerina venusta deurnensis Meuter and Laga 1977, p.144, pl.1, figs.7-8;

King 1983, p.23, pl.2, fig.36.

Remarks.

King (1983) recorded this species in his NSB12b (Late Miocene) to NSB13b Zones (Early Pliocene).

Uvigerina macrocarinata Papp and Turnovsky. Pl.7, fig.5a-b.

Uvigerina macrocarinata Papp and Turnovsky 1953, S.123, Taf.5, Abb. B, figs.1-3.

Remarks.

This species was noted in this study in wells 29/10-1, Zone AB11B Late Oligocene-Early Miocene, 21/11-1, Zone CB7B, late Early Oligocene, and 21/30-1, Zones CB13-15, Early-Late Miocene. Shell Expro. U.K. noted this species in the Oligocene-?Early Miocene.

GENUS: Angulogerina Cushman 1927.

Primarily differs from Trifarina Cushman 1923 in having a less strongly developed triangular section.

i. A. fluens Todd. Similar to iv but with a more rounded cross section. Chambers covered in fine longitudinal costae.

ii. A. gracilis (Reuss). Similar to Uvigerina pygmaea langeri Daniels and Spiegler, but without such distinct longitudinal costae, and a more angular test.

iii. A. germanica Cushman and Edwards. Strong broken longitudinal costae giving a very 'roughened' appearance to the test. Later chambers more rapidly inflated than earlier ones compared to i, ii, and iv.

iv. A. angulosa (Williamson). Subangular cross section. Test with fine longitudinal costae, except at the subangular margins where costae are thicker and stronger.

Angulogerina fluens Todd.

Angulogerina fluens Todd 1948, p.288, pl.36, fig.1a-f; King 1983, p.22, pl.2, fig.10.

Trifarina fluens (Todd), Feyling-Hanssen *et al*. 1971, p.242, pl.7, figs.12-15, pl.18, fig.10.

Remarks.

King (1983) recorded this species in his Zones NSB13b (Early Pliocene) to NSB15 (Late Pliocene). It is often caved in wells in this study.

Angulogerina gracilis (Reuss).

Uvigerina gracilis Reuss 1851, p.77, pl.5, fig.39a-b.

Trifarina gracilis (Reuss, 1863), Doppert 1980, p.266, pl.21, fig.2a-b.

Angulogerina gracilis (Reuss), Hughes 1981, p.190, pl.15.1, fig.17; King 1983, p.22, pl.2, fig.13.

Remarks.

Doppert (1980) recorded this species in his FE Zone, Late Oligocene-Early Miocene. Hughes (1981) noted this species in the Late Rupelian, Middle Oligocene. King (1983) recorded *A. gracilis* (Reuss) in the Late Eocene (NSB6b) to the Early Miocene (NSB9). This species was often reworked in this study into later Miocene sediments.

Angulogerina germanica Cushman and Edwards.

Angulogerina germanica Cushman and Edwards 1938, p.85, pl.15, figs.14-15; King 1983, p.22, pl.2, figs.11-12.

Angulogerina gracilis Reuss var. *germanica* Cushman and Edwards, Batjes

1958, p.136, pl.6, fig.4.

Uvigerina germanica (Cushman and Edwards), Murray and Wright 1974, pl.7, fig.2; Murray *et al*. 1981, pl.8.9, figs.21-22.

Remarks.

King (1983) recorded *A. germanica* Cushman and Edwards in his Zones, NSB5 (Middle Eocene), to NSB6 (Middle-Late Eocene). Murray *et al*. (1981) recorded this species in the Hamstead Formation, Middle Oligocene. Rare in wells in this study.

Angulogerina angulosa (Williamson)

Uvigerina angulosa Williamson 1858, p.67, pl.5, fig.140.

Trifarina angulosa (Williamson), Feyling-Hansen *et al*. 1971, p.241, pl.18, figs.8-9.

Angulogerina angulosa (Williamson), King 1983, p.22, pl.2, fig.9.

Remarks.

King (1983) recorded this species in his NSB13b Zone (Late Miocene-Early Pliocene) to NSB15a (early Late Pliocene). This species was usually caved in wells in this study.

GENUS: *Trifarina* Cushman 1923.

Tests distinctly triangular in cross section.

i. *T. bradyi* Cushman. Angular, slightly thickened peripheral margins. Chambers closely appressed, with almost flush sutures.

Trifarina bradyi Cushman.

Pl.7, fig.6a-b.

Trifarina bradyi Cushman 1923, p.99, pl.22, figs.3a-9b; Batjes 1958, pl.5, fig.18.

Remarks.

Shell Expro. U.K. record this species from the Eocene into the Early Pliocene (in the Central Graben Central North Sea). It was noted in this study in the Southern North Sea Eocene.

FAMILY: TURRILINIDAE Cushman, 1927.

SUBFAMILY: TURRILININAE Cushman, 1927.

GENUS: Turrilina Andreae, 1884.

i. T. brevispira ten Dam. Very similar to ii but initial end 'sharper'. Non radiate wall.

ii. T. alsatica Andreae. Chambers often as broad as high in later stages. Radiate wall.

Turrilina brevispira Ten Dam.

Pl.7, fig.7a-b.

Turrilina brevispira Ten Dam 1944, p.110 pl.3 fig.4; Kaasschieter 1961, p.188 pl.11 fig.1; Murray et al. 1981, p.259-260, pl.8.9 fig.17-18; van Morkhoven et al. 1986, p.305-308, pl.100.

Description.

Last 3 chambers of high trochospire inflated. Basal slit-like aperture.

Remarks.

Rare. Very small in the London Clay. Surface smooth. Aperture often obscured, due to broken test. Recorded by Williams (1971) from the London Clay, and from NSB3 of King (1981) from the North Sea (earliest Eocene). Van Morkhoven et al. 1986, recorded this species in Late Palaeocene (P6a of Berggren, 1972) through Late Eocene (P15); they noted that it was most common in outer neritic and bathyal deposits, but also occurs in abyssal material. This species, like all those referred to the genus Turrilina, differ from Bulimina is possessing a small interiomarginal arched aperture.

Turrilina alsatica Andreae.

Pl.7, fig.8a-b.

Turrilina alsatica Andreae 1884, p.120, pl.8, fig.18a-c; Batjes 1958, pl.4 fig.15; Kiessel 1970, p.255, pl.12, fig.6; Ulleberg 1974, p.277, pl.6, figs.3-4; Hughes 1981, pl.15.1, fig.11; King 1983, p.23, pl.2, fig.27.

Remarks.

Small examples are similar to the Eocene species T. brevispira ten Dam. Hansen (1972) pointed out that these two species are best separated on their wall structure. Ulleberg's (1974) specimens of T. alsatica Andreae had a radiate wall. King (1983) recorded T. alsatica from the Late Eocene (Zone NSB6) to the Late Oligocene (NSB8c). The FDO of this species was used as a marker species for the Oligocene in this study.

FAMILY: SPHAEROIDINIDAE Cushman 1927.

GENUS: Sphaeroidina d'Orbigny 1826.

i. S. bulloides d'Orbigny. Globose test, very inflated. Sutures only slightly depressed.

ii. S. variabilis Reuss. Very inflated chambers with much more depressed sutures than i. Chambers also more rounded than i.

Sphaeroidina bulloides d'Orbigny.

Pl.8, fig.1.

Sphaeroidina bulloides d'Orbigny 1826, p.267; Loeblich and Tappan 1964, p.548, fig.432, 1-3; Doppert 1980, pl.16, fig.2, pl.20, fig.5; Murray 1984, pl.3, fig.10-11; van Morkhoven et al. 1986, p.80-83, chart no.24, pl.24..

Remarks.

Doppert (1980) recorded this species in his FE and FD Zones, Late Oligocene-Early Miocene to Middle Miocene. Van Morkhoven et al. (1986) noted that this is mostly a middle to upper bathyal species; and that it is a stratigraphically long ranging form, being recorded from the late Early Oligocene (P19 of Berggren 1972) through Pleistocene (N23).

Sphaeroidina variabilis Reuss.

Sphaeroidina variabilis Reuss 1851, p.88, pl.7, figs.61-64b.

Remarks.

This species was described from the Eocene of Germany. Recorded in this study in well 21/11-1, ?Late Oligocene, and well 21/30-1, Zone PK13, Middle Miocene. Rare to few in this study.

FAMILY: BOLIVINITIDAE Cushman, 1927.

GENUS: Brizalina Costa, 1856.

i. B. anglica Cushman. Rounded, relatively small test, smooth. Sutures depressed near the margins. Covered in small, scattered pores.

ii. B. cookei (Cushman). Most of the test is covered in 'meandering' longitudinal costae. Last chambers smooth, punctate. Acute periphery.

iii. B. antiqua (d'Orbigny). Thicker test, and larger than i. More rounded peripheral margins than ii. Smooth test with higher but narrow chambers than i and ii. Surface punctate with slightly depressed sutures throughout.

Brizalina anglica Cushman.

Pl.8, fig.2.

Bolivina anglica Cushman 1936, p.50, pl.7 fig. 11; Kaasschieter 1961, p.194, pl.9 fig.18-19.

Bolivina punctata Sherborn and Chapman (not d'Orbigny) 1886, p.743, pl.14, fig.10; Bowen 1954, p.139.

Brizalina anglica (Cushman), Murray *et al.* 1981, p.246, pl.8.3 fig.15,16.

Notes.

Biserial, small, elongate tapering test, three times as long as broad. Compressed with rounded periphery. Constrictions in the test show the chamber boundarys. Sutures strongly oblique. Aperture loop-shaped.

Remarks.

Occurs in 75μm sieve fractions. *B. antiqua* (d'Orbigny, 1846) is similar but the sutures are not as constricted. Bowen (1954) noted the presence of *B. punctata* in the London Clay, and pointed out that Brady (1884) considered this to be the same species as *B. antiqua*. Kaasschieter (1961) also suggested that *B. punctata* of Bowen belongs to *B. anglica*.

Brizalina cookei (Cushman).

Pl.8, fig.3.

Bolivina cookei Cushman 1922, p.126, pl.29, fig.1; Kaaschieter 1961, p.195, pl.8, figs.25-26.

Brizalina cookei (Cushman), Murray *et al.* 1981, pl.8.3, figs.17-18; King 1983, p.22, pl.2, fig.15.

Remarks.

King (1983) recorded this species in his NSB6 Zone, Late Eocene. It was used in this study to mark Zone CB6, Late Eocene, in the Southern North Sea.

Brizalina antiqua (d'Orbigny).

Bolivina antiqua d'Orbigny 1846,p.240, pl.14, figs.11-13; King 1989, p.467, pl.9.4, fig.22.

Brizalina antiqua (d'Orbigny), Doppert 1980, pl.18, figs.1a-b; King 1983, p.22, pl.2, fig.14.

Remarks.

D'Orbigny (1846) described this species from the Tertiary of the Vienna Basin, Austria. King (1983) recorded *B. antiqua* (d'Orbigny) in the Early Oligocene (Zone NSB7) through Early Miocene (NSB9). Rare in wells in this study, noted for example in well 29/10-1, Zone AB11B, Late Oligocene-Early Miocene. King (1989) used this species as a marker for his revised NSB8 Zone, Late Oligocene.

GENUS: *Bolivina* d'Orbigny 1839.

i. *B. punctata* d'Orbigny. Coarse pores covering wall giving it a rough appearance. Distinctly depressed sutures.

Bolivina punctata d'Orbigny.

Bolivina punctata d'Orbigny 1839, p.63, pl.8, figs.10-12.

Remarks.

This species was recorded in this study in Zones AB11B and AB11, Late Oligocene-Early Miocene (see range chart for AB Zones). *B. punctata* was noted in well 21/11-1, Zone PK11, Late Oligocene-Early Miocene, and wells 21/30-1 Zone CB15 Late Miocene, 29/10-1 Zones AB11B- CB12, Early Miocene. Examples of this species from the North Sea are coarser walled than *B. punctata* s.s. Superficially similar to *B. pseudoplicata* Heron-Allen and Earland (and noted in the well descriptions as such) but without the distinct "raised process zig-zagging down each parallel series of chambers" (Ellis and Messina 1940, *et. seq.*) typical of the later species.

GENUS: Tappaninina Montanaro Gallitelli 1955.

i. T. selmensis (Cushman). Test small (see Ellis and Messina 1940 et. seq. for size of holotype). Chambers distinctly cuneiform. Sutures depressed. Broad chamber faces, concave, with narrow sides strongly convex. Smooth, finely perforate wall.

Tappanina selmensis (Cushman).

Bolivinita selmensis Cushman 1933, p.58, pl.7, figs.3-4.

Bolivinita selmensis Cushman, Brotzen 1948, p.56, pl.9, fig.7.

Tappanina selmensis (Cushman), Koch 1977, p.64, pl.17, figs.8-9; Murray et al. 1981, p.258, pl.8.9, figs.14-15; Tjalsma and Lohmann 1983, p.37, pl.11, fig.4; van Morkhoven et al. 1986, p.332-334, chart no.108, pl.108.

Remarks.

In deep-water facies this species, according to Tjalsma and Lohmann (1983), is restricted to the Late Palaeocene (Zone P4 of Berggren, 1972) to Early Eocene (Zone P6b to possibly P8 of Berggren, op. cit.), although they did record it from the Late Cretaceous and Early Palaeocene. Van Morkhoven et al. (1986) recorded this species stratigraphic range as being from the Late Cretaceous (Maastrichtian) to Early Eocene (Zone P6b of Berggren, 1972). T. selmensis, according to van Morkhoven et al. (op. cit.), was mostly an outer neritic species, although it was also noted in bathyal facies. In this study T. selmensis was recorded rarely in the Early Palaeocene (Zone CB1 marker species) in the Southern North Sea. Murray et al. (1981) recorded this species in the Thanet Formation, Late Palaeocene. King (1983) used T. selmensis as a marker species for his Danian NSB1a Zone.

FAMILY: EOUVIGERINIDAE Cushman, 1927.

GENUS: Stilostomella Guppy, 1894.

i. S. paleocenica (Cushman and Todd). Differs from iii in having less globular chambers. Spines do not form such distinct rows at the base of each chamber as in iii, also the spines are less numerous. Spines may form longitudinal costae between the chambers.

ii. Stilostomella sp. Smooth, unornamented form. Depressed sutures, slightly arcuate test, and very distinct basal spine.

iii. S. adolphina (d'Orbigny). Globular chambers, very depressed sutures. Characteristic 'rows' of spines towards the base of each chamber.

iv. S. hirsuta (d'Orbigny). Globose chambers with very depressed sutures, more so than i-iii, and v. Very hispid test.

v. S. spinescens (Reuss). Differs from i and ii in having less depressed sutures, less globular chambers and less distinct spines. Spines form distinct rows towards the base of each chamber.

Stilostomella paleocenica (Cushman and Todd).

Pl.7, fig.4.

Ellipsonodosaria paleocenica Cushman and Todd 1946, p.61, pl.10 fig.26.

Stilostomella paleocenica (Cushman and Todd), Berggren and Aubert 1975, p.160, pl.2 fig.2a-b.

Notes.

Slender, slightly arcuate test. Constricted sutures. Wall slightly hispid in early part, with distinct spines in later part. Small basal spine.

Remarks.

Similar to S. paleocenica (type level Paleocene) but differs in the nature of the spines. In the London Clay species the spines cross the sutures, which they do not in S. paleocenica s. str.. This may be a broken example of S. adolphina [(d'Orbigny 1846), type level Miocene of the Vienna Basin, but noted by Ulleberg (1974) from the Oligocene of Denmark], but later chambers (only found as fragments, see Text-Fig.4, fig.5) do not have the characteristic rows of spines along the base of each chamber, and the spines again do not cross the sutures in the early chambers.

Stilostomella sp.

Notes.

Chambers inflated. Increase gradually in size towards aperture. Sutures constricted, perpendicular to test axis. Test slightly arcuate. Aperture on short neck.

Remarks.

Common. Aperture always broken. See Wetherell's (1838) Plate Fig.3 *Nodosaria*. Similar in general appearance to *N. soluta* (Reuss, 1851), in Sherborn and Chapman (1886). Unfortunately the 'crenulations' around the lip which would help to distinguish this genus from *Siphonodosaria* cannot be seen in these examples.

Stilostomella adolphina (d'Orbigny).

Pl.8, fig.5a-d.

Dentalina adolphina d'Orbigny 1846, p.51, pl.2, fig.18-20; ten Dam and Reinhold 1942, p.59.

Stilostomella adolphina (d'Orbigny), Ulleberg 1974, p.277, pl.2, fig.1, pl.6, fig.7.

Remarks.

This species was recorded by Ulleberg (1974) in the Middle Oligocene Viborg Formation of Denmark. It was originally recorded in Miocene marl, Baden area of the Vienna Basin, Austria. *S. adolphina* differs from *S.*

spinescens (Reuss) by having broader and more depressed sutures between the chambers, which are also more rounded.

Stilostomella hirsuta (d'Orbigny)

Nodosaria hirsuta d'Orbigny 1826, p.252.

Siphonodosaria hirsuta (d'Orbigny), Batjes 1958, p.120, pl.3, fig.12.

Stilostomella hirsuta (d'Orbigny), Ulleberg 1974, p.277, pl.2, figs.5-6.

Remarks.

This species was recorded by Ulleberg (1974) in the Middle Oligocene Viborg Formation of Denmark. Rare in wells in this study.

Stilostomella spinescens (Reuss).

Pl.8, fig.6.

Dentalina spinescens Reuss 1851, p.62, pl.3, fig.10.

Nodosaria spinescens (Reuss), Batjes 1958, p.116, pl.3, fig.13.

Stilostomella spinescens (Reuss), Ulleberg 1974, p.278, pl.2, fig.2, pl.6, fig.8.

Remarks.

Noted by Ulleberg (1974) in the Middle Oligocene, Viborg Formation. Noted in Oligocene material from the North Sea Basin in this study. This species is typically poorly preserved in the North Sea Oligocene, and the aperture is unclear.

GENUS: Siphonodosaria A. Silvestri 1924.

i. S. pauperata (d'Orbigny). Slender, slightly curved test. Sutures distinct, flush in the initial stages, becoming depressed in later parts. Smooth wall, finely perforate. Chambers broader than high in the initial part, becoming as broad as high in the later stages.

Siphonodosaria pauperata (d'Orbigny).

Dentalina pauperata d'Orbigny 1846, p.46, pl.1, figs.57-58.

Nodogenerina pauperata (d'Orbigny), Marks 1951, p.56, pl.7, fig.6.

Remarks.

This species was described from the Tertiary of the Vienna Basin, Austria, and recorded by Shell Expro. U.K. from the Middle Oligocene to the Miocene in the North Sea Basin.

GENUS: *Eouvigerina* Cushman, 1926.

i. *E. aculeata* (Ehrenberg). Differs from ii in having higher, less compressed chambers above the distinct ridge along each chamber.

ii. *E. americana* Cushman. Chambers more angular than i, almost polygonal.

Eouvigerina aculeata (Ehrenberg).

Loxostomum aculeata Ehrenberg 1854, p.22 pl.27, fig.21-22, pl.28 fig.26.

Eouvigerina aculeata (Ehrenberg) Murray *et al.* 1981, p.188, pl.7.8 fig.3-4.

Notes.

Small tapering test. Periphery angularly lobulate in side view. Chambers in early portion indistinct, later ones distinct. Sutures more depressed in later chambers, which have a distinct ridge across upper half of each with test slightly concave below. Finely perforate, broken rounded(?) aperture.

Remarks.

Found at British Library site. Examples broken. *E. aculeata* is an Upper Cretaceous foraminifera (Coniacian to Lower Maastrichtian). This species has (according to Hart *et al* (1981)) been referred to as *E. cretacea* (Heron-Allen and Earland) and *E. serrata* (Chapman). *E. aculeata* Cushman (1933 p.62 pl.7 fig.8a-b), is a junior secondary homonym.

Eouvigerina americana Cushman 1926, pl.34, figs.1-5.

Remarks.

This is an Upper Cretaceous species. It was noted in this study in well 21/11-1 (rare), Zone CB2 Early-early Late Palaeocene (Zone NS17, late Early Danian, LTG.teste).

SUPERFAMILY: NODOSARIACEA Ehrenberg, 1838.

FAMILY: NODOSARIIDAE " "

SUBFAMILY: NODOSARIINAE " "

GENUS: Pseudonodosaria Boomgart, 1949.

i. Pseudonodosaria sp.1. Test shorter than iii, with each chamber enclosing more of the previous one in the initial part.

ii. Pseudonodosaria sp.2. Test almost globular, and very short when compared to i and iii.

iii. Pseudonodosaria sp.3. More chambers visible than i-ii, and less embracing.

Pseudonodosaria sp. 1.

Pl.8, fig.7.

Notes.

Last formed chamber more globular and inflated than the rest.

Remarks.

Rare, only noted in the London Clay in this study. Well preserved, large. Glandulonodosaria Silvestri (1900) may prove to be a senior synonym of Pseudonodosaria but the type figures of type species (Nodosaria ambigua Neugeboren 1856) are inadequate and the type specimens appear not to have been redescribed.

Pseudonodosaria sp. 2.

Pl.8, fig.8.

Notes.

Test subovate. Final chamber overlapping earlier chambers.

Remarks.

Rare, only noted in the London Clay in this study. Surface of test worn.

Pseudonodosaria sp 3.

Pl.8, fig.9.

Notes.

4 large, 3 small subglobular chambers increasing in size towards the aperture (broken - just a hole). Sutures deeply incised. The first few chambers more strongly embracing than the later.

Remarks.

Rare, only noted in the London Clay in this study.

GENUS: *Saracenaria* Defrance in de Blainville, 1824.

Saracenaria sp.

Pl.8, fig.10.

Remarks.

Later uncoiling of test unclear. However, triangular section, and broad apertural face supports the conclusion that the above belongs to the genus *Saracenaria*.

GENUS: *Marginulina* d'Orbigny, 1826.

i. *M.* cf. *attenuata* Neugeboren. Sutures slightly depressed and curved. Chambers few, inflated in the later part. Short test.

Marginulina cf. attenuata Neugeboren.

Pl.8, fig.11.

see Marginulina attenuata Neugeboren 1851, p.121, pl.4 fig.3-6; Sherborn and Chapman 1889, pl.11.

Notes.

Test has a stout appearance. Aperture eccentric, closed.

Remarks.

This species differs from M. attenuata s. str in that the example figured by Ellis and Messina (1940 et seq.) is more elongate with more chambers in the uncoiled part, but similar in that the first formed section is tightly coiled. M. triangularis danvillensis Howe and Wallace (1932) is also similar to the above but differs from M. attenuata s. str. in that there are fewer chambers, the test has a more squat appearance, and the sutures are slightly curved. M. triangularis danvillensis also has a subtriangular cross-section which M. cf. M. attenuata does not possess. M. cf. attenuata was only noted in the Early Eocene, London Clay Formation in this study.

GENUS: Percultazonaria Loeblich and Tappan, 1986.

i. P. wetherellii (Jones). Elongate test, with subacute peripheral margin. Double peripheral keel which may be spinose. Sutures strongly elevated and thickened. Surface may also be covered by longitudinal costae. Sutures become depressed in last formed chambers in the adult forms.

Percultazonaria wetherellii (Jones, 1854).

Pl. 8 , fig.12, pl.9, fig.1a-b.

Abbreviated Synonymy.

Marginulina wetherellii 1854, Jones. Name given to test figured by Sowerby in 1840 p.135 pl.IX, fig.12.

Cristellaria fragraria (non Gümbel, 1868). Burrows and Holland 1896, p.38 pl.iii.

Marginulina enbornensis 1954, Bowen, p.149-151, fig.B, 1-4.

Vaginulinopsis decorata (Reuss, 1855), Berggren and Aubert 1976, p.336 pl.1, fig.1; King 1983, pl.2 fig.7; King 1989, pl.9.4 fig.11.

Notes.

Laterally compressed oval in cross section. Test ornamentation of longitudinal costae or tubercules.

Remarks.

This species is especially common in the London Clay and is a key element of the 'NRA' (Nodosariid rich association) referred to by King (1981). There is considerable variation in the size and ornamentation of specimens from the same locality. Shorter specimens are sometimes more stoutly built.

This species has been figured and described under different names by various authors, as can been from the above abbreviated synonymy list. P. wetherelli is of particular interest, being first illustrated by Wetherell (1838),as Marginulina (see Text-fig. 4, fig. 12). M. enbornensis was described by Bowen in 1954 from the London Clay, and he places into his synonymy M. wetherellii of Rupert Jones. Bowen examined what he took to be the original type specimens and concluded that they were not the same as those figured by Jones in his type description for M. wetherellii. He therefore renamed his London Clay specimens as M. enbornensis, this being erroneous. The forms he examined were labelled Cristellaria italica var. wetherellii, and it appears that he assumed that these were meant to be M. wetherellii. However, this is not the case, as Burrows and Holland (1896) state that R. Jones had pointed out to them that his M. wetherellii was not the same species as Cristellaria italica var. wetherellii. Burrows and Holland (op. cit.) also argued that M.

wetherellii should be placed into the genus *Cristellaria*. As there already was a separate species of *Cristellaria wetherellii*, they renamed the form *Cristellaria fragraria* (Gümbel). However, the generic term *Cristellaria* is not valid, the new genus *Percultazonaria* Loeblich and Tappan (1986) more accurately describing this species. It differs from *Vaginulinopsis* in having a more prominent early coil, and in the ornamentation of elevated and costate sutures. *Marginulinopsis*, an alternative generic name, also differs in having later chambers that are more laterally compressed, and in having weaker longitudunal costae. *Marginulina* does not describe this species either, as the coiling in the initial stage is not completely enrolled. Hence this form may be referred to as *Percultazonaria wetherellii*. *Vaginulinopsis decorata*, referred to by King (1983) as occurring in the Tertiary of the North Sea (zone NSB6 Late Eocene to zone NSB7 Early Oligocene), was first described from the Turonian of Mecklenberg (although according to C. King, pers. comms., the type specimen actually came fron Eocene material), is very similar to *P. wetherellii* in many ways. However, *V. decorata* is more compressed than the London Clay forms, and is generally less ornate. *P. wetherellii* (1854) is also the senior name to *V. decorata* (1855). It was suggested by Berggren and Aubert (1976) that *V. decorata* may be different from the Tertiary form, and that with futher study it might be given a new name. However, this is unnecessary as the species has been established correctly since 1854 by R. Jones.

The type specimens for several of the aforementioned species have been examined in the British Museum (Natural History).

Percultazonaria wetherellii Jones var.

Pl.9, fig.2.

Notes.

Small, no tubercules, just short longitudinal ridges in the early portion, which has a circular cross-section. The rest of the test is smooth. Aperture on a short neck, radiate.

Remarks.

Less common than the tuberculate P. wetherellii. Probably a megalospheric juvenile.

GENUS: Vaginulinopsis Silvestri 1904.

i. V. aff. jonesi (Reuss). Narrower initial coil than later uniserial pert. Sutures slightly depressed, surface covered in continuous costae.

ii. V. praelonga ten Dam. Much broader test than i. Sutures almost flush. Smooth, unornamented test.

Vaginulinopsis aff. jonesi (Reuss).

Pl.9, fig.3.

see Cristellaria (Marginulina) jonesi Reuss 1863, S. 63, Taf.5, fig.19.

Remarks.

This species differs from V. jonesi (Reuss) s.s. in having a more prominent initial coil, and less depressed sutures in the uniserial section. Rare. Only found in this study in the Oligocene. V. jonesi s.s. was an Early Cretaceous form.

Vaginulinopsis praelonga ten Dam.

Pl.9, fig.4.

Vaginulinopsis praelonga ten Dam 1944, p.102, pl6, fig.8a-b; Berggren and Aubert 1976, p.332, pl.1, fig.2.

Remarks.

This species was described from the Ypresian of the Netherlands. Typical V. praelonga is more rounded in section than the form noted in this study, with more depressed sutures. Berggren and Aubert (1976, text-fig.4) noted this form in the Early Eocene (nannoplankton Zone NP13), Orphan Knoll, at the edge of the Labrador Basin. It was noted in this study in the Late Palaeocene, Thanetian, nannoplankton Zone NP8, Pegwell Bay.

GENUS: Lenticulina Lamarck, 1804.

i. Lenticulina sp.1. More inflated test than iii-vi. Sutures may be slightly raised. Surface covered in faint striae.

ii. Lenticulina sp.2. Initial chamber globular, 'sack-like'.

iii. L. subangulata (Reuss). Flattened test, slightly depressed sutures. More compressed test than i-viii.

iv. L. cf. pseudovortex (Cole). Similar to v but with a less distinct central umbilical boss, and more compressed test.

v. L. cultrata (de Montfort). Distinct, raised umbilical boss. More inflated than iv.

vi. L. multiformis (Franke). Distinctly raised sutures, more raised near the umbilicus. Apertural face with strong shouders. A relatively large form.

vii. L. gutticostata Gümbel. Beaded, raised and thickened sutures.

viii. L. calcar (Linnaeus). Inflated form, with a very thin, often broad keel. Sutures flush. A more inflated form than i, iii-vii.

Lenticulina sp. 1.

Pl.9, fig.7.

Notes.

Acute margin, with keel. Biumbonate, chambers increasing gradually in size. Sutures slightly depressed to flush, slightly curved. The early chambers show some concentric striae which fade leaving the last chamber smooth.

Remarks.

Similar to L. inornata, but broader in width when viewed from the apertural face. The surface also displays some concentric striae as mentioned above. Rare. Large, occuring in 250μm fraction.

Lenticulina sp. 2.

Notes.

Small, sack-like. Aperture slightly raised on periphery, slit-like. Test has 'wrinckled' appearance. Thin keel.

Remarks.

Rare. Very similar to Ellipsocristellaria Silvestri 1920, but this genus, according to Loeblich and Tappan (1964) is only applicable to forms in the Upper Cretaceous. Coiling as in Lenticulina. This is probably a juvenile megalospheric form of Lenticulina, with just the first globose chamber followed by a 'coiled' second.

Lenticulina subangulata (Reuss).

Pl.9, fig.6.

Cristellaria subangulata Reuss 1862, Tf.8 fig.7; Franke 1928, Tf.10 fig.13.

Robulina subangulata (Reuss), Reuss 1863, Tf.6, fig.54.

Cristellaria (Robulus) subangulata Reuss, Ten Dam 1944, p.89 Tf.3, fig.3

Notes.

Chambers gradually increase in size towards the aperture. Test free, planispiral, lenticular. Faint keel. Sutures curved, and flush to slightly depressed. Surface smooth. Large, radiate, peripheral aperture, with 'apertural groove'.

Remarks.

Rare. Occurs in the 250 m to 125 m fractions.

Lenticulina cf. *pseudovortex* (Cole).

Pl.9, fig.5.

cf. *Robulus* *pseudovortex* Cole 1927, p.19 pl.1, fig.12.

Lenticulina sp. cf. *Lenticulina* *pseudovortex* (Cole), Kaasschieter 1961, p.172, pl.7 fig.6.

Notes.

Sub-quadrate, planispiral test. Biconvex. Involute, five chambers in the final whorl separated by curved, flush, limbate sutures. Thin, prominent keel, peripheral radiate aperture.

Remarks.

Occurs in 500μm and 250μm fractions in the London Clay. Possibly Wetherell's Fig.13 '*Rotalia*' (Text-fig.4). Differs from *L.* *pseudovortex* (Cole) s. str. in having a noticeable keel. May be a form of *L.* *cultrata* (Montfort, 1808), albeit generally slightly more compressed. Other, less compressed forms were also observed. Because de Montfort's type drawings are not particularly clear, it was felt that this species is better referred to here as *L.* cf. *pseudovortex* (Cole). This species was noted from the London Clay by Sherborn and Chapman 1886, and called *Cristellaria* *cultrata* (Montfort) (pl.15, fig.28a,b).

Lenticulina *cultrata* (de Montfort).

Pl.9, fig.8.

Robulus *cultratus* de Montfort 1808, p.214-215.

Cristellaria *(Robulus)* *cultrata* Ten Dam and Reinhold 1942, p.53.

Lenticulina (Robulus) cultrata (Montfort), Bartenstein et al. 1962, p.365, Tab.20, Taf.54, fig.1-3b.

Lenticulina cultrata (de Montfort), Doppert and Neele 1983, p.6, pl.9, fig.3a-b.

Remarks.

This species was recorded by Doppert and Neele (1983) in their FH Zone, ?Early-Late Eocene. In this study this species was noted in the Eocene, Zones CB3-6. Variants of this species occurred in the Early Oligocene (noted as L. cultrata s.l.).

Lenticulina multiformis (Franke).

Pl.9, fig.9a-c.

Cristellaria multiformis Franke 1911, p.111, Taf.3, Fig.3-8.

Lenticulina (Lenticulina) multiformis (Franke), Bartenstein et al. 1962, p.366, Tab.20, Taf.52, fig.3-5.

Lenticulina multiformis (Franke), King 1983, p.21, pl.2, figs.1-2; Doppert and Neele 1983, p.9, pl.24, fig.5a-c.

Remarks.

Doppert and Neele 1983 record this species in their FJ Zone, Late Palaeocene. King 1983 noted L. multiformis in his NSB1 Zone, early Late Palaeocene-Early Palaeocene. This species was noted in Zone CB2, in this study, Early-early Late Palaeocene.

Lenticulina gutticostata (Gümbel)

Robulina gutticostata Gümbel 1868, p.643, pl.1, fig.74a-b.

Lenticulina gutticostata (Gümbel), King 1989, p.463, pl.9.3, fig.19.

Remarks.

This species was described by Gümbel (1868) from the Eocene of

Germany; King (1989) recorded this forms range as Middle-?Late Eocene. It was noted in this study in Zone NS11, Late Eocene of well 14/29-1, and Zones CB4-CB6, late Early-Late Eocene.

Lenticulina calcar (Linnaeus).

Pl.9, fig.10.

Nautilus calcar Linnaeus 1767, S.1162, No.272.

Robulina calcar (Linnaeus) d'Orbigny 1846, Taf.4, figs.18-20.

Cristellaria calcar (Linnaeus) Brady 1884, Taf.70, figs.9-12; Nuttall 1927, p.86, pl.5, fig.8.

Lenticulina (Lenticulina) calcar (Linnaeus), ten Dam and Reinhold 1942, Taf.2, fig.7.

Remarks.

Nuttall (1927) noted this species in the Oligocene-Miocene of the Naparima Region of Trinidad. This species was noted in the ?Oligocene and Eocene by Shell Expro. U.K. In this study *L. calcar* (Linnaeus) was noted in well 14/29-1, Zone NS11, Late Eocene, and well 21/30-1, Zones CB8-PK12, early Late Oligocene-Early Miocene.

GENUS: *Lagena* Walker and Jacob in Kanmacher 1798.

i. *L. elongata* Ehrenberg. Very elongated form, smooth.

ii. *L. hispida* Reuss. Globular, very hispid test.

Lagena elongata Ehrenberg.

Lagena elongata Ehrenberg 1884, see Brady 1884, p.9, pl.56, figs.27-28; van Voorthuysen 1958, pl.2, fig.17; Doppert 1980, p.263, pl.12, fig.1.

Remarks.

Doppert (1980) recorded this species in his FC Zone, Late Miocene. Shell Expro. U.K. recorded this species in the Oligocene-Pliocene.

Lagena hispida Reuss.

Lagena hispida Reuss 1858, S.434; Reuss 1862, S.335, Taf.6, fig.77-79; ten Dam and Reinhold 1942, S.69; ten Dam 1944, p.103.

Remarks.

Ten Dam (1944) noted this species in the Bartonian (late Middle Eocene) of the Netherlands. It was noted in this study in well 49/9-1, Zone CB6 (NS11, LTG.teste), Late Eocene, and in well 21/30-1, Zone PK12 (NS5, LTG.teste), ?late Early Miocene.

GENUS: Dentalina Risso, 1826.

i. D. multilineata Bornemann. Fine striations cover the test. Sutures less depressed than ii-iii.

ii. D. elegantissima (Hantken) var.A. Thick longitudinal costae covers the test. Sutures covered and almost indistinct. Large basal spine.

iii. D. elegantissima (Hantken) var.B. Surface covered in longitudinal costae with occasional short, stubby spines. Differs from ii in having more depressed sutures, and thinner costae.

iv. D. megalopolitana Reuss. Short, stubby and inflated test, with a very rounded cross-section. Sutures only slightly depressed in the later part. Surface smooth.

v. D. eocenica Cushman. Relatively small test with smooth walls and slightly depressed sutures.

vi. D. inornata (d'Orbigny). Similar to v but much larger, with less depressed sutures in the initial stages, and slightly more arcuate test.

vii. Dentalina sp. Slightly arcuate test. Sutures oblique. Short test with high chambers, smooth.

Dentalina multilineata Bornemann.

Pl.10, fig.1.

Dentalina multilineata Bornemann 1855, p.325 pl.13 fig.2; Sherborn and Chapman 1886, pl.15 fig.14.

Notes.

Straight test. Initial chamber plain.

Remarks.

Similar to D. obliquestriata Reuss 1851 (p.63 pl.3 fig.12,13); but in D. multilineata the 'striations' follow the test axis , while in D. obliquestriata they are slightly oblique.

Dentalina elegantissima (Hantken) var.A.

Nodosaria elegantissima Hantken 1875, p.24 pl.12 fig.16.

Stilostomella cf. elegantissima (Hantken), Hagn 1956, p.155, pl.13 fig.24.

Nodosaria sp. cf. Nodosaria elegantissima (Hantken), Kaasschieter 1961, p.176 pl.7, fig.20.

Notes.

Strongly arcuate test. Ridges form prominent longitudinal features, often discontinuous. They begin at the top of each chamber and just extend over the central part of the suture. Sutures more depressed near the aperture. The aforementioned ridges are continuous near base of test, and form one large basal spine. Chambers gradually increase in size towards aperture. Often large, and broken. Possibly a microspheric form.

Remarks.

See below for further comments on this species.

Dentalina elegantissima (Hantken) var.B.

Pl.10, fig.2.

Notes.

Chambers inflated, with sutures more obviously constricted than var.A above. Heavy longitudinal ridges present but not so well developed as in var.A. They tend to be more continuous over both chambers and sutures. Later chambers are very spiny. They increase in size gradually, towards the terminal aperture.

Remarks.

This is probably a megalospheric form of *D.* cf. *elegantissima.*

Sherborn and Chapman (1886) figured an example of *Dentalina spinulosa* (Montagu 1808) from the London Clay. They described it as; "an extremely variable form which passes from true spines to triangular points (as in Sowerby's figure), from points to winged terminal riblets at the base of the chambers, and further to riblets often continuous over the first formed portion of the test." *D. spinulosa* differs from *D.* cf. *elegantissima* in having more spinose later chambers. In the later the spines are invariably joined in some form of ridge.

Dentalina megalopolitana Reuss.

Dentalina megalopolitana Reuss 1855, p.267, pl.8, fig.10; Doppert and Neele 1983, pl.16, fig.2a-b.

Remarks.

Recorded by Doppert and Neele (1983) in their FI Zone, Early Eocene. Occurred in this study in Eocene material.

Dentalina eocenica Cushman.

Dentalina eocenica Cushman 1944, p.36, pl.6, fig.1; Cushman 1951, p.22, pl.6, figs.30-33.

Remarks.

This species was noted by Cushman (1951) from the Palaeocene of the Gulf Coastal region of the U.S.A. and surroundings. It was noted in this study in wells 21/11-1 (few), Zone PK2, Late Palaeocene, and 14/29-1 (rare), Zone CB2 (and Zone NS18, Early Palaeocene, LTG.*teste*), Early-early Late Palaeocene.

Dentalina inornata d'Orbigny.

Pl.10, fig.3.

Dentalina inornata d'Orbigny 1846, p.44 pl.1, fig.50-51; Terquem 1882, p.37, pl.1 fig.41; Kaasschieter 1961, p.176 pl.7 fig.18-19.

Notes.

Sutures less distinct away from the aperture which is produced on a short neck. Test slightly curved. Aperture eccentric. Sutures slightly oblique, almost perpendicular to the test axis.

Remarks.

Common. Small. *D. elegans* d'Orbigny 1846, very similar to *D. inornata*; most notable difference being, that in *D. elegans* the sutures are perpendicular to the test axis, while in *D. inornata* (d'Orbigny, 1846) the sutures are more oblique. This species was noted in the range charts as *Laevidentalina inornata*. *Laevidentalina* (Loeblich and Tappan 1986) differs from *Dentalina* in having a smooth delicate test. Loeblich and Tappan (op. cit.) regarded *Dentalina* s.s. as being costate. In this thesis it was decided that as test ornamentation was so varied between and within species, it was not, in the case of *Dentalina*, a good basis for generic diagnosis.

Dentalina sp.

Pl.10, fig.6.

Notes.

Slightly arcuate test. Sutures not very distinct. Test smooth, no spines. Chambers increase in size from base to aperture. Specimens short, with few broad chambers. Aperture on a raised 'neck', and 'slit-like'.

Remarks.

Usually well preserved. Common in 75µm to 125µm fractions from the London Clay, Early Eocene. Occasionally occurs in 250µm fraction. Featured by Wetherell (1838) as Figure 4 '*Nodosaria*'.

GENUS: *Nodosaria* Lamarck, 1812.

i. *N. longiscata* d'Orbigny. Smooth wall, tubular test. Lomg chambers. 'Bulbous' initial part.

ii. *N. latejugata* Gümbel. Test with regular, very continuous costae. Relatively very large test, larger than vii with thicker more bladed costae. Depressed sutures.

iii. *N.* aff. *raphanus* (Linnaeus). 6 regular but widely spaced, low but thick costae. Sutures only very slightly depressed. Test gently flaring.

iv. *N. intermitens* Roemer. Similar to xi but with thinner longitudinal costae, and more twisted. Depressed sutures, globular chambers.

v. *N. emaciata* (Reuss). Smooth test. Arcuate, with almost horizontal chambers that have clear, glassy sutures. Chambers may be compressed or elongated. Small basal spine.

vi. *N. ewaldi* (Reuss). Very thin, elongated test with high, numerous narrow chambers and generally constricted sutures. Aperture may appear to be produced. Sutures more depressed than i.

vii. *N. minor* Hantken. Similar to ii in ornamentation, but sutures less depressed in the earlier parts.

viii. *Nodosaria* sp.1. Very large form similar to iii but with larger, and more bladed costae. Sutures flush.

ix. *Nodosaria* sp.2. Sutures slightly depressed, tapers in later chambers towards the aperture. Smooth test.

x. *N. torsicostata* ten Dam. Sutures depressed. Chambers globular. Longitudinal costae may be slightly twisted, thicker than iv. Specimens also longer.

xi. *N. consobrina* (d'Orbigny). Globular chambers, that become more elongated towards the aperture.

xii. *N. konincki* (Reuss). Large test, with discontinuous slightly irregular costae, that are slightly twisted. Sutures less depressed than xi and iv. The twisting of the costae only occurs near the centre and base of the test. In iv the sutures are twisted on each chamber. Costae coarser than in iv.

Nodosaria longiscata d'Orbigny.

Nodosaria longiscata d'Orbigny 1846, p.32 pl.1 fig.10-11; Sherborn and Chapman 1889, p.486, pl.11 fig.17-18.

Description.

Test long, tubular, slender and smooth. Individual chambers are long and circular in section. First formed chambers inflated. Chambers increase in width at the sutures. Pores very small, and apertures not found.

Remarks.

Always occurs in sample studied as broken segments.

Unlike the description given for *N. longiscata* by Papp and Schmid

(1985), sutures are often constricted and the chambers do not increase in width at this point.

Nodosaria latejugata Gümbel.

Pl.10, fig.4a-b.

Nodosaria latejugata Gümbel 1870, p.619 pl.1, fig.32; Kaasschieter 1961, p.177 pl.7 fig.22; Doppert and Neele 1983, p.6, pl.10, fig.1-2..

Notes.

Uniserial test with inflated chambers. Thick longitudinal ribs that cross the depressed sutures.

Remarks.

Abundant, occurring with Percultazonaria wetherellii. Large and broken. Part of King's (1981) NRA fauna, in the London Clay. Doppert and Neele (1983) recorded this species in their FH Zone, ?Early-Late Eocene.

Nodosaria aff. raphanus (Linnaeus).

Pl.10, fig.5.

see Nautilus raphanus Linnaeus 1767, p.1164, No.283.

see Nodosaria raphanus (Linnaeus) var., Sherborn and Chapman 1886, pl.14, fig.37.

Notes.

Test with pronounced longitudinal ridges, which may be twisted. Sometimes fade towards the base. Sutures between the chambers horizontal, only slightly depressed. Test flares towards the broken Nodosariid aperture.

Remarks.

Rare. Similar to Wetherell's (1838) 'Articulina?'

Nodosaria intermittens Roemer.

Nodosaria intermittens Roemer 1838, p.382, pl.3, fig.2; Doppert and Neele 1983, p.4-6 ,pl.5, fig.5.

Remarks.

This species was recorded by Doppert and Neele (1983) in their FF/FG Zone, Early-Middle Oligocene.

Nodosaria emaciata (Reuss).

Dentalina emaciata Reuss 1851, p.63, pl.3, fig.9.

Nodosaria emaciata (Reuss), Batjes 1958, pl.3, fig.20.

Nodosaria emaciata (Reuss) and var., Doppert and Neele 1983, p.4-6, pl.5, figs.204.

Remarks.

This species was recorded by Doppert and Neele (1983) in their FF/FG Zone, Early-Middle Oligocene. Shell Expro. U.K. record this species in the Oligocene-Miocene.

Nodosaria ewaldi Reuss.

Nodosaria ewaldi Reuss 1851, p.58, pl.2, fig.2; Batjes 1958, p.117, pl.3, fig.20.

Remarks.

This species was recorded by Shell Expro. U.K. in the Middle Oligocene-?Miocene.

Nodosaria minor Hantken.

Nodosaria bacillum Defrance var. *minor*, Hantken 1875, p.26, pl.2, fig.7; Staesche and Hiltermann 1940, pl.39, fig.3.

Nodosaria minor Hantken, Doppert and Neele 1983, p.6, pl.12, fig.3a-b.

Remarks.

This species was recorded by Doppert and Neele (1983) in their FH Zone, ?Early-Middle Eocene. This species was a useful index form, its FDO being in the Late Eocene in this study, Zone CB6.

Nodosaria sp. 1.

Notes.

Large 'ribbed' nodosariid. Sutures between the chambers flush, and not obvious unless test is 'wetted'. Test flares towards aperture (cannot be seen here as the test is broken).

Remarks.

Very large, very rare. Only recorded in the Early Eocene, London Clay formation. Similar to Wetherell's (1838) Fig.10 and Nodosaria aff. raphanus. Preservation good.

Nodosaria sp. 2.

Pl.10, fig.7.

Notes.

Smooth walled, with the penultimate chamber more inflated than the others. Sutures between chambers only slightly depressed. Earlier chambers have a slightly arcuate appearance. One broken basal spine.

Remarks.

Small nodosariid, quite rare. Usually well preserved.

Aperture on most specimens broken, but appears to be radiate. Recorded only in the London Clay, Early Eocene in this study, Zone CB3.

Nodosaria torsicostata ten Dam.

Nodosaria torsicostata ten Dam 1944, p.96, pl.2, fig.16; Bartenstein et al. 1962, p.364, Tab.20, Taf.52, fig.12; Doppert and Neele 1983, p.9, pl.20, fig.1, pl.22, fig.2; King 1983, p.21 ,pl.2, fig.4..

Remarks.

This species was recorded in the FI and FJ Zones of Doppert and Neele (1983), Early Eocene-Late Palaeocene. It was noted by King (1983) in his NSB1 Zone, Early-early Late Palaeocene, and in Zone CB2 in this study.

Nodosaria consobrina (d'Orbigny).

Pl.10, fig.8.

Dentalina consobrina d'Orbigny 1846, p.46, pl.2, figs.1-3.

Nodosaria consobrina (d'Orbigny), Bowen 1954, p.152, fig. B,5,6.

Remarks.

This species was recorded in the London Clay Formation and the Eocene of the North Sea in this study. Bowen (1954) recorded N. consobrina in the London Clay from the London and Hampshire basins. It was also noted in this study in well 14/29-1, Zone CB5 Middle Eocene (NS12, late Middle Eocene, LTG.teste).

Nodosaria konincki (Reuss .

Dentalina konincki Reuss 1861; Doppert 1980, pl.9, fig.3.

Nodosaria konincki (Reuss), Batjes 1958, p.115, pl.3, fig.5; King 1983, p.21, pl.2, fig.3.

Remarks.

Doppert (1980) recorded this species in his FC Zone, Late Miocene.

King (1983) noted this species in his NSB10-NSB14 Zones, Middle Miocene-Late Pliocene.

SUFAMILY: PLECTOFRONDICULARIINAE Cushman 1927.

GENUS: Plectofrondicularia Liebus 1902.

i. P. seminuda (Reuss). Broad test, compressed and elongate. Sutures slightly depressed in later parts, flush in earlier parts. Surface covered in regular 'medium' costae.

Plectofrondicularia seminuda (Reuss).

Pl.10, fig.9a-b.

Frondicularia seminuda Reuss 1851, S.65, Taf.3, figs.15-16; ten Dam and Reinhold 1942, Taf.4, fig.8; Batjes 1958, p.112, pl.3, fig.8.

Plectofrondicularia seminuda (Reuss), King 1983, p.21, pl.2, fig.5.

Remarks.

This species was recorded by King (1983) in the Early Oligocene (Zone NSB7) to Early Miocene (NSB9). The FDO of this species was used in this study to mark Zone CB10 Early Miocene; rare to few recorded.

SUBFAMILY: POLYMORPHININAE d'Orbigny 1839.

GENUS: Guttulina d'Orbigny in de la Sagra 1839.

i. G. frankei Cushman and Ozawa. Inflated test. Chambers more inflated than S. regularis (Roemer). Cross section almost triangular with subrounded peripheral margins. Acute apertural and initial ends.

Guttulina frankei Cushman and Ozawa.

Guttulina frankei Cushman and Ozawa 1930, p.28, pl.4, fig.1a-c; Ulleberg 1974, p.276, pl.1, figs.1-6.

Guttulina problema d'Orbigny var. frankei Cushman and Ozawa, Batjes 1958, p.121, pl.4, fig.11.

Remarks.

This species was described from the Middle Oligocene, Sollingen, Germany. It was noted by Ulleberg (1974) in the Middle Oligocene, Viborg Formation from Denmark.

GENUS: Sigmomorphina Cushman and Ozawa 1928.

i. S. regularis (Roemer). 'Tear-drop' shaped test, compressed. Relatively very large. Sutures depressed.

Sigmomorphina regularis (Roemer).

Polymorphina (Polymorphinen) regularis Roemer 1838, p.385, pl.3, fig.21a-b.

Sigmomorphina regularis (Roemer), Batjes 1958, p.125, pl.4, fig.2.; Doppert 1980, p.266, pl.20, fig.4a-b.

Remarks.

Doppert (1980) recorded this species in his Stainforthia schriebersiana -Sigmomorphina regularis, FE Zone, Late Oligocene-Early Miocene. King (1983) noted S. regularis (Roemer) in his NSB7 (Early Oligocene) to NSB10 (Early-Middle Miocene) Zones. In this study the FDO of this species was used to mark Zone CB9, Late Oligocene.

SUBFAMILY: OOLININAE Loeblich and Tappan 1961.

GENUS: Oolina d'Orbigny 1839.

i. O. hexagona (Williamson). Test of a single globular chamber covered in distinct hexagonal reticulations.

Oolina hexagona (Williamson).

Entosolenia squammosa var. hexagona Williamson 1848, p.20, pl.2, fig.23.

Oolina hexagona (Williamson 1884); ten Dam 1944, p.103; Haynes 1958 (part 3), p.72, pl.17, figs.8-8b; Doppert 1980, p.260, pl.3, fig.8.

Remarks.

Haynes (1958, part 3) noted this species in the Pegwell Marls, Palaeocene, and noted that it had been recorded in Upper Cretaceous to Eocene and Recent material. Doppert (1980) recorded this species in his FA Zone, Early Pleistocene-Late Pliocene. Noted in this study in well 21/30-1, Zone PK12, Early Miocene. Often caved.

GENUS: Fissurina Reuss 1850.

i. F. laevigata Reuss. Ovate test. Surface smooth, with a keel. Slit-like aperture.

Fissurina laevigata Reuss.

Fissurina laevigata Reuss 1850, Loeblich and Tappan 1964, p.540-541, Fig.425, 8a-b.

Remarks.

Loeblich and Tappan (1964) noted F. laevigata Reuss in the Tertiary of Germany. Rare in wells in this study.

3.3.2. Agglutinated Benthic Foraminifera.

ORDER: FORAMINIFERIDA Eichwald, 1830.

SUBORDER: TEXTULARIINA Delage and Hérouard, 1896.

SUPERFAMILY: ASTRORHIZACEA Brady, 1891.

FAMILY: RHABDAMMINIDAE Brady, 1884.

SUBFAMILY: RHABDAMMININAE Brady,1884.

GENUS: Bathysiphon Sars, 1872.

Bathysiphon sp.

Notes.

Small, uniserial, coarse-walled. Rarely straight.

Remarks.

Occurs commonly, but in small numbers in the London Clay Formation, Early Eocene. Very similar to Bathysiphon filiformis Sars, 1872. Often thin, and twisted.

GENUS: Rhabdammina M. Sars, 1969.

i. R. discreta Brady. Relatively large, tubular test. Round cross section. Medium to coarse walled, straight.

Rhabdammina discreta Brady.

Pl.10, fig.10a-b.

Rhabdammina discreta Brady 1881, p.48, pl.22, figs.7-10.

Hyperammina intermedia Mjatliuk 1970, pl.1, figs.16-17, pl.2, figs.11-12, pl.3, figs.6-8, pl.4, fig.3, pl.6. figs.1-4.

Rhabdammina ex gr. discreta Brady. Geroch 1960, p.36, pl.1, figs.12-15; Kaminski et al. 1988, p.183 pl.1, figs.8-9.

Bathysiphon discreta (Brady) var.B. Gradstein and Berggren 1981, p.240, pl.1, figs.7-10.

Notes.

Wall of well sorted coarse grains. Rectilinear test.

Remarks.

Occurs only as broken sections so making generic designation difficult. Common in the Rhabdammina biofacies of Brouwer (1965), and King (1983). According to Loeblich and Tappan (1988) Rhabdammina, occurs in deep water, from 700m to 4,800m.

The stratigraphical range of this species in flysch-type assemblages from Trinidad (see Kaminski et al. 1988, fig.3), is from the Upper Cretaceous (Maastrichtian) to above the Early Eocene (Ypresian).

GENUS: Rhizammina Brady, 1879.

i. R. indivisa Brady. Elongate, thin tubular tests, often twisted, and may be coarse or medium grained. Sometimes branched. Test smaller than Rhabdammina gr. discreta (Brady).

Rhizammina indivisa Brady.

Pl.10, fig.11a-b, Pl.11 fig.1a-b.

Rhizammina indivisa Brady 1884, p.277, pl.29, figs.5-7; Geroch 1960, pl.1, figs.1-7; Gradstein and Berggren 1981, p.240, pl.1, figs.1-3; Kaminski et al. 1988, p.183, pl.1, figs.10-13.

Notes.

Few branching forms seen. Test often flattened and or distorted. Test may be finely finished.

Remarks.

Commonly occurs in the Rhabdammina biofacies. Loeblich and Tappan (1988, p.24) suggest that this genus occurs in deep water, in depths of 1,260m to 5,800m.

In Kaminski et al.'s (1988, see fig.3) material from Trinidad this species ranges from the Upper Cretaceous (Maastrichtian) to above the Early Eocene (Ypresian).

SUBFAMILY: DENDROPHRYINAE Haeckel, 1894.

GENUS: Dendrophyra T.S. Wright, 1891.

i. D. excelsa Grzybowski. Compressed test. 'Medium' grained wall. Straight, does not twist like Rhizammina indivisa Brady. Test branches.

ii. D. cf. latissima Grzybowski. Test more compressed, flatter and broader than i. Straight test, no branched sections observed in this thesis.

iii. D. robusta Grzybowski. Similar to ii but thicker and generally much larger.

Dendrophyra excelsa Grzybowski.

Dendrophyra excelsa Grzybowski 1898, p.16, pl.10, figs.2-4; Geroch 1960, pl.1, figs.1-9; Hanzlíková 1972, p.32, pl.2, fig.6; Verdenius and van Hinte 1983, p.198, pl.3, figs.3, 4; Kaminski et al. 1988, p.182, pl.1, figs.4-5.

Notes.

Tubular test. Flattened, and moderately coarse walled. Most fragments straight, rarely branched.

Remarks.

I follow Kaminski et al. (1988) in keeping this group in open nomenclature, as, according to them, there is considerable variation in the wall thickness and grain size in specimens of this species in the Grzybowski collection.

Again, more common in the Rhabdammina biofacies. Top occurence (first downhole occurence) above the Eocene according to Kaminski et al. (1988).

Dendrophyra cf. latissima Grrzybowski.

Pl.11, fig.2a-c.

see Dendrophyra latissima Grzybowski 1898, p.17, pl.10, fig.8; Kaminski et al. 1988, p.182, pl.1, fig.6.

Notes.

Wide, flat tube often with thin wall.

Remarks.

More common in the Rhabdammina biofacies. Examples from the North Sea often more coarse walled than examples drawn by Grzybowski (1898), but both smooth and coarse varieties noted. Often slightly wider than Grzybowski's (1898) type figure shows, but always very compressed as in his cross section. Only occurs as short fragments so generic designation is difficult to ascertain.

According to Kaminski et al. (1988) ranges in his material from the Cretaceous into the Danian, top of Berggren's (1969) P.1c M. trinidadensis Zone. D. latissima s.str. was described from Eocene sediments from the Outer (Flysch) Carpathians. D. cf. latissima has been observed from Oligocene beds from the North Sea area.

Dendrophyra robusta Grzybowski.

Dendrophyra robusta Grzybowski 1898, pl.10, fig.7.

Notes.

Test compressed, flat tube with thick wall.

Remarks.

Similar to D. cf. latissima but thicker walled, and with a much larger test. Only broken fragments found, and none with any branching strucures. This species may, therefore, belong to the genus Bathysiphon Sars

1872.

This species was described from the Eocene sediments of the Outer (Flysch) Carpathians. Occurs in Eocene and Oligocene sediments from North Sea wells examined for this thesis.

FAMILY: PSAMMOSPHAERIDAE Haeckel, 1894.

SUBFAMILY: PSAMMOSPHAERINAE Haeckel, 1894.

GENUS: Psammosphaera Schulze, 1875.

i. P. fusca Schulze. Single globular chamber, often very coarse walled.

Psammosphaera fusca Schulze.

Pl.11, fig.3.

Psammosphaera fusca Schulze 1875, p.113, pl.2, fig.8; Verdenius and van Hinte 1983, p.189, pl.3, fig.6; Jones 1988, p.148, pl.1, fig.6.

Psammosphaera sp. var.A, Gradstein and Berggren 1981, p.241, pl.1, figs.13, 14, (NON 12?).

Notes.

Roughly globular chamber. Coarse to medium grained wall, grain size fairly homogeneous.

Remarks.

Illustrated example from the Early Eocene London Clay Formation. Jones (1988, fig.3) records this species from the upper part of his middle slope (500-1000m palaeowater depth) in Unocal well 9/12A-5, U.K. sector, Viking Graben. Ksiazkiewicz (1975) suggests that, with few exceptions, P. fusca occurs in bathyal depths.

Described originally from the Recent by Schulze (1875). Verdenius and van Hinte (1983, fig.5-7, 9-10) record this species from the Eocene of

D.S.D.P. wells 345-347, 359-350, Leg 38,and the Oligocene and Early Miocene of well 348 (fig.8).

FAMILY: SACCAMMINIDAE Brady, 1884.

SUBFAMILY: SACCAMMININAE Brady, 1884.

GENUS: Placentammina Thalmann, 1947.

i. P. placenta (Grzybowski). Globular chamber which is always compressed. Aperture on a very small neck.

ii. P. complanata (Franke). Differs from i in having a thin elongate neck, and being smaller.

Placentammina placenta (Grzybowski).

Pl.11, fig.4.

Reophax placenta Grzybowski 1898, p.276, pl.10, fig.9-10.

?Bogdanovicziella complanata (NON Franke) sensu Mjatliuk 1970, p.51-52, pl.7, fig.12a-b, pl.8, figs.5-10, pl.15, figs.3-4.

Saccammina placenta (Grzybowski). Hanzlíková 1972, p.33, pl.1, fig.9; Gradstein and Berggren 1981, p.241, pl.2, fig.3; Miller et al. 1982, p.19, pl.1, fig.4; Kaminski et al. 1988, p.183, pl.2, fig.9.

Placentammina placenta (Grzybowski). Loeblich and Tappan 1988, pp.31-32, pl.21, figs.17-19.

Notes.

Finely agglutinated test, usually with depressed centre.

Remarks.

Common in North Sea sediments examined in this thesis. Differs from P. complanata in being more finely agglutinated and has a smaller, more delicate neck, located at any position on the test surface. According to Loeblich and Tappan (1988, p. 32) this genus is typically found in flysch deposits.

This genus occurs in Cretaceous to Miocene sediments. In Kaminski et al.'s (1988) material from Trinidad, this form tops in the Early Eocene (Ypresian, top of Berggren's P.6b Zone). It originally was described from the Upper Eocene, near Krosno, Poland.

Placentammina complanata Franke.

Pl.11, fig.5.

Pelosina complanata Franke 1912, p.107, pl.3, fig.1.

Saccammina complanata (Franke). Rögl 1976, pl.3 figs.7-8; Miller et al. 1982, p.19, pl.1, fig.3; Tjalsma and Lohmann 1983, p.19; Loeblich and Tappan 1988, pl.21, figs.15-16.

Notes.

Spherical outline to test. Flattened. Wall of quite coarse grains. Aperture often on the periphery.

Remarks.

Occurs with P. placenta in the Rhabdammina biofacies.

This species was originally described from the Lower Eocene of Northern Germany. Observed in Oligocene beds from the Central North Sea, area Central Graben, in material studied for this thesis.

Saccammina Carpenter, 1869.

i. S. sphaerica Brady. Globular test. Coarser walled than Plactenammina placenta (Grzybowski) and finer than Psammosphaera fusca Schulze. Rarely compressed.

Saccammina sphaerica Brady.

Saccammina sphaerica Brady 1871, p.183; Loeblich and Tappan 1988, p.32,

pl.23, fig.8.

Notes.

Test of a single chamber. Rounded aperture. Often with a wall of relatively large quartz grains with a finer matrix.

Remarks.

Of no stratigraphic value in this study.

SUPERFAMILY: HIPPOCREPINACEA Rhumbler, 1895.

FAMILY: HIPPOCREPINIDAE Rhumbler, 1895.

SUBFAMILY: HYPERAMMININAE Eimer and Fickert, 1899.

GENUS: Hyperammina Brady, 1878.

i. H. subnodosiformis Grzybowski. Smooth walled species with globular 'sections'.

Hyperammina subnodosiformis Grzybowski.

Hyperammina subnodosiformis Grzybowski 1898, p.274, pl.10, fig.5; Geroch 1960, pp.38-39, pl.1, fig.21; Jurkiewicz 1967, pp.42-43, pl.1, figs.10-11. Hyperammina ex gr. subnodosiformis Grzybowski, Kaminski et al. 1988, p.184, pl.1, figs.14-15.

Notes.

Finely agglutinated tubes with irregular annular constrictions. Specimens often flattened.

Remarks.

This species was noted by Kaminski et al. (1988) in the Danian, Early Palaeocene, of Trinidad.

SUPERFAMILY: AMMODISCACEA Reuss, 1862.

FAMILY: AMMODISCIDAE Reuss, 1862.

SUBFAMILY: AMMOVOLUMMININAE Chernykh, 1967.

GENUS: Ammodiscus Reuss, 1862.

i. A. cretaceus (Reuss). Large test with a many coiled overlapping chamber. Depressed centre.

ii. A. latus Grzybowski. Thinner than i, and also large, but with fewer coils.

iii. A. planus Loeblich. Small test, and thinner walled than i, otherwise similar.

Ammodiscus cretaceus (Reuss).

Pl.11, fig.6a-b.

Operculina cretacea Reuss 1845, p.35, pl.13, figs.64-65a-b.

Ammodiscus cretaceus (Reuss). Rogl 1976, pl.2, fig.22; Hanzlíková 1972, p.34, pl.3 figs.7, ?9; Gradstein and Berggren 1981, p.241, pl.2, figs.12-13; Miller et al. 1982, p.19, pl.1, fig.17; Kaminski et al. 1988, p.184, pl.3 fig.7.

Ammodiscus siliceus (NON Involutina silicea Terquem), sensu Verdenius and van Hinte 1983, p.190, pl.3, fig.8.

?Ammodiscus infimus (NON Orbis infimus Strickland), sensu Geroch and Nowak 1984, pl.1, fig.11.

Ammodiscus peruvianus NON Berry? sensu Gradstein and Berggren 1981, p.241, pl.2 ,figs.14-15; sensu Kaminski et al. 1988, p.185, pl.3, figs.11-12.

Notes.

Large evolutely coiled test, of 8 to 10 whorls. Distinct coiling suture. Usually finely agglutinated wall.

Remarks.

A very variable form that often appears to be distorted in sediments from the North Sea area. Verdenius and van Hinte (1983, p.190) state that "the morphologic, taxonomic and stratigraphic relations in the genus Ammodiscus are in need of a revision". Kaminski et al. (1988, p.184) places A.

involvens Grzybowski, A. polygyrus Grzybowski, A. angygyrus Grzybowski and Cornuspira angusta Freidberg into synonymy with Ammodiscus cretaceus. A. incertus sensu Kaaschieter (1961), according to Charnock and Jones (in preparation), probably belongs to A. cretaceus, as Operculina incerta d'Orbigny is a Cornuspira.

The stratigraphical range of A. cretaceus is difficult to ascertain if all the above species are included within the species concept.

Ammodiscus latus Grzybowski.

Ammodiscus latus Grzybowski 1898, pl.10, figs.27-28; Gradstein et al. 1988, fig.2.

Notes.

Large, very flat Ammodiscid with medium grained wall.

Remarks.

A fairly common form. Differs from A. planus Loeblich in its larger size, coarser wall, and less closely appressed chambers in the planispire.

According to Gradstein et al. (1988, fig.2) ranges from the top of the Middle Eocene into the Early Oligocene.

Ammodiscus planus Loeblich.

Pl.11, fig.7.

Ammodiscus planus Loeblich 1946, p.133, pl.22, fig.2; Gradstein et al. 1988, fig.2; Kaminski et al. 1988, p.185, pl.3, fig.13.

Notes.

Very thin walled, fine grained. Often compressed.

Remarks.

Rare. May simply be a juvenile form of A. cretaceus, but it has been separated from that species in this thesis partly on a morphological basis, and partly because it is a biostratigraphically useful form.

According to Gradstein *et al.* (1988) the stratigraphical range of this species is from the Middle Early to Middle Late Palaeocene in the Central North Sea area.

SUBFAMILY: TOLYPAMMININAE Cushman, 1928.

GENUS: *Ammolagena* Eimer and Fickert, 1889.

i. *A. clavata* (Jones and Parker). Initial globular chamber, smooth walled, with the later part being less globular and often coiled. Adheres to other foraminifera.

Ammolagena clavata (Jones and Parker).

Pl.11, fig.8a-b.

Trochammina irregularis (d'Orbigny) var. *clavata* Jones and Parker 1860, p.304. *Ammolagena clavata* (Jones & Parker) Miller *et al.* 1982, p.20, pl.1, fig.9; Kaminski *et al.* 1988, p.185, pl.3 fig.24; Loeblich and Tappan 1988, p.49, pl.36, fig.16.

Remarks.

Test partly attached to agglutinated benthic foraminifera. Rare in thesis material from the North Sea. Jones' (1988, p.148) *Tolypammina* sp. is very similar and occurs in the lower part of his upper slope (200-500m palaeowater depth), to middle slope (500-1000m). It occurred more commonly in the latter. Jones' species was found attached primarily to quartz grains, and rarely possesed a globular proloculus. However, the example he illustrates (pl.1, fig.7) appears to have a broken initial part which was probably originally inflated.

The FDO (first downhole occurence) of this species is in Berggren's P.6b (Early Eocene, Ypresian) Zone according to Kaminski *et al.* (1988, fig.3).

SUBFAMILY: AMMOVERTELLININAE Saidova, 1981.

GENUS: Glomospira Rzehak, 1885.

i. G. gordialis (Jones and Parker). Smooth walled, slightly irregularly coiled, but mostly streptospiral species.

ii. G. irregularis (Grzybowski). Often smooth walled test, but may also be coarse. More irregularly coiled than i, with very little stretospirallity.

Glomospira gordialis (Jones and Parker).

Pl.12, fig.1.

Trochammina squamata Jones and Parker var. gordialis Jones and Parker 1860, p.304.

Glomospira gordialis (Jones and Parker). Miller et al. 1982, p.19, pl.1, figs.14-15; Hart 1988, p.122, pl.2, figs.3-4; Kaminski et al. 1988, p.185, pl.3, fig.17; Loeblich and Tappan 1988, pp.50-51, pl.38, figs.5-6.

Notes.

Similar to Repmanina charoides (Jones and Parker), but more irregularly coiled.

Remarks.

Occurs with R. charoides, and may simply be a variant of the latter. Ksiazkiewicz (1975) pointed out that G. gordialis has been recorded from neritic and bathyal depths from the Mediteranean Sea, from depths of 18-410m from the Gulf of California, and from the Gulf of Mexico from depths of 320-1000m. This species most commonly occurs in bathyal and abyssal depths.

Occurs in Late Palaeocene (Selandian, P.4 of Berggren, 1969) to Early Eocene (Ypresian, P.7 of Berggren, 1969) sediments from Trinidad (see Kaminski et al., 1988). Hart (1988) records this species from Early Miocene sediments from D.S.D.P. site 603 (N.W. Atlantic Ocean).

Glomospira irregularis (Grzybowski)

Pl.12, fig.2.

Ammodiscus irregularis Grzybowski 1898, p.285, pl.11, fig.2-3.

Glomospira irregularis (Grzybowski). Geroch 1960, p.126, pl.4, fig.9-10; Gradstein and Berggren 1981, p.246, pl.3, figs.1-4; Miller *et al.* 1982, p.19, pl.1, fig.12; Kaminski *et al.* 1988, p.185, pl.3, figs.20-21.

Notes.

Test irregularly coiled, and often flattened.

Remarks.

Varieties exist morphologically between this "species" and *Glomospira gordialis.* A very variable 'group', in which the morphocharacters have to be used (taxonomically) quite arbitarily (because nothing is known of the biology) in the hope that records will be useful stratigraphically or palaeoecologically.

In Kaminski *et al.*'s (1988) material this species LAD (last appearance datum) is in the Late Palaeocene (P.4 of Berggren, 1969).

GENUS: *Glomospirella* Plummer, 1945.

i. *G.* cf. *diffundens* (Cushman and Renz). Initial part a small streptospire, followed by a very distinctive planispire. Superficially similar to *A. planus* Loeblich in overall appearance except for streptospire.

Glomospirella cf. *diffundens* (Cushman and Renz).

Pl.12, fig.3a-b.

see *Glomospira gordialis* (Jones and Parker) var. *diffundens* Cushman and Renz 1946, p.15, pl.1, fig.30; Geroch 1960, pp.46-47, pl.4 fig.1, pl.10, fig.2.

see *Glomospira diffundens* (Cushman and Renz). Geroch and Nowak 1984, pl.1, fig.10; Kaminski *et al.* 1988, p.185, pl.3, figs.18-19.

Notes.

Robust test, and chamber is broad.

Remarks.

Differs from the genus *Glomospira*, and the species *G. diffundens* s.str., in having a more distinctive planispiral later stage.

"*Glomospira*" *diffundens* of Kaminski *et al.* (1988) ranges from the Upper Cretaceous (Maastrichtian) to the Upper Palaeocene (Selandian, top of P.4, Berggren 1969).

SUBFAMILY: USBEKISTANIINAE Vyalov, 1968.

GENUS: *Repmanina* Suleymanov, 1966.

i. *R. charoides* (Jones and Parker). Fine walled test. Initial proloculus followed by a tubular chamber trochospirally coiled. More regularly coiled than *Glomospira gordialis* (Jones and Parker) and *G. irregularis* (Grzybowski).

Repmanina charoides (Jones and Parker).

Pl.12, fig.4a-b.

Trochammina squamata Jones and Parker var. *charoides* Jones and Parker 1860, p.304.

Ammodiscus charoides (Jones and Parker). Grzybowski 1896, pp.280-281, pl.8, figs.39-43.

Glomospira charoides (Jones and Parker) var. *corona* Cushman and Jarvis 1928, p.89, pl.12, figs.9-11.

Glomospira charoides (Jones and Parker). Geroch 1960, pl.4, figs.3-4; Bartenstein *et al.* 1962, pp.387-388, pl.59, figs.11-12; Bieda 1969, pl.XCV, fig.1; Grun 1969, pl.LXVI, figs.1-4; Gradstein and Berggren 1981, pp.243-246, pl.3,, figs.5-7; Miller *et al.* 1982, p.19, pl.19, figs.10-11; Kaminski *et al.* 1988, p.185, pl.3, figs.14-15.

Glomospira corona (Cushman and Jarvis). Krashenninikov 1974, pl.7, fig.5.

Repmanina charoides (Jones and Parker). Loeblich and Tappan 1988, p.52, pl.39, figs.24-26.

Notes.

Test spherical in shape and (according to Gradstein and Berggren, 1981, p.246) "resembles the sporangia of Chara" (the female spore sacks of lime secreting algae). Some specimens may have a small "crown" on the test.

Remarks.

I agree with Kaminski et al.'s (1988) view, that the differences between charoides and corona reflect ontogeny. Repmanina (like R. charoides differs from Usbekistania Suleymanov 1960 (a possible alternative name to Repmanina, see Loeblich and Tappan 1988, p.52, pl.39, figs.17-20, 27-29) in being without final planispiral whorls, and in the wall being made up of calcareous material, that is, not of quartz particles in an insoluble cement. Differs from Glomospira in its more regular trochospiral chamber arrangement. Glomospira coils irregularly, or in a streptospiral manner. Ksiazkiewicz (1975) points out that although this species has been reported mostly from depths greater than 200m, it has also been noted from the inner neritic zone.

This species was originally described from Recent sediment in the eastern Mediteranean. Gradstein and Berggren (1981) noted that this form was common to abundant in Maastrichtian to Palaeocene sediments from the Labrador Sea area, and in Palaeocene shales from the North Sea area. It was less common in Early or Middle Eocene sediments.

SUPERFAMILY: RZEHAKINACEA Cushman, 1933.

FAMILY: RZEHAKINIDAE Cushman, 1933.

GENUS: Rzehakina Cushman, 1927.

i. R. minima (Cushman and Renz). Smaller, narrower test with narrower chambers visible in side view than ii. Peripheral margin is also more angular than ii, often with a keel.

ii. R. epigona (Rzehak). Test larger and broader than i, with a more rounded periphery.

Rzehakina minima (Cushamn and Renz).

Rzehakina epigona (Rzehak) var. minima Cushman and Renz, 1946, p.24, pl.3, fig.5.

Rzehakina minima (Cushamn and Renz). Hanzlíková 1972, p.39, pl.4, fig.11; Gradstein et al. 1988, pp.100-101, fig.2; Jones 1988, p.148, pl.2, fig.2; Kaminski et al. 1988, p.186, pl.7, figs.8-9.

Notes.

Evolute, laterally compressed test with many whorls.

Remarks.

Common only in well 25/10-1, Viking Graben. Differs from Rzehakina epigona (Rzehak) mainly in being more evolute. Similar to R. epigona var. fissistomata of Hanzlíková (1972).

According to Gradstein et al. (1988) this species ranges from the Early Palaeocene to the very base of the Early Eocene. It occurs most commonly in their Trochammina ruthven murrayi-Reticulophragmium paupera Zone, Selandian, Late Palaeocene, Zones P.3-P.4 of Blow (1979).

Rzehakina epigona (Rzehak).

Pl.12, fig.5.

Silicina epigona Rzehak 1895, p.214, pl.6, fig.1.

Rzehakina epigona (Rzehak), Jednorowska 1975, pp.47-48, pl.3, figs.8-9; Kaminski et al. 1988, p.186, pl.7, figs.6a-7.

Rzehakina epigona epigona (Rzehak), Geroch and Nowak 1984, pl.3, fig.12.

Remarks.

This species was only rarely noted in this study. Kaminski *et al.* (1988) noted it in the Late Cretaceous (Campanian) through Late Palaeocene (P6a of Berggren, 1969) in flysch-type assemblages, Trinidad.

GENUS: *Spirosigmoilinella* Matsunaga, 1955.

i. *S. compressa* Matsunaga. Fewer chambers visible in side view than *R. minima* (Cushman and Renz). Chambers relatively inflated, and test less compressed. Sutures may be depressed.

Spirosigmoilinella compressa Matsunaga.

Pl.12, fig.6a-b.

Spirosigmoilinella compressa Matsunaga 1955, p.49, figs.1-2; Miller *et al.* 1982, p.20, pl.2, fig.5; Loeblich and Tappan 1988, p.55, pl.40, figs.10-11.

Sigmoilina tenuis (NON *Quinqueloculina tenuis* Czjek 1848), *sensu* Rasmussen 1974, p.13.

'*Rzehakina*' sp.1 Gradstein and Berggren 1981, p.250, pl.5, figs.3-4.

Silicosigmoilina sp. Hughes 1981, pl.15.1, figs.3-4; King 1983, p.21, pl.1, fig.23.

Spirosigmoilinella sp. Verdenius and van Hinte 1983, p.192, pl.4, figs.10-17.

Notes.

Wall fine to very fine grained. Sutures often indistinct.

Remarks.

Occurs in high numbers in Central North Sea wells covered by this thesis. Caves very easily. *Spirosigmoilinella* differs from *Silicosigmoilina* in having a less distinctive sigmoidal coiling mode, in having a rounded aperture produced on a short neck without an apertural tooth, and in not having an ovoid outline (see Loeblich and Tappan, 1988, pp.54-55).

The stratigraphical range of this species in the North Sea Tertiary is from the Late Eocene, uppermost NSB6b to Early Miocene NSB9 of King (1983). He uses this species as a marker for the top Oligocene-Early Miocene. This species was described from the Lower Middle Miocene of Japan. Gradstein et al. (1988, p.105), however, regard this species as a constituent of their Rotaliatina bulimoides (Reuss) Zone, Rupelian, Early Oligocene (Blow's 1979 Zones P.18-P.19).

SUPERFAMILY: HORMOSINACEA Haeckel, 1894.

FAMILY: ASCHEMOCELLIDAE Vyalov, 1966.

GENUS: Kalamopsis de Folin, 1883.

i. K. grzybowski (Dylążanka). Very smooth walled species. Elongate proloculus with straight later sections that may have constrictions. Test often compressed.

Kalamopsis grzybowskii (Dylążanka).

Pl.12, fig.7a-b, Pl.13, fig.1.

Hyperammina grzybowskii Dylążanka 1923, p.65, pl.7, fig.5; Geroch 1960, p.39, pl.1, figs.22-23.

Kalamopsis grzybowskii (Dylążanka). Hanzlíková 1972, p.36, pl.2, fig.8; Geroch and Nowak 1984, pl.1, fig.2-3, pl.5, fig.2-3; Kaminski et al. 1988, p.187, pl.1, figs.18-20.

Notes.

Occurs as single chambered flattened sections. May have bulbous initial part. Thin walled.

Remarks.

Common. Usually occurs within the Rhabdammina biofacies.

This species was originally described from the "Upper Cretaceous, Senonian or Danian, Inoceramus beds" in Szymbark, Poland. Kaminski et al. (1988, fig.3) notes that it also occurs in Eocene sediments fron Trinidad.

FAMILY: HORMOSINIDAE Haeckel,1894.

SUBFAMILY: REOPHACINAE Cushman, 1910.

GENUS: Reophax de Montfort, 1808.

i. Reophax sp.1. Flattened 'disc-like' chambers in an arcuate series.

ii R. subfusiformis Earland. Large fusiform final chamber, often very coarse walled.

Reophax sp.1.

Notes.

Coarse wall. Overlapping chambers.

Remarks.

Similar to Reophax sp.1 of Gradstein and Berggren (1981, p.248, pl.3, figs.8-9), but chambers generally do not overlap so much in the North Sea forms. Reophax sp.1 sensu Gradstein and Berggren (1981) was not recorded by the latter authors from the North Sea area, but from Maastrichtian shales from the Labrador Shelf region.

Reophax sp.1 from the North Sea area was recorded from as high as the Oligocene in this study.

Reophax subfusiformis Earland, emend. Höglund.

Reophax subfusiformis Earland 1933, p.74, pl.2, figs.16-19.

Reophax subfusiformis Earland, emend. Höglund 1947, pp.77, 82, pl.9, figs.1-4, pl.26, figs.1-36, pl.27, figs.1-19, Text-figs.43-50; Gradstein and Berggren 1981, p.248, pl.2, figs.8-9; Kaminski et al. 1988, p.187, pl.2, figs.18-19.

Notes.

Rough wall.

Remarks.

Rare in wells studied. North Sea examples observed in this study very similàr to Earland's illustration (1933) fig.19 of pl.2. Gradstein and Berggren's (1981) examples appear to be compressed, and differ from the type specimens illustrated by Earland (1933), in having a coarse wall with very little cement (as was often the case in those specimens observed in this study), similar to those shown by Höglund (1947, pl.9, fig.1-2) which he referred to as "central variant" (fig.1) and "extreme variant no.1" (fig.2).

Höglund (1947) recorded this species from the Recent. Examples observed in this study from the Oligocene. Kaminski et al. (1988) records this species in Upper Cretaceous to Early Eocene (P.7 of Berggren, 1969), Ypresian sediments from Trinidad.

GENUS: Nodellum Rhumbler, 1913.

i. N. velascoense (Cushman). Smooth walled, with granular chambers that compress easily. Sutures very depressed.

Nodellum velascoense (Cushman).

Nodosinella velasoensis Cushman 1926, p.583, pl.20, figs.9a-b.

Nodellum velascoense (Cushman), Geroch 1960, p.44, pl.3, figs.4-7; Kaminski et al. 1988, p.187, pl.1, figs.21-22.

Remarks.

This large, finely agglutinated species was noted by Cushman (1926) as "chitinous". However, according to Kaminski et al. (1988) the nature of the test wall needs to be resolved. Kaminski et al. (ibid.) noted this species in the Late Cretaceous (Maastrichtian) through Early Eocene (Ypresian, P8 of Berggren, 1969).

SUBFAMILY: HORMOSININAE Haeckel, 1894.

GENUS: Hormosina Brady, 1879.

Differs from Reophax de Montfort in it's more rectilinear test, and distinctly overlapping globular chambers.

i. H. duplex (Grzybowski). Compressed test. Fewer chambers than ii, and more than iii.

ii. H. pilulifera (Brady). Flattened, rounded chambers, gradually enlarging as added, coarse walled, with sutures that are horizontal and depressed. Differs from Reophax sp.1 in not being in an arcuate series, and in having a neck.

iii. H. ovulum (Grzybowski). A single globular chamber, wall smooth to coarse with a smooth finish. Test never compressed, but always found inflated.

Hormosina duplex (Grzybowski).

Reophax duplex Grzybowski 1896, pp.276-277, pl.8, figs.23-24; Liska and Liskowa 1981, p.167, pl.1, fig.12; Gradstein and Berggren 1981, p.248, pl.2, fig.7; Kaminski et al. 1988, p.187, pl.2, fig.15.

Notes.

Coarse walled. Test of two flat overlaping chambers of unequal size.

Remarks.

This genus has been reported by Loeblich and Tappan (1988, p.61) from depths of 3,750m to 5,800m in the N. Pacific, from 1,776m to 3,758m in the tropical Pacific, and from 2,700m to 3,229m in the N. Atlantic.

This species was first described from the Lower Oligocene of Poland. Gradstein and Berggren (1981, table 6) record this species from the Maastrichtian to Palaeogene of the Labrador and Newfoundland Shelves, and from the Palaeogene of the Central North Sea area. This species has also been recorded in Campanian to Early Eocene sediments by Kaminski et al. (1988, fig.3) from Trinidad.

Hormosina pilulifera (Brady).

Pl.13, fig.2.

Reophax pilulifera Brady 1884, p.292, pl.30, figs.18-20; Gradstein and Berggren 1981, p.248, pl.2, figs.8-9.

Notes.

Test composed of few chambers (3 to 5). Chambers spherical. Walls coarse, but often smoothly finished. Aperture terminal, centrally placed.

Remarks.

Examples from the North Sea very similar to Gradstein and Berggren's (1981) photograph on his pl.2, fig.10. Rare in wells studied for this thesis.

Described originally by Brady (1884) from the Recent. Gradstein and Berggren (1981, table 6) noted this species from the Maastrichtian to Palaeogene of the Labrador and Newfoundland Shelves. They did not record it from their North Sea wells. Noted in the Central North Sea, Central Graben, in wells in this study, from Oligocene beds.

Hormosina ovulum (Grzybowski).

Pl.13, fig.3.

Reophax ovulum Grzybowski 1896, p.276, pl.8, figs.8-9.

Hormosina ovulum (Grzybowski), Geroch 1960, p.43, pl.2, figs.20-22, pl.10, figs.8-9; Jurkiewicz 1967, pp.52-53, pl.1, fig.28.

Pelosina caudata (Montanaro-Galltelli), Hanzlikóva 1972, p.34, pl.1, figs.2-6 (with synonyms).

Carpathiella ovulum (Grzybowski), Mjatliuk 1966, pp.262-263, pl.1, figs.2-4b, pl.2, figs.1-3, pl.3, fig.2; Mjatliuk 1970, p.52, pl.8, fig.12, pl.9, figs.8-13.
Carpathiella ovulum ovulum (Grzybowski), Szczechura and Pozaryska 1974, pp.27-28, pl.3, fig.19.
Hormosina ovulum ovulum (Grzybowski), Geroch and Nowak 1984, pl.1, figs.19, 21; Kaminski et al. 1988, p.186, pl.2, fig.10.

Notes.

Thick wall.

Remarks.

Kaminski et al. (1988) noted this species in the Early Palaeocene (Danian) through Early Eocene (Ypresian, P6b of Berggren, 1969).

SUPERFAMILY: LITUOLACEA de Blainville, 1827.

FAMILY: HAPLOPHRAGMOIDIDAE Maync, 1952.

GENUS: Cribrostomoides Cushman, 1910.

i. "C." subglobosus (G. Sars). Very wide form when viewed from the apertural face. Coarse walled with a smooth finish. Sutures flush to slightly depressed.

"Cribrostomoides" subglobosus (G. Sars).

Pl.13, fig.4a-b.

Lituola subglobosa G Sars 1872 (1871).
Alveophragmium subglobosum (G Sars), Barker 1960, Tax. Notes to H.M. Brady 1884, pl.34, figs.7-8, 10.
"Cribrostomoides" subglobosus (G Sars), Gradstein and Berggren 1981, p.252, Pl.6, figs.10-11.

Remarks.

Gradstein and Berggren (1981) placed Haplophragmoides suborbicularus (Grzybowski) into the synonymy of 'C'. subglobosus (G. Sars).

Kaminski et al. (1988) however regard the former species as a seperate form. All the North Sea examples of 'C'. subglobosus did not show any apertural features (due to fossilisation?) other than an indistinct basal slit on some specimens although the shape and arrangement of chambers matches that given for this species. Gradstein and Berggren (1981) noted this species as common in their Maastrichtian through Eocene material.

GENUS: Haplophragmoides Cushman, 1910.

i. H. kirki Wickenden. More inflated and rounded chambers than ii, often coarse walled, with fewer chambers in the final whorl than ii and more lobulate periphery.

ii. H. walteri (Grzybowski). Chambers often compressed, smooth walled. Subrounded periphery with less depressed sutures than i, and more chambers in the final whorl.

iii. Haplophragmoides sp.1. Deeper umbilicus on one side, slighty convex opposite side.

Haplophragmoides kirki Wickenden.

Pl.13, fig.5a-c.

Haplophragmoides kirki Wickenden 1932, p.85, pl.1, fig.1; Gradstein et al. 1988, pp.100-101, fig.2.

Haplophragmoides suborbicularis var. bulloidiformis Jurkiewicz 1967, p.76, pl.4, fig.9.

Notes.

Fine to medium grained wall. 4 chambers in the final whorl. Inflated chambers, with very lobulate periphery.

Remarks.

Close to the holotype. Similar to H. porrectus Maslakova sensu

Kaminski et al. (1988, pl.5, figs.7-8), but differs mainly in having coarser wall. On some specimens the slit-like interiomarginal aperture can be seen even though it is not clearly visible in the SEM.

According to Gradstein et al. (1988, pp.100-101, fig.2) this species ranges from Late Palaeocene to the base of the Middle Eocene.

Haplophragmoides walteri (Grzybowski).

Pl.13, fig.6.

Trochammina walteri Grzybowski 1898, p.290, pl.11, fig.31.

Asanospira walteri (Grzybowski). Mjatliuk 1970, pp.78-79, pl.19, figs.5a-7, pl.20, figs.1a-2b.

Haplophragmoides walteri (Grzybowski). Geroch 1960, pp.49-50, pl.5, fig.5; Gradstein and Berggren 1981, pp.250-252, pl.6, Figs.5-7: Miller et al. 1982, p.20, pl.2, fig.7; Verdenius and van Hinte 1983, pp.192-193, pl.5, figs.1-2; Gradstein et al. 1988, pp.100-101, fig.2; Hart 1988, p.122, pl.3, figs.1-2; Jones 1988, p.148, pl.2, fig.6; Kaminski et al. 1988, p.190, pl.5, figs.14-15.

Notes.

Compressed planispiral test. 8 or more chambers in the last whorl. Has circular outline. Finely agglutinated wall.

Remarks.

Common in the Palaeogene of the North Sea area.

According to Gradstein et al. (1988, fig.2) this species dies out in the Middle to Late Eocene. However, I have noted this species from Oligocene sediments from the North Sea. Hart (1988) records H. walteri from Miocene material from D.S.D.P. site 603 (N.W. Atlantic Ocean).

Haplophragmoides sp.

Pl.14, fig.1.

Notes.

Coarse walled, planispirally coiled. Chamber shape and numbers indistinct.

Remarks.

Similar to Haplophragmoides sp.1 of Williams 1971, pl.13 Fig.5a-c. His specimens were, like those observed from the London Clay, very easily broken and distorted.

GENUS: Labrospira Hoglund, 1947.

Labrospira has a more evolute coil than Cribrostomoides Cushman, more flattened sides, a more coarsely agglutinated wall, and a single areal aperture, rather than a row of pores. According to Jones and Charnock (in preparation) Cribrostomoides is in fact streptospiral.

i. L. scitula (Brady). Similar in gross morphology to "C." subglobosus (G. Sars) but without the wide apertural face of the latter. Also often smoother walled, with depressed umbilicus on both sides. Sutures depressed, glassy.

Labrospira scitula (Brady).

Pl.14, fig.2a-b.

Haplophragmium scitulum Brady 1881, p.50.

Cribrostomoides scitulus (Brady). Gradstein and Berggren 1981, p.252, pl.6, figs.8-9.

?Budashevaella sp. aff. B. multicamerata (Budasheva). Vedenius and van Hinte 1983, p.195, pl.7, figs.3-4,8-10.

Notes.

Large. Fig.2, plate 14 shows a coarse walled form. Aperture, a single areal? slit.

Remarks.

Common in the Palaeogene of the North Sea area. Well preserved. Ksiazkiewicz (1975) noted that "Haplophragmoides scitulus (Brady)" has been reported fom below 250m water depths in the Mediteranean Sea. L. scitula from the North Sea is very similar to Budashevaella sp. aff. multicamerata of Verdenius and van Hinte (1983). However, Kaminski et al. (1988, p.188, pl.5, fig.1, pl.10, fig.1) notes that his examples of B. cf. multicamerata have a streptospiral initial portion with an evolute planispiral latter portion. The latter authors place Verdenius and van Hinte's B. sp. aff. multicamerata into synonymy with their B. cf. multicamerata.

Labrospira scitula (Brady) was originally described from the Recent. Gradstein and Berggren (1981) records this species in Maastrichtian to Eocene sediments from the Labrador and Newfoundland Shelves, and Central North Sea area, and from the Campanian/Maastrichtian of West Greenland.

FAMILY: LITUOTUBIDAE Loeblich and Tappan, 1984.

GENUS: Lituotuba Rhumbler, 1895.

i. L. lituiformis (Brady). Coarse-medium walled test, tightly coiled with the tubular chamber standing upright from the initial part.

Lituotuba lituiformis (Brady).

Pl.14, fig.3.

Trochammina lituiformis Brady 1879, p.59, pl.5, fig.16.

Lituotuba lituiformis (Brady). Kaminski et al. 1988, p.190, pl.4, figs.14-15; Loeblich and Tappan 1988, p.69, pl.53, fig.3.

Notes.

Early part of the test generally irregular becoming distinctly planispiral. Wall surface often rough.

Remarks.

North Sea specimens of L. lituiformis are generally larger, and more irregular than the type species.

Ranges higher than the Early Eocene (P.8 of Berggren, 1969) in Kaminski et al.'s (1988) material.

GENUS: Paratrochamminoides Soliman, 1972.

i. P. subcoronatus (Grzybowski). Distinctly depressed disc-shaped chambers in a regular coil. Often very smooth walled.

Paratrochamminoides subcoronatus (Grzybowski).

Trochammina subcoronata Grzybowski 1896, pp.283-284, pl.9, fig.3a-c; Grzybowski 1898, p.287, pl.11, fig.11.

Trochammina contorta Grzybowski 1898, p.287, pl.11, figs.12-14.

Trochamminoides subcoronatus (Grzybowski). Kaminski et al. 1988, p.192, pl.4, fig.19.

Notes.

Test finely agglutinated with rough surface. Large globular chambers arranged in an evolute planispire, often distorted and compressed.

Remarks.

I agree with Kaminski et al. (1988) in regarding "Trochammina" contorta Grzybowski 1898 as a junior synonym of "Trochammina" subcoronatus Grzybowski 1896. "Trochammina" coronata Brady 1879 is a very similar form, but Brady's type drawing (1879, p.58, pl.5, fig.5) shows an undistorted species which is far less compressed than the examples of P. subcoronatus observed in this study. It is possible that these species are the same, but until the types of both have been re-examined it is not possible for me to say so. The early stage of most examples of this species from the North Sea was obscured because of distortion of the test, but appeared to be streptospiral rather than the initial part having an irregular coil as in Trochamminoides Cushman 1910. Trochamminoides differs from Paratrochamminoides in often having an aperture which has a distinct lip. No such feature was observed in the North Sea forms, although this structure may not have been preserved.

"Trochammina" subcoronata Grzybowski 1898 was originally described from the Lower Oligocene of Poland. It was also observed by Grzybowski (1898) in the Upper Eocene or Lower Oligocene of "Nikoltschitz, Moravia". The junior synonym of the latter species,"Trochammina" contorta Grzybowski, was described from Eocene beds of the Outer(Flysch) Carpathians. Trochamminoides (sic.) subcoronatus was noted from Cretaceous to Eocene (Ypresian) sediments from Trinidad by Kaminski et al. (1988, fig.3). Examples were observed from the Oligocene of the Central North Sea basin, Central Graben, in wells used for this thesis.

FAMILY: LITUOLIDAE de Blainville, 1827.

SUBFAMILY: AMMOMARGINULININAE Podobina, 1978.

GENUS: Ammobaculites Cushman, 1910.

i. A. cf. jarvisi Cushman and Renz. Coarse walled test with globular chambers in the uniserial part, that are broader than high.

Ammobaculites cf. jarvisi Cushman and Renz.

Pl.14, fig.4a-c.

see Ammobaculites jarvisi Cushman and Renz 1946, p.46, pl.19, fig.6; Kaminski et al. 1988, p.188, pl.4, fig.4.

Notes.

Large, with 3 to 4 chambers in the planispiral part.

Remarks.

Uniserial part often absent. Only found in the London Clay formation. Differs from A. jarvisi s.str. in having more deeply depressed sutures in the planispiral section.

Kaminski et al. (1988, fig.3) records A. jarvisi from the Maastrichtian to the Selandian (P.4 of Berggren, 1969) in Trinidad.

GENUS: Ammomarginulina Wiesner, 1931.

i. A. macrospira Bykova. Coarse walled and often with a smooth finish. Sutures slightly depressed. Peripheral margin rounded and has a characteristically 'serated' appearance. Sutures dark.

Ammomarginulina macrospira Bykova.

Pl.14, fig.5.

Ammomarginulina macrospira Bykova 1953, p.231, pl.2, fig.7.

Ammobaculites aff. polythalmus Loeblich, sensu Gradstein and Berggren 1981, p.253, pl.4, figs.6-8; sensu Miller et al. 1982, range chart; sensu Gradstein et al. 1988, fig.2, p.104.

Ammomarginulina aubertae Gradstein and Kaminski 1989, pp.74, 77-79, pl.3, figs.1-8, pl.4, figs.1-3; text-figure 2.

Notes.

Planispiral part rounded in outline, discoidal. Some specimens more evolute than others. At the centre of the planispire the coil of the preceeding chambers is visible. Uniserial part elongate when present. Distinctly uneven periphery. Sutures uneven, slightly depressed, but can be easily seen when the test is moistened with oil or water.

Remarks.

Common only in Well 25/10-1, Viking Graben, Northern North Sea. This species was placed into Ammobaculites aff. polythalmus Loeblich 1946 by Gradstein and Berggren (1981). However, their form does not belong to the genus Ammobaculites as the latter has a terminal, centrally placed aperture. The species name macrospira more accurately describes Gradstein and Berggren's (1981) examples.

Bykova (1953) and Charnock and Jones (in preparation) point out that some specimens of this species have incipient alveolar wall structure. Bykova (1953) therefore suggested that if the wall of A. macrospira was shown to be truly alveolar, it should be placed into the genus Pseudocyclammina Yabe and Hanzawa. However, Pseudocyclammina differs from Ammomarginulina (like A. macrospira) in having a cribrate aperture. A possible alternative name, if A. macrospira has a truly alveolar wall, is Phenacophragma Applin, Loeblich and Tappan. Examples of A. macrospira from the North Sea are similar in many ways to Phenacophragma beckmanni Kaminski and Geroch (see Kaminski et al., 1988, p.190, pl.4, fig.8-9), but differs in having more chambers in the final whorl, a more strongly compressed, carinate test, and less distinct ?alveolae. More work needs to be done on the wall structure of A. macrospira, but this unfortunately is outside of the scope of this project. A. aubertae Gradstein and Kaminski (1989) differs from A. macrospira Bykova (1953) only in the number of chambers in the spiral part, and is considered by the present writer to be a junior synonym.

This species was originally described from the Lower Eocene of Soviet Central Asia. Gradstein et al. (1988, fig.2) record A. macrospira from the latest Cretaceous to the earliest Middle Eocene from the Central North Sea. A constituent member of the latter authors Subbotina patagonica Zone

(Zones P.6b–P.8 of Blow, 1979), Ypresian, Early Eocene. Miller et al. (1982) records this species in the Late Palaeocene to Middle Eocene in sediments from the Central North Sea area, and in the Maastrichtian to Middle Eocene sediments from the Labrador Shelf region.

GENUS: Eratidus Saidova, 1975.

i. E. foliaceus (Brady). Thin, compressed, small test. Smaller than Ammomarginulina macrospira Bykova, with a more even peripheral margin. Straight uniserial part. Rounded peripheral margin with slightly depressed umbilical region on both sides.

Eratidus foliaceus (Brady).

Pl.14, fig.6a–b.

Haplophragmium foliaceum Brady 1881, p.50 [no type figure given]; Brady 1884, p.304–5, pl.33, figs.20–25.

Eratidus foliaceus (Brady). Saidova 1975, p.94, pl.26, fig.4; Loeblich and Tappan 1988, p.75, pl.59, fig.1–3.

Notes.

Numerous broad chambers with slightly depressed sutures.

Remarks.

Never abundant in samples from the North Sea. Smaller in size than that described by Saidova (1975). I agree with Charnock and Jones (in preparation) in regarding Ammobaculites expansus Plummer (1933, p.65, pl.5, figs.4–6) as a possible junior synonym. The latter species was described from the Eocene of Midway, Texas, U.S.A., but it may be thicker walled. It also appears to be coarser in wall texture. This, however, has not been verified by examining the types. Such action is outside the scope of this project. E. foliaceus is similar to Ammobaculites strathaernensis Cushman and LeRoy 1938 (p.122, pl.22, figs.1-2, see also Verdenius and van Hinte, 1983, pl.6, figs.13-14), but the latter differs in having an "involute early coiled portion with fewer chambers, smaller uncoiled portion with fewer chambers" (Cushman and LeRoy, 1938, p.122). In the specimens of *E. foliaceus* in the North Sea the aperture appears to be a long elongate slit, so the genus *Eratidus* is accepted. The coiled portion of the test appears to be wholly evolute in the type species and although preservation is poor, in the North Sea specimens.

Described originally by Brady (1881) from the Recent. Occurs in Oligocene material from wells examined in this thesis. Figured specimens from 29/10-1, Central North Sea area, Central Graben.

SUPERFAMILY: HAPLOPHRAGMIACEA Eimer and Fickert, 1899.

FAMILY: AMMOSPHAEROIDINIDAE Cushman, 1927.

SUBFAMILY: AMMOSPHAEROIDININAE Cushman, 1927.

GENUS: *Adercotryma* Loeblich and Tappan, 1952.

i. *A. agterbergi* Gradstein & Kaminski. Flat spiral side with chambers in the early whorl visible, very convex umbilical side. Distinct, slightly curved and incised sutures. Wall coarse to fine. Sharply angular periphery.

Adercotryma agterbergi Gradstein and Kaminski.

Pl.14, fig.7a-c.

Adercotryma agterbergi Gradstein and Kaminski 1989, p.73, Pl.1, figs.1a-5c, Pl.2, figs.1a-3b, text-fig.1.

Remarks.

The FDO of this species is a useful marker for the Early Oligocene in this study, Zone AB10. Gradstein and Kaminski (1989) note that the type level for this species is in the Late Eocene to Early Oligocene (*Reticulophragmium amplectens* Zone to *Rotaliatina bulimoides*-*Dorothia seiglae* Zone of Gradstein et al., 1988). Gradstein and Kaminski (op. cit.) noted this as a bathyal species.

GENUS: Cystammina Neumayr, 1889.

i. C. pauciloculata (Brady). Smooth wall. Final chamber larger, and more inflated than earlier ones. Rounded later part, pointed initial end. Differs from Praecystammina globigerinaeformis (Krasheninikov) in having an aperture without a rim.

Cystammina pauciloculata (Brady).

Pl.14, fig.8a-b.

Trochammina pauciloculuta Brady 1879, p.58, pl.5, figs.13-14.

Cystammina pauciloculata (Brady). Loeblich and Tappan 1988, p.82, pl.68, figs.1-6.

?Cystammina aff. globigerinaeformis (Krashenininkov) sensu Gradstein et al. 1988, pp.100-101, fig.2 (NON Praecystammina globigerinaeformis Krasheninikov, 1973).

Notes.

Ovoid test. Aperture an extremely narrow slit. Finely agglutinated test. Sutures only slightly depressed.

Remarks.

Only poorly preserved examples noted from 29/10-1, Central North Sea area. They were always green in colour, probably due to the presence of glauconite. The slit-like aperture typical of this species was rarely observed. For comments concerning Gradstein et al.'s (1988) Cystammina aff. globigerinaeformis see remarks for P. globigerinaeformis below.

Specimens noted from the Palaeocene to Early Eocene of the Central North Sea in this study. Recorded originally from the Recent by Brady (1879).

Loeblich and Tappan (1988, p.82) point out that the genus Cystammina Neumayr ranges from the Eocene to the Holocene.

GENUS: Praecystammina Krasheninikov, 1973.

i. P. globigerinaeformis (Krasheninikov). Differs from Cystammina pauciloculata (Brady) in possessing an aperture with a rim, having more depressed sutures, and a more rounded initial end.

Praecystammina globigerinaeformis (Krasheninikov).

Pl.15, fig.1a-b.

Praecystammina globigerinaeformis Krasheninikov 1973, p.211; Gradstein and Berggren 1981, p.258, pl.9, figs.11-15; Loeblich and Tappan 1988, p.82, pl.67, figs.4-7.

Cystammina globigerinaeformis (Krasheninikov). Miller et al. 1982, pl.2, figs.13, 17, 21.

?Cystammina pauciloculata (Brady) sensu Gradstein et al. 1988, p.100-101, fig.2 (NON Trochammina pauciloculata Brady, 1879).

Notes.

Test with broadly rounded peripheral margin. Last whorl of 3 inflated, oval, hemispherical to reniform chambers. The position of the aperture varies and may occur on either side.

Remarks.

There is some disagreement as to the generic status of this species. Miller et al. (1988) placed it in synonymy with Cystammina. However, according to Krasheninikov (1973), it differs from Praecystammina Krasheninikov in having high, inflated elongate chambers, making it similar in gross morphology to representatives of the calcareous CHILOSTOMELLIDAE. Krasheninikov (op. cit., p.211) also suggests that Ammosphaeroidina, a possible generic alternative, differs from *Praecystammina* in its "globose test with three embracing chambers in the final whorl" and "low arch-like aperture at the base of the last chamber". North Sea Palaeocene to Eocene examples of *P. globigerinaeformis* often have an aperture that differs from that of the type description of the type species, in that it tends to be more slit-like rather than oval, and it is also often near the base of the final chamber (as in figs.1a, 1c, Krasheninikov, 1973).

The form illustrated as *Cystammina pauciloculata* (Brady) by Gradstein *et al.* 1988 (fig.2) actually bears a closer resemblance to *Praecystammina globigerinaeformis* (Krasheninikov). It would seem likely that the names at the top of his fig.2 have been switched around. That is, his *C.* aff. *globigerinaeformis* is meant to be *C. pauciloculata*, and vice-versa.

C. pauciloculata, according to Ksiazkiewicz (1975), frequently occurs below water depths of 250m.

This species was originally described from the Upper Cretaceous, Santonian to Campanian, Hole 198A, D.S.D.P. Leg 20. Occurs in Early Eocene and older sediments from the Central North Sea. Generally tops at a higher level within the Early Eocene than *C. pauciloculata*.

SUBFAMILY: RECURVOIDINAE Alekseychik-Mitskevich, 1973.

GENUS: *Thalmannammina* Pokorný, 1951, emend. Geroch, 1962.

Differs from *Recurvoides* Earland (1934) (according to Loeblich and Tappan, 1988, p.83) in having a rounded basal aperture, instead of an areal one with a distinct lip. Charnock and Jones (in preparation) point out that the aperture is often indistinct in fossil forms due to poor preservation. They therefore recognise the two genera on the basis that *Thalmannammina* has a meandrine type of streptospiral coiling, whereas *Recurvoides* coils in a more regular streptospire.

i. T. walteri (Grzybowski). Coarse walled. Meandering streptospiral coiling. Sutures depressed. Central part of the test inflated, rounded.

Thalmannammina walteri (Grzybowski).

Pl.15, fig.2.

Haplophragmoides walteri Grzybowski 1898, p.280, pl.10, fig.24.

Recurvoides walteri (Grzybowski). Jurkiewicz 1967, p.78, pl.4, fig.14.

Thalmannammina walteri (Grzybowski). Hanzlíková 1972, p.44, pl.7, fig.6.

Recurvoides ex gr. walteri (Grzybowski). Gradstein and Berggren 1981, p.253, pl.8, figs.1-7; Jones 1988, p.148, pl.2, fig.1.

Notes.

Aperture often indistinct, but may be basal. A very variable form in the nature of the shape of the test, and the degree of overlap and number of visible chambers.

Remarks.

A common form in the Rhabdammina biofacies of the North Sea. If Charnock and Jones's (in preparation) view concerning the genera Thalmannammina and Recurvoides is adopted (see comments on genera) this species appears to fit into the former genus. However, this generic distinction in many North Sea Palaeogene forms cannot be seen. It is possible that these genera are in fact synonymous. If this proves to be the case then Recurvoides would be the senior and valid name as suggested by Gradstein and Berggren (1981). Thalmmanammina subturbinata (Grzybowski) is very similar to T. walteri and Charnock and Jones (in preparation) regard these two species as being part of the same plexus. Loeblich and Tappan (1988, p.83) record Thalmmannamina from water depths of 635m to 1,864m, and Recurvoides from 50m to 4,224m.

Loeblich and Tappan (ibid.) also record *Thalmannammina* from Albian (Lower Cretaceous) to Holocene sediments, and *Recurvoides* from the Middle Jurassic and the Upper Oligocene to Holocene. Gradstein and Bergren (1981, table 6) noted "*R.*" *walteri* forms from the Maastrichtian to Palaeogene of the Labrador and Newfoundland Shelves, and from the Palaeogene of the North Sea.

SUPERFAMILY: CYCLOLINACEA Loeblich and Tappan, 1964.

FAMILY: CYCLAMMINIDAE Marie, 1941.

SUBFAMILY: ALVEOPHRAGMIINAE Saidova, 1981.

GENUS: *Reticulophragmium* Maync, 1955.

i. *R. amplectens* (Grzybowski). Central part of test thick, tapering towards the periphery. Compressed peripheral margin with 'diamond-shaped' chambers when viewed from the apertural face.

ii. *Reticulophragmium* sp.1. Similar to i but test often crushed, leaving a thick peripheral band.

iii. *R. placenta* (Reuss). May be coarse or fine walled. Acute to rounded peripheral margin. Depressed sutures.

iv. *R. rotundidorsata* (Hantken). A more inflated form than iii, with a broadly rounded periphery.

v. *R. paupera* (Chapman). Fine walled test, very smoothly finished compared to i-iv. Often compressed. Subacute periphery. Sutures radiate. Depressed umbilicus.

Reticulophragmium amplectens (Grzybowski).

Pl.15, fig.3a-d, Pl.17, fig.2.

Cyclammina amplectens Grzybowski 1898, pl.12, fig.1-2; Gradstein and Berggren 1981, pp.253-254, pl.7, figs.13-17; King 1983, pl.1, figs.20,26;

Verdenius and van Hinte 1983, p.194, pl.5, fig.9, pl.6, figs.4-6.

Reticulophragmium amplectens (Grzybowski). Gradstein et al. 1988, pp.100-101, fig.2.

Notes.

Umbilicus depressed. Greater than 10 narrow chambers in the final whorl. Sutures straight to slightly curved, forward or backwards. Fine to medium grained test.

Remarks.

Cyclammina Brady differs from Reticulophragmium Maync in having an equatorial interiomarginal slit-like aperture with a series of areal pores with raised margins scattered over the apertural face. Reticulophragmium does not posess these areal apertures, but only has a marginal slit, bordered by a lip at its upper margin. R. amplectens was common on the Southern North Sea wells, and present in all Central North Sea wells examined in this study. A thick section of R. amplectens is shown on plate 17 figure 2 which shows the two lobed chamber shape typical of this species.

A useful marker species for the Early to Middle/?Late Eocene. Occurs in an acme zone in King's (1983) NSB4 Zone. This is the nominate taxon for Gradstein et al.'s (1988) R. amplectens Zone Middle (-Late) Eocene. Last occurence of Spiroplectammina spectabilis (Grzybowski) within that Zone.

Reticulophragmium sp.1.

Pl.15, fig.4.

Notes.

Inflated chambers, with rounded periphery. Examples from the North Sea Palaeocene and Eocene are often crushed. Approximately 9 chambers in the final whorl, tending to increase rapidly in height. Large alveoli, mostly of one size.

Remarks.

As pointed out in the description above, many specimens from the North Sea were crushed. Shell Expro. U.K. referred to this form as Cyclammina challinori (Haynes, 1958, p.60, pl.15, fig.8). However, the present writer regards this as incorrect, as the latter species generally has more inflated chambers. It is also difficult to ascertain the nature of the aperture in the North Sea forms due to the aforementioned compression.

C. challinori was described by Haynes (1958) from the Upper Palaeocene, Thanetian, upper part of the Thanet formation from Pegwell Bay. southeastern England. Reticulophragmium sp.1 was noted from the Eocene of the Southern North Sea area, and rarely in the Palaeocene in the Central North Sea in wells examined for this thesis.

Reticulophragmium placenta (Reuss).

Pl.15, fig.5a-e, Pl.16, fig.1a-b, Pl.17, fig.1.

Nonionina placenta Reuss, p.72, pl.5, fig.33.

Cyclammina placenta Mjatliuk 1970, pp.91-92, pl.6, figs.29-33, pl.25, fig.6, pl.26, figs.1-3, pl.27, figs.5-6; Gradstein and Berggren 1981, p.254, pl.7, figs.1-8; Verdenius and van Hinte 1983, pp.193-194, pl.5, fig.8.

Notes.

Wall rough or smooth. Sutures often only weakly depressed, and may be almost straight. Number of chambers in the last whorl varies (according to the size of test) from 8 to 11.

Remarks.

A common species in the Central North Sea Palaeogene. Verdenius and van Hinte (1983) synonymised Cyclammina placenta (Reuss) with

Cyclammina cancellata Brady. C. cancellata, the true Cyclammina posesses true areal apertures with raised margins. The preservation of much of the North Sea material used for this thesis was such that it was difficult to ascertain the nature of the apertures in many forms here referred to Reticulophragmium. However, thick sections cut of R. placenta (see plate 17, figure 1 for an example) showing the characteristic chamber shape for this species, also indicate that it is a Reticulophragmium.

R. placenta (Reuss) was originally described from the Eocene, near Berlin, Germany. Gradstein et al. (1988, fig.2) record this species mostly from Early Eocene to Late Oligocene sediments from the Central North Sea, but it may also occur in smaller numbers in the Miocene.

Reticulophragmium rotundidorsata (Hantken).

Pl.16, fig.2a-c.

Haplophragmium rotundidorsatum Hantken 1875, p.12, pl.1, fig.2.

Cyclammina rotundidorsata (Hantken). Gradstein and Berggren 1981, p.256, pl.7, figs.9-12; Verdenius and van Hinte 1983, p.194, pl.5, figs.11-12; Gradstein et al. 1988, pp.100-101, fig.2.

Notes.

Medium to fine grained wall. 9 or more chambers in the last whorl.

Remarks.

Charnock and Jones (in preparation) point out that the study by Samuel (1977) of comparative material from the type area for Haplophragmium rotundidorsata Hantken, suggested that the latter species was indeed a Haplaphragmium, and not a Cyclamminid. They suggest that these forms should therefore be referred to as Reticulophragmium orbiculare (Brady). I agree with them in that I regard my North Sea forms as belonging to the genus

Reticulophragmium, however, I have not been able to verify whether or not rotundidorsata belongs to Haplophragmium in this study, so the species name rotundidorsata has been retained. R. orbiculare is a Recent more inflated form than my North Sea Palaeogene specimens, and the sutures appear to be more distinct, and more strongly curved.

According to Gradstein et al. (1988, fig.2) this species is most commonly found in the middle of the Middle Eocene to the earliest part of the Early Oligocene, but it may occur as high as the Early Middle Miocene in the Central North Sea.

Reticulophragmium paupera (Chapman).

Pl.16, fig.3a-b.

Cyclammina paupera Chapman 1904, p.229, pl.22, fig.6.

Reticulophragmium paupera (Chapman), Gradstein et al. 1988, p.100-101, fig.2.

Remarks.

R. paupera sensu Gradstein et al. (1988) is recorded by the latter authors from the Palaeocene of the Central North Sea, and it is an important part of their Late Palaeocene Trochammina ruthven murrayi- R. paupera Zone (NSP2, NSB1 of King, 1983, P.3 to P.4 of Blow, 1979). Noted in this study in Zone AB2, early Late Palaeocene.

GENUS: Reticulophragmoides Gradstein and Kaminski 1989.

Test with limbate sutures and umbilical boss. According to Gradstein and Kaminski (ibid.) a blind tubular extension of the chamber protrudes into the umbilical region. Later chambers with simple alveoli. Interiomarginal aperture (as in Haplophragmoides), without lip or supplementary apertures.

i. R. jarvisi (Thalmann). Very smooth walled test, similar to Reticulophragmium *paupera* (Chapman) in that respect. Distinctly 'kinked' and glassy appearance to the sutures. Compressed test.

ii. *Reticulophragmoides* sp.5 of Gradstein and Kaminski. A much more rounded peripheral margin than i. Similar to small examples of *R. rotundidorsata* (Hantken) but without such a broad periphery and possesses glassy sutures that show a few alveolae only in the later chambers, and only along the sutures.

Reticulophragmoides jarvisi (Thalmann) emend. Gradstein & Kaminski.

Nonion cretacea Cushman and Jarvis 1932, p.41, pl.12, fig.12a-b.

Nonion jarvisi (new name) Thalmann 1932, p.312-313.

Haplophragmoides(?) *jarvisi* (Thalmann), Kaminski *et al.* 1988, p.190, pl.7, figs.1a-2b.

Reticulophragmoides jarvisi (Thalmann), Gradstein and Kaminski 1989, p.81, pl.7, figs.1a-8, text-fig.4.

Notes.

6-9 chambers in the final whorl. Acute periphery, with keel. Circular to slighty lobulate outline. Depressed slightly curved, strongly limbate sutures.

Remarks.

This is the type species of the genus *Reticulophragmoides.*

According to Gradstein and Kaminski (1989) this species ranges from the Late Palaeocene (P4) to Early Oligocene (their *Rotaliatina bulimoides*-*Dorothia seiglae* Zone). It was used in this study to mark the *R. jarvisi* acme Zone AB7, early Middle Eocene.

Reticulophragmoides sp.5 of Gradstein & Kaminski.

Reticulophragmoides sp.5, Gradstein & Kaminski 1989, p.83, pl.8, fig.1a-4c.

Notes.

Involute, with shallowly depressed umbilicus. 8-10 chambers in the last whorl. Broadly rounded periphery. Straight, limbate flush sutures. Alveoles only present in the later part of the test, concentrated around the sutures.

Remarks.

A bathyal species according to Gradstein and Kaminski (1989).

Noted by Gradstein and Kaminski (ibid.) in the Oligocene of the Central North Sea.

GENUS: Sabellovoluta Loeblich and Tappan, 1985.

According to Loeblich and Tappan (1988, p.100) Sabellovoluta differs from Ammobaculites by having a thick alveolar wall structure, broad, low and curved early chambers, and a slit aperture produced on a neck.

i. S. humboldti (Reuss). Wall very coarse. test with a subacute peripheral margin. Sutures distinct and depressed in the later part, more indistinct in the initial part.

Sabellovoluta humboldti (Reuss).

Pl.16, fig.4a-c.

Spirolina humboldti Reuss 1851, p.65, pl.3, figs.17-18.

Haplophragmium humboldti (Reuss). Staesche and Hiltermann 1940, pl.38, fig.1.

Ammobaculites? humboldti (Reuss). Bartenstein 1952, p.319, pl.3, fig.9, pl.7, fig.16.

Ammobaculites humboldti (Reuss). King 1983, p.1, figs.16-17.

Sabellovoluta humboldti (Reuss). Loeblich and Tappan 1988, p.100, pl.97, figs.12-15.

Notes.

Alveoli can be seen when test is broken.

Remarks.

Periphery not as rounded as in S. humboldti s.s. Examples from the Palaeogene of the North Sea area often have very short uniseral sections that may be the same width as the diameter of the coiled section. The forms noted from the North Sea area are very similar to Haplophragmium humboldti (Reuss) var. latum Andreae 1884, which differs from S. humboldti s.str. in having a wider uniserial part, and more angular periphery. Sutures in the uniserial stage of S. humboldti from the North Sea area tended to be more curved than those in S. humboldti s.str., and H. humboldti var. latum.

S. humboldti s.str. was described from the Eocene of Germany. H. (sic.) humboldti var. latum was described from the Middle Oligocene of France. S. humboldti sensu King (1983) was recorded by the latter author from latest NSB6b to middle NSB7b. This is approximately equivalent to P.16/17 to P.19 of Blow (1979). According to Loeblich and Tappan (1988) S. humboldti s.str. ranges from the Lower to the Middle Oligocene.

SUBFAMILY: CYCLAMMININAE Marie, 1941

GENUS: Cyclammina Brady, 1879.

C. cf. garcillassoi (Frizzell). Many more chambers in the final whorl than in any of the species of Reticulophragmium noted in this thesis. Alveoli become distinctly elongated and concentrated around the sutures, which are straight to sinuous.

Cyclammina cf. garcilassoi (Frizzell).

Pl.17, fig.3, Pl.18, fig.1.

see Cyclammina garcilassoi Frizzell 1943, p.338, pl.55, fig.11.

Reticulophragmium cf. garcilassoi Frizzell. Kaminski et al. 1988, p.192, pl.7, figs.3-5b, pl.10, fig.5.

Notes.

Depressed umbilicus. Chambers regular in form, smooth finely agglutinated wall.

Remarks.

This is a very primitive cyclamminid. It differs from the type drawing in having more regular chambers, and distinct alveoli around the sutures. However, it is very similar to Gradstein and Berggren's (1981) *Alveophragmium* sp.1, and Gradstein *et al.*'s (1988, fig.2) illustration of *R. paupera*. The North Sea form noted from the wells used in this thesis has much in common with Kaminski *et al.*'s (1988) *Reticulophragmium* cf. *garcilassoi* (Frizzell), but is usually more inflated. *C.* cf. *garcilassoi* from the North Sea differs from *R. garcilassoi sensu* Gradstein *et al.* (1988), together with the camera lucida drawings of *R.* cf. *garcilassoi sensu* Kaminski *et al.* (op. cit., pl.10, fig.5), in not having alveoli covering most of the chamber surface. Kaminski *et al.* (ibid.) noted that his *R.* cf. *garcilassoi* may have alveoli concentrated around the sutures, and that that form is very similar to *R. paupera sensu* Gradstein *et al.* (op. cit.) from the North Sea. Thick sections done in this study of *C.* cf. *garcilasoi* prove that this species belongs to the genus *Cyclammina* (see plate 17, figure 3).

Cyclammina garcilassoi was originally described by Frizzell (1943) from the Upper Cretaceous of Peru. *R.* cf. *garcilassoi sensu* Kaminski *et al.* (1988) was recorded from the Late Palaeocene and Eocene of Trinidad.

SUPERFAMILY: SPIROPLECTAMMINACEA Cushman, 1927.

FAMILY: SPIROPLECTAMMINIDAE Cushman, 1927.

SUBFAMILY: SPIROPLECTAMMININAE Cushman, 1927.

GENUS: *Spiroplectammina* Cushman, 1927.

Spiroplectammina appears to be relatively very coarse grained when compared with *Bolivinopsis* Yakovlev, with which it has often been confused. The wall structure of *Spiroplecta rosula* Ehrenberg, the type of *Spiroplectoides* Cushman, a junior synonym of *Bolivinopsis*, was examined under the S.E.M. in order to determine the grain size. The examples of *B. rosula* used were from the Magoramorna Chalk in Ireland and from the Portsdown Anticline in Hampshire. *B. rosula* (see plate 18, fig.2) was shown to have a calcareous, finely agglutinated but 'radial' wall structure. Some fine grained examples of *Spiroplectammina* (such as *S. spectabilis*) do exist, but they are coarser walled than examples of *Bolivinopsis*, which are often so fine grained that they may appear to be hyaline. The aperture in the latter genus differs than that of *Spiroplectammina* in being a high arch in the centre of the apertural face. *B. rosula* is a delicate species, very small (for example 0.2mm long), straight sided, with an initial planispire which is the same diameter as, or slightly wider than, the width of the biserial portion of the test. *Bolivinopsis* (according to Banner pers. comm.) exists in typically chalk facies in depths of 600-1000m, in carbonate seas of normal marine salinities. It is commonly found in Late Cretaceous sediments. *Spiroplectammina* is (according to Banner pers. comm.) common in hyposaline environments and in high latitudes. It can flourish in cold, rather brackish waters, often rather euryhaline.

Spiroplectinella Kisel'man (and its junior synonym *Spirorutilus* Hofker) differs from *Spiroplectammina* in having a more flaring test, generally a small initial planispire, and often posesses raised thickened sutures. The cross section of *Spiroplectinella* is diamond shaped, while that of *Spiroplectammina* is often more compressed.

i. *S. navarroana* Cushman. Slightly flaring test. Rounded cross section.

ii. *S. biformis* (Parker and Jones). Compressed test. Differs from iii in its coarser wall, and more compressed test.

iii. S. spectabilis (Grzybowski). Smoother test than ii with a more 'diamond-shaped' cross-section.

Spiroplectammina navarroana Cushman.

Pl.17, fig.3a-b.

Spiroplectammina navarroana Cushman 1932, p.96, pl.11, fig.14; Hanzlíková 1972, p.47, pl.10, figs.5-7; Gradstein and Berggren 1981, p.260, pl.3, figs.11-12; ?Verdenius and van Hinte 1983, p.195, pl.7, figs.6-7; Gradstein et al. 1988 pp.100-101, fig.2; Kaminski et al. 1988, p.193, pl.7, figs.13-15; Gradstein and Kaminski 1989, p.83, pl.9, figs.1a-12, text-figure 5.

?Textularia plummerae Lalicker 1935, p.50, pl.6, fig.10.

Textularia plummerae Lalicker, sensu King 1983, p.21, pl.1, fig.28.

Notes.

Small planispiral initial portion, slightly flaring to straight sided test in biserial part. Sutures distinct, slightly depressed. Coarsely agglutinated, but may be smoothly finished. Narrow arched aperture at the inner margin of the apertural face.

Remarks.

The species T. plummerae Lalicker is an agglutinated form which was described as being biserial throughout. It appears to be identical in almost every other aspect to S. navarroana Cushman. Both have a coarsely agglutinated wall, elongate slightly flaring tests, distinct sutures which are nearly at right angles to the periphery, and have a low arched slit at the base of the last formed chamber (compare Lalicker, 1935, fig.10, with Cushman 1932, fig.14). King's (1983) T. plummerae is S. navarroana. T. plummerae Lalicker may well be a junior synonym of S. navarroana, if it can be shown that the former species has an initial planispiral portion, or that the types of T. plummerae have been broken, and have lost their initial planispires as it would appear from Lalicker's (1935) type illustration. However, I have not been able to examine the types of either species. North Sea examples of S. navarroana examined in this thesis tend to have more flaring tests than that shown in the type drawing (Cushman, 1932, pl.11, fig.14).

T. plummerae was described from the Eocene, Midway group, Wills Point formation, Texas, U.S.A., and according to Gradstein and Berggren (1981, p.261) is considered to be a Palaeocene marker. King (1983) notes T. plummerae (=S. navarroana) from Zone NSB4 Early Eocene in the North Sea. S. navarroana was described from the Cretaceous, Upper clay member of the Navarro, Navarro County, Texas, U.S.A., while Stewart (1987) notes this species in Early Eocene beds (Ypresian), just above his Globigerina ex gr. linaperta Zone.

Spiroplectammina biformis (Parker and Jones).

Textularia agglutinans d'Orbigny var. biformis Parker and Jones 1865, p.370, pl.15, figs.23-24.

Notes.

Very small test. Quite coarse walled. Initial spire of equal diameter, or slghtly larger than, the width of the biserial portion.

Remarks.

A rare species in North Sea sediments examined. According to Ksiazkiewicz (1975) it occurs in very shallow to abyssal depths, and in the Gulf of Mexico it is recorded from depths greater than 700m.

No type level was given for this species by Parker and Jones (1865), although they did record it from "Recent, and Cretaceous, Gault and Chalk" (Ellis and Messina 1940 et seq.).

Spiroplectammina spectabilis (Grzybowski).

Pl.18, fig.4a-d.

Spiroplecta spectabilis Grzybowski 1898, p.293, pl.12, fig.12.

Spiroplecta brevis Grzybowski 1898, p.293, pl.12, fig.13.

Spiroplecta foliacea Grzybowski 1898, p.294, pl.12, figs.14-15

Spiroplecta costidorsata Grzybowski 1989, p.294, pl.12, fig.11.

Spiroplecta clotho Grzybowski 1901, p.224, pl.8, fig.18.

Spiroplectoides californica Cushman and Campbell 1934, p.70, pl.9, figs.15-17 [holotype fig.15].

Spiroplectammina mexiaensis Lalicker 1935, p.43, pl.6, figs.5-6.

Spiroplectoides directa Cushman and Siegfus 1939, p.26, pl.6, figs.7-8.

Spiroplectammina grzybowski Frizzell 1943, p.106, pl.55, figs.12-13.

Spiroplectammina trinitatensis Cushman and Renz 1948, p.11, pl.2, figs.13-14.

Spiroplectammina perplexa Israelsky 1951, p.12, pl.3, figs.9-14 [holotype figs.9-11].

Spiroplectammina brunswickiensis Todd and Kniker 1952, p.6, pl.1, fig.16.

?Spiroplectammina calathusi Yeremeyeva 1957, p.11, pl.1, fig.7.

Spiroplectammina spectabilis (Grzybowski). Geroch 1960, pl.6, figs.10-11; Gradstein and Berggren 1981, p.260, pl.4, figs.1-5; King 1983, pl.1 fig.24; Tjalsma and Lohmann 1983, p.20, pl.1, fig.11, pl.9, figs.8-10; Kaminski 1984, pp.31-36, pls.12-13, Text-figs.1-4 [with synonymy]; Jones 1988, p.148, pl.2, fig.5; Kaminski et al. 1988, p.193, pl.7, figs.16-18.

Bolivinopsis spectabilis Hanzlìková 1972, p.48, pl.10, fig.8.

Notes.

Fine grained species. Sutures flush to slightly depressed. Initial planispire generally has a wider diameter than the width of the biserial portion (in megalospheric forms).

Remarks.

For a fuller synonymy see Kaminski (1984). He included many microspheric forms of certain species that had previously been regarded as distinct from S. spectabilis (such as, S. clotho [Grzybowski, 1901]). Such forms differ from the generic description of Spiroplectammina in that the first few biserial chambers are actually larger in width than the diameter of the initial planispire. S. spectabilis also differs from the description of the genus in that it has a more compressed, lozenge shaped cross section. However, it differs from Bolivinopsis Yakovlev, in having a much more robust, coarser walled test. In cross section spectabilis is similar to Spiroplectinella carinata but is again generally much more compressed. It also has a less flaring test than Spiroplectinella. The species spectabilis is difficult to place with much certainty into any of the aforementioned genera, but it bears a closer resemblance to Spiroplectammina, than any other.

Two forms of S. spectabilis were noted from the North Sea. Form A (plate 18, fig.4c-d) is an Eocene species which is generally more compressed than the Palaeocene Form B (see plate 18, fig.4a-b), which has a more diamond shaped cross section. Microspheric, as well as megalospheric forms were sometimes observed. Form A is the same as King's (1983) S. aff. spectabilis.

According to van Morkhoven et al. (1986, figs.5-6) the Palaeocene form of S. spectabilis occurs in "Velasco-type" faunas, in middle to upper bathyal depths (500m-700m), together with Stensioina beccariiformis (White), Osangularia velascoensis (Cushman), and Nuttallides truempyi (Nuttall) (van

Morkhoven *et al.* [ibid.], fig.5). The Eocene form of *S. spectabilis* (see van Morkhoven *et al.* [ibid.], fig.6) occurs, according to the aforementioned authors, in a faunal 'type' which is transitional between the "Barbados-type", and the "Jackson Clairborne-type", in upper bathyal depths (200m-300m), together with *Gaudryina hiltermanni* (Meisl), *Anomalinoides capitatus* (Gumbel), *Vaginulinopsis decorata* (Reuss) (=*Percultazonaria wetherellii* [Jones]), *Cibicidoides eocaenus* (Gumbel), and *Turrilina robertsi* (Howe and Ellis).

Jones (1988, fig.3) demonstrated that *S. spectabilis* was common in his Northern North Sea wells in his upper slope (200m-500m) assemblages, less common in his middle slope (500m-1000m) ones, but increased in numbers again in his basin floor (1000m-1500m) assemblages, in Late Palaeocene (zone p.3 of Blow, 1979) times.

S. spectabilis is common in the *Rhabdammina* biofacies (which Kaminski [1984] related to a "Velasco-type" fauna) in the Upper Maastrichtian to Upper Eocene. This biofacies is a "flysch-type" fauna which occurs in "cool, turbid, deep-water environments with old (i.e. sluggish) bottom water and pelagic substrates with high organic matter content, though the relative importance of any particular parameter is not yet clear" (Kaminski, 1984, p.42).

Spiroplectammina calathusi Yeremeyeva (described from the Upper Eocene of the U.S.S.R.) has a great similarity to *S. spectabilis*. The former supposedly differs from the latter in having "narrow, depressed sutures, which furthermore are well expressed only at the peripheral margin. The spiral suture is almost never visible" (Yeremeyeva, 1957, p.11). The form illustrated by Yeremeyeva (1957, pl.1, fig.7) is probably a microspheric example of *S. spectabilis*, although until the types of *S. clathusi* have been examined I cannot be certain of this.

Form A is a good marker for Middle Eocene and older age (Zone AB8 in this study), Form B occurs in the top half of the Late Palaeocene marker species for Zone AB2) in wells examined for this thesis. King's (1983) *S. spectablis* occurs in his NSB.1 Zone, Early to Middle Late Palaeocene. His *S.* aff. *spectabilis* was recorded from the Early Eocene (Zone NSB.3) to the Lower Middle Eocene (Zone NSB.5).

GENUS: *Spiroplectinella* Kisel'man, 1972.

i. *S. adamsi* (Lalicker). Distinctively raised sutures, that are rough, with smooth chamber walls.

ii. *S. carinata* (d'Orbigny). Smooth chamber walls with depressed though rough sutures, spinose to keeled periphery which is acute. Often with a high final chamber.

iii. *S. deperdita* (d'Orbigny). Acute periphery without spines, with a less distinct keel than ii. Wall with a rough surface, slightly depressed sutures. Chambers inflated.

iv. *S. wilcoxensis* (Cushman and Ponton). Smooth wall and sutures, which are slightly depressed, subacute periphery.

v. *S. excolata* (Cushman). Compact strongly flaring test. Sides flat to slightly concave. Distinctively curved chambers that increase in size rapidly as added, with smooth wall and rough raised sutures.

Spiroplectinella adamsi (Lalicker).

Pl.18, fig.5a-b.

Spiroplectammina adamsi Lalicker 1935, p.39, pl.6, figs.1-2; Todd and Kniker 1952, p.6, pl.1, figs.18-19; ? Kaaschieter 1961, p.139, pl.1, figs.9-11.

Bolivinopsis adamsi (Lalicker). Murray *et al.* 1981, p.242, pl.8.1, fig.1.

Notes.

Compressed lozenge shaped cross section. Thickened axial portion, raised and thickened sutures usually present. Aperture slit-like.

Remarks.

Typical examples of this species occur in the London Clay Formation, but also noted from the Southern North Sea area. Todd and Kniker (1952) suggested that the chamber walls of this species often collapses, leaving the sutures raised. They pointed out that specimens with collapsed and non-collapsed tests look quite different. All examples of this species that were observed from the London Clay Formation and the Eocene of the Southern North Sea area had 'collapsed' chambers. Murray et al. suggested that this species occurs in "normal marine to slightly brackish, inner to mid shelf, fine sediment substrate" (1981, p.242).

Examples of this species were noted by Todd and Kniker (1952) from the Eocene Martinez formation of California, the Middle Eocene of Cape Blanco, Oregon, U.S.A., and from the Upper Eocene Agua Fresca Shale of the Megallanes Province, southern Chile. Murray et al.'s (1981) Bolivinopsis (sic.) adamsi (Lalicker) was from the London Clay formation, Alum Bay, Isle of Wight. He lsied the range of this species in the Belgian Basin as being from the Ypresian to the Paniselian (based on Kaaschieter, 1961), and the total range in Great Britain as the Early Eocene.

Spiroplectinella carinata (d'Orbigny).

Pl.18, fig.6.

Textularia carinata d'Orbigny 1846, p.247, pl.14, figs.32-34.

Spiroplectammina carinata (d'Orbigny). Batjes 1958, p.99, pl.1, fig.2; Kaaschieter 1961, p.140, pl.1, fig.12.

Spirorutilus carinatus (d'Orbigny). Hofker 1976, p.69.

Spirorutilis (sic.) carinata (d'Orbigny). Banner and Pereira 1981, p.102.

Spiroplectinella carinata (d'Orbigny). Papp and Schmid 1985, pp.86-87, pl.80, figs.1-4.

Notes.

Flattened wedge-shaped test, usually with a distinct marginal ridge. Chambers low.

Remarks.

Textularia carinata d'Orbigny was selected as the genoholotype for Spirirutlus by Hofker (1976). However, Spirorutilus Hofker 1976, has been shown to be a junior synonym of Spiroplectinella Kisel'man 1972, (see Loeblich and Tappan, 1988, and Papp and Schmid, 1985, pp.86-87). Ksiazkiewicz (1975) pointed out that this species occurs in great depths in the Pacific ocean area.

In Papp and Schmid's (ibid.) review of A. d'Orbigny's monograph on the Tertiary of the Vienna Basin area, this species occured in Badenian (Middle Miocene) sediments; the lower boundary of which corresponds to the base of Zone N.9 (Papp and Schmid, 1985, p.13) of Blow (1969), while the upper boundary occurs at Zone N.13. Hofker (1976, p.69) regarded S. carinata as a common species in the Oligocene and Miocene.

Spiroplectinella deperdita (d'Orbigny).

Pl.18, fig.7a-c.

Textularia deperdita d'Orbigny 1846, p.244, Pl.14, figs.23-25.

Remarks.

The species noted from the North Sea had sutures that were not as indented as in d'Orbignys illustration. Both the forms illustrated as

Spiroplectammina deperdita (d'Orbigny) by Murray and Wright (1974, Pl.1, figs.4-5), and Kaaschieter (1961, Pl.1, fig.13) as Spiroplectammina carinata (d'Orbigny) var. deperdita (d'Orbigny) have less acute peripheries than both d'Orbignys original drawing, and the examples noted in this study. The North Sea examples are morphologically similar to S. carinata, but do not possess such a distinctly spinose, or keeled periphery.

The type level for this species is in the Tertiary of the Vienna Basin, Austria. It was noted in this study in the Eocene, for example in Wells 49/19-1, earliest Early Eocene, 1230'DC, Zones AB4, PK6, CB3, and 14/29-1, ?Middle Eocene, 2450'DC, Zone ?CB5.

Spiroplectinella wilcoxensis (Cushman and Ponton).

Pl.18, fig.8, Pl.19, fig.1.

Spiroplectammina wilcoxensis Cushman and Ponton 1932, p.51, Pl.7, fig.1a-b; Cushman and Garret 1939, p.78, Pl.13, figs.1-2.

?Textularia thanetana Lalicker 1935, p.51, pl.7, fig.7.

Notes.

Broad, compressed test with subacute periphery. Chambers distinct, low and broad in the early parts of the test, increasing in height as added, slightly inflated. Sutures slightly depressed. Smooth wall. Aperture a low arch at the base of the final chamber.

Remarks.

North Sea examples of this species were generally larger than that illustrated by Cushman and Ponton (1932). This species type level is the Eocene, "Wilcox age", from Alabama, U.S.A. It was noted in this study in the Eocene, for example in Wells 21/11-1, Late Eocene, 3080'DC, Zone ?CB6, and 14/29-1, Middle Eocene, 2330'DC, Zones CB5, PK6. 'Textularia' thanetana

Lalicker is very similar to examples of S. wilcoxensis from the North Sea, and it may be a junior synonym. However, the sutures are more depressed in the former, with a less angular peripheral margin.

Spiroplectinella excolata (Cushman).

Pl.19, fig.2.

Textularia excolata Cushman 1926, p.585, pl.15, Fig.9a-b.

Spiroplectammina excolata (Cushman), Cushman 1946, p.27, pl.5, Figs.9a-b, 10a-b; Hofker 1966, p.306, pl.66, Figs.7-8; Kaminski et al. 1988, p.192, pl.7, fig.12.

Notes.

Broad thick test, with a smooth finish, raised and thick sutures.

Remarks.

Kaminski et al. (1988) noted this species in the Early Palaeocene, Danian (Zone P2, Berggren 1969). It was described from the Upper Cretaceous, Velasco Shale, Mexico. It was noted in this study in the Late Eocene, for example in Well 14/29-1, 2270'DC, Zone NSB6 of King (1983).

SUPERFAMILY: TROCHAMMINACEA Schwager, 1877.

FAMILY: TROCHAMMINIDAE Schwager, 1877.

SUBFAMILY: TROCHAMMININAE Schwager, 1877.

GENUS: Trochammina Parker and Jones, 1859.

The genus Trochammina has been radically revised (for example by Brönimann and Whittaker 1988) so that the Superfamily Trochamminacea contains more than a dozen genera distinguished on their apertural characteristics. These morphocharacters are not visible on the North Sea microfossils.

i. Trochammina sp. 4 subglobular-ovate chambers in final whorl. Low trochospire. Coarse wall.

ii. *T. subvesicularis* Homola and Hanzlikóva. Test often assymetrically biconvex. 6-10 chambers in final whorl.

iii. *T. ruthvenmurrayi* Cushman and Renz. High-spired test.

iv. *T. globigeriniformis* (Parker & Jones). 3-3½ globular chambers in the final whorl, with a low trochospire. Often compressed and distorted. Medium grained wall.

Trochammina sp.

Notes.

Coarse walled. Trochospiral, subgobular to ovate chambers. 4 chambers in final whorl.

Remarks.

Often well preserved in the London Clay Formation, Early Eocene. Similar to *Trochammina deformis* (Grzybowski) but the North Sea examples noted by Gradstein and Berggren (1981. pl.8, figs.8-10) were collapsed, and the above were not. Chambers indistinct.

Trochammina subvesicularis Homola and Hanzlikóva.

Pl.19, fig.4a-d.

Trochammina subvesicularis Homola and Hanzlikóva 1955, p.402, Pl.7, figs.1-3; Gradstein and Berggren 1981, p.258, Pl.9, figs.5-8.

Notes.

Plano-convex to assymetrically biconvex test with 6-10 chambers in the final whorl. Open umbilicus. Aperture a basal interiomarginal slit. Coarse wall.

Remarks.

Gradstein and Berggren (1981, p.258) noted that this species closely resembles "*Morozovella angulata* (White)" in shape. This species was noted by Gradstein and Berggren (1981) in the Palaeocene, with examples of *Spiroplectammina spectabilis* Grzybowski. It was originally described from the Palaeogene of the Western Carpathians. It was noted in this study in the Late Palaeocene, for example in Wells 21/30-1, 6690'SWS, Zones AB2 (the marker species for which is *S. spectabilis*), CB2, ?PK2, and 14/29-1, 4790'DC, Zone AB2.

Trochammina ruthven murrayi Cushman and Renz.

Pl.19, fig.5a-c.

Trochammina ruthven-murrayi Cushman and Renz 1946, pp.24-25, pl.3, Fig.13; Kaminski *et al.* 1988, p.193, pl.8, Fig.6a-c; Gradstein *et al.* 1988, Fig.2.

Trochammina aff. *albertensis* Wickenden, Gradstein and Berggren 1981, p.258, pl.9, figs.1-4.

Notes.

Generally high-spired, of approximately 4 whorls.

Remarks.

According to Kaminski *et al.* (1988) the shape of this species resembles *Globotruncana contusa*. Kaminski *et al.* (ibid.) recorded this species in the Palaeocene, Danian (P1 of Berggren 1969) to "Selandian" (P6a of Berggren op. cit.) of Trinidad. Gradstein *et al.* (1988) used this species to mark their *T. ruthven murrayi-Reticulophragmium paupera* Zone, early Late Palaeocene (P3-P4 of Blow, 1979) in the North Sea.

Trochammina globigeriniformis (Parker and Jones).

Lituola nautiloidea Lamarck var. *globigeriniformis* Parker and Jones 1865, p.407, Pl.15, figs.46-47, Pl.17, figs.96-98.

Trochammina globigeriniformis (Parker and Jones), Jurkiewicz 1967, p.92, Pl.6, fig.13; Gradstein and Berggren 1981, p.256, Pl.8, fig.13.

Remarks.

Gradstein and Berggren (1981) pointed out that Hilterman (1972) regarded this as a deep-water species in recent oceans. Gradstein and Berggren (op. cit.) noted this species in the Late Cretaceous, Maastrichtian, through Eocene.

SUPERFAMILY: VERNEUILINACEA Cushman, 1911.

FAMILY: VERNEUILINIDAE Cushman, 1911.

SUBFAMILY: VERNUILININAE Cushman, 1911.

GENUS: Gaudryina d'Orbigny, 1839.

G. hiltermanni (Meisl). Subtriangular cross section in early stage, later part biserial.

Gaudryina hiltermanni (Meisl).

Pl.19, fig.6a-c.

Gaudryina (Pseudogaudryina) hiltermanni Meisl 1959, p.411, pl.19 Fig.1-7.
Gaudryina hiltermanni (Meisl) Murray et al. 1981, p.242 pl.8.1 Fig.5-6.

Notes.

Coarsely arenaceous, triangular test in cross section. Multiserial, elongate. Later part biserial. Aperture subterminal, round.

Remarks.

Noted in the London Clay Formation, Early Eocene, Ypresian. Common in the Early Eocene of the Southern North Sea, a marker species for Zone AB4.

SUPERFAMILY: ATAXOPHRAGMIACEA Schwager, 1877.

FAMILY: GLOBOTEXTULARIIDAE Cushman, 1927.

SUBFAMILY: LIEBUSELLINAE Saidova, 1981.

GENUS: Matanzia Palmer 1936.

M. varians (Glaessner). Internal vertical partitions partially subdivide the chambers. These subdivisions appear as darker vertical 'wavy' lines at the base of each chamber.

Matanzia varians (Glaessner).

Textularia? varians Glaessner 1937, p.366-367, Pl.2, fig.15.

Matanzia varians (Glaessner), Jurkiewicz 1967, pp.94-95, Pl.5, fig.17; Gradstein et al. 1988, pp.100-101, fig.2; Kaminski et al. 1988, p.196, Pl.9, fig.14a-b, Pl.10, fig.14.

Remarks.

Gradstein et al. 1988 noted M. varians (Glaessner) in the Late Cretaceous, through "Selandian", 'middle' Late Palaeocene, it was more commonly found in the Cretaceous and Danian of the North Sea Tertiary. Kaminski et al. (1988) noted this species in the Late Cretaceous through Late Palaeocene ("Selandian", Zone P6a of Berggren 1969), Trinidad.

SUPERFAMILY: TEXTULARIACEA Ehrenberg, 1838.

FAMILY: EGGERELLIDAE Cushman, 1937.

SUBFAMILY: DOROTHIINAE Balakhmatova, 1972.

GENUS: Dorothia Plummer, 1931.

i. D. principiensis Cushman and Parker. Inflated chambers, lobulate periphery. Biserial portion almost makes up the entire test which is almost parallel sided. Oval cross section. Fine wall.

ii. D. eocenica Cushman. Slender, elongate test. Rounded cross section. Coarse wall.

iii. D. beloides Hillebrandt. Elongated ovoid shape.

iv. D. seigliei Gradstein and Kaminski. Very fine thin wall, smooth. Often compressed. Conical test with rounded cross section when not compressed. Chambers globular, few, and increase in size rapidly as added.

Dorothia principiensis Cushman and Bermudez.

Pl.19, fig.7.

Dorothia principiensis Cushman and Bermudez 1936, p.57 pl.10 fig.3,4; Todd and Knicker 1952, p.12 pl.2 figs 8,9; Verdenius and Van Hinte 1983, p.196 pl.7 fig.1.

Notes.

Early stage trochospiral with 4/5 chambers (inflated). Broadly rounded periphery. Oval cross section. Aperture a low crescentric slit at the base of the final chamber, with smooth band/very low lip around it. Sutures obscur in early part, depessed and distinct in biserial part. Wall surface quite fine grained with abundant matrix.

Remarks.

A variable form in London Clay, although distinctive. An Eocene species, type from the Eocene Lower Principe formation in Havana, Cuba.

Dorothia eocenica Cushman.

Pl.19, fig.8.

Dorothia eocenica Cushman 1936, p.28 pl.4 fig.14a,b.

Notes.

Elongate test, slender. Rounded cross-section. Coarse wall. Sutures distinct, slightly depressed, almost horizontal in adult. Aperture arched, at base of final chamber.

Remarks.

Rare. Pyritised. Type level, Eocene (from Biarritz, France).

Dorothia beloides Hillebrandt.

Dorothia beloides Hillebrandt 1962, p.39, textfigure 3, Pl.2, figs.8-14, Pl.15, figs.12-13; Kaminski et al. 1988, p.195, Pl.9, figs.4-5.

Notes.

Elongated ovoid shape with a long multiserial to irregularly biserial growth stage.

Remarks.

Kaminski et al. 1988 recorded this species in the Late Palaeocene, Trinidad. It was noted in the early Late Palaeocene in this study, for example in Well 21/30-1, 6712'SWS-6770'SWS, Zone AB1.

Dorothia seigliei Gradstein and Kaminski.

Dorothia seigliei Gradstein and Kaminski 1989, p.79, pl.5, figs.1-6, pl.6, figs.1-5, text-fig.3.

Remarks.

Small test, less than 500 microns according to Gradstein and Kaminski (1989). They record the stratigraphic range of this species as being from the Late Eocene to the Oligocene, possibly to the Miocene at DSDP sites in the Norwegian-Greenland Sea. It was used in this study to mark Zone AB10, Early Oligocene, together with the calcareous benthic foraminifera R. bulimoides. According to Gradstein and Kaminski (op. cit.) this is a bathyal species.

GENUS: Marssonella Cushman, 1931.

i. M. oxycona (Reuss). Conical shape, with flatttened terminal face. Fine wall.

ii. Marssonella sp. Conical shape. Very coarse wall.

Marssonella oxycona (Reuss).

Pl.19, fig.9, Pl.20, fig.1.

Gaydryina oxycona Reuss 1860, p.33, Pl.12, fig.3.

Dorothia oxycona (Reuss), Gradstein et al. 1988, pp.100-101, fig.2; Kaminski et al. 1988, p.195, Pl.9, fig.9.

Notes.

Large conical test. Finely agglutinated wall. Aperture at the base of the final chamber (with rim?).

Remarks.

Gradstein et al. 1988 recorded this species in Cretaceous through Late Palaeocene in the North Sea Tertiary, it was most common in the Cretaceous and Early Palaeocene (Danian). Kaminski et al. 1988 noted this species from Trinidad, in Late Cretaceous (Campanian) through Late Palaeocene ("Selandian", Zone P6a of Berggren 1969).

Marssonella sp.

Pl.20, fig.2.

Notes.

Coarsely agglutinated, conical flaring test. Slit like aperture at base of last chamber.

Remarks.

Rare. Large. Only noted in the London Clay Formation, Parliament Hill site, Early Eocene, Ypresian, Zone AB4.

SUBFAMILY: EGGERELLINAE Cushman, 1937.

Karreriella Cushman, 1933.

i. K. (Karreriella) siphonella (Reuss). Elongate test, last two chambers higher than broad. Narrow initial stage. Coarse wall. Distinctive oval aperture with rim (low neck?).

ii. K. (?Karreriella) siphonella chilostoma (Reuss). Last two chambers very inflated. Apertural margin raised.

iii. K. (?Meidamonella) mexicana (Nuttall). Wall with a fine finish. Flaring test, chambers increasing rapidly in size as added, parallel sided. Aperture with hooked lip.

iv. K. (Meidamonella) bradyi (Cushman). Flaring test. Crescentric aperture with rim. Distinctly depressed sutures in biserial part. Test often compressed. Usually smooth walled.

v. K. (?Karrerulina) danica Cushman. Small, sharply flaring initial stage, relatively large biserial part, which is only slightly flaring. Coarse walled.

vi. K. (Karrerulina) horrida Mjatliuk. Short, thick cylindrical test. No biserial stage. Coarse wall.

vii. K. (Karrerulina) conversa (Grzybowski). Elongated test, with later distorted biseral stage.

viii. K. (Karrerulina) lenis (Grzybowski). Short, cylindrical test, tapers sharply at both ends.

Karreriella (Karreriella) siphonella (Reuss).

Pl.20, fig.3a-b.

Gaudryina siphonella Reuss 1851, p.78 pl.5 Fig.41-42.

Karreriella siphonella (Reuss) Cushman 1937, p.125 pl.14; Batjes 1958, p.100, pl.1 Fig.6-8.

Notes.

Arenaceous multiserial, elongate. Later stage biserial. Flattened sides to test. Oval shaped aperture with lip. Slightly twisted about the test axis.

Remarks.

Loeblich and Tappan (1988) regard K. siphonella (Reuss) as the type species for Karreriella Cushmam. Karreriella has an aperture that is as long as broad, or up to 4-5 times as long as broad. Meidamonella (Loeblich and Tappan 1986) differs from Karreriella in having an elongate slit-like aperture which is at least ten times as long as broad, bordered by a low lip, instead of a rounded to oval aperture produced on a neck. Examples of Karreriella (Karreriella) siphonella were commonly noted from the London Clay Formation, Early Eocene, Parliament Hill site, and in the Wetherell Collection in the British Museum (Natural History) from Copenhagen Fields Islington. One example from the latter collection had a lip (neck?) around the aperture, one did not. It was decided that it was better to give Meidamonella a subgeneric status as the presence or absence of a neck or lip appears to be variable.

Karreriella (?Karreriella) siphonella chilostoma (Reuss).

?Gaudryina siphonella Reuss 1851, p.78, Pl.5, fig.40a-b.

Textularia chilostoma Reuss 1852, p.18, tf.a-b.

Karreriella siphonella (Reuss), Doppert and Neele 1983, p.4-6, Pl.5, fig.1a-b.

Remarks.

This species was noted by Doppert and Neele (1983) in his FF/FG Zone (as K. siphonella (Reuss)), Early-Middle Oligocene. Noted in this study in the ?Late Oligocene-Early Miocene, Zone AB11b (see Rangechart for AB Zones). Loeblich and Tappan (1985b, p.202) regard Reuss' 1851 Gaudryina siphonella, fig.40a-b, Pl.5 (not figs.41-42b), as K. chilostoma. They regarded Reuss Fig.42a-b as a megalospheric flaring example of K. siphonella, and designated it as the lectotype of that species. They also place K. chilostoma s.s. into their genus Meidamonella, due to its elongated slit-like aperture. The forms noted from the North Sea, however, did not have such a distinctly elongated aperture, and possessed a short ?neck.

Karreriella (?Meidamonella) mexicana (Nuttall).

Pl.20, fig.4a-b.

Verneulina mexicana Nuttall 1932, p.6, Pl.12, figs.1-2.

Karreriella mexicana (Nuttall), Cushman 1937, p.130, Pl.15, figs.13 (paratype)-14(holotype); Cusham and Stainforth 1945, p.18, Pl.2, figs.8-9.

Notes.

Subconical initial part. Sutures depressed. Aperture at the base of the final chamber, an elongate slit with a slight neck (?lip). Wall with a fine finish. Later stage in adults distinctly biserial, much larger than initial part.

Remarks.

The original type figured by Nuttall (1932) was a juvenile of this species according to Cushman (1937). Cushman (op. cit.) noted that adult forms would probably have a distinct biserial later stage. Cushman and Stainforth (1945, Pl.2, fig.9) illustrated examples with the beginnings of a biserial development. In examples in this study of this species the aperture is not in such a distinctive depression as in Cushmans (1937) juveniles. Nuttall (1932) described this species from the lower Oligocene of Vera Cruz, Mexico, while Bermudez (1938) recorded this species from the

Eocene of Cuba. This species was noted in this study in the Late Eocene, for example in Well 21/11-1, 3080'DC, Zone ?CB6.

Karreriella (Meidamonella) bradyi (Cushman).

Gaudryina bradyi Cushman 1911, p.67, Text-figs.107a-b.

? Textularia chapapotensis Cole 1928, p.206, Pl.33, fig.9.

? Karreriella chapapotensis (Cole), Tjalsma and Lohmann 1983, p.32, Pl.9, fig.2.

Remarks.

The specimens in this study are close to the types of chapapotensis Cole, but direct comparisons are difficult because of the poor preservation of some of the North Sea examples. Some specimens of K. (M.) bradyi Cushman were coarser walled than typical bradyi and chapapotensis. Tjalsma and Lohmann (1982) noted K. chapapotensis in the earliest Eocene (Zone P6b of Berggren 1972), through Oligocene.

Karreriella (?Karrerulina) danica Cushman.

Pl.20, fig.5a-b.

Karreriella danica Cushman 1937 (non Franke), p.116 pl.14 Fig.20-22; Willems 1983, p.244 pl.2 fig.9.

Notes.

Most of the test is biserial with oval transverse section. The initial part of the test tapers rapidly and comprises only about a fifth of the length of fully grown specimens. Parallel sided part of test has a lobulate periphery. Inflated chambers separated by slightly depressed sutures perpendicular to the test axis. Coarsely arenaceous. Aperture a depressed crescentic oval.

Remarks.

Test often broken around the aperture. Williams 1971, places Bowen's 1954 species Gaudryina (Gaudryina) ashfordi into the above synonymy.

Cushman 1937 illustrated examples of K. danica (Franke) from the London Clay (100ft above base). However, his examples differ from K. danica (Franke) s. str. by having a valvulinide early portion, an elongate aperture with an indistinct neck near the base of the final chamber, and in its more broadly rounded section in the biserial part. Brotzen 1948, refers the Danish E. Eocene K. danica (Franke) to the genus Bermudezina Cushman 1937, and calls the English species K. danica.

Karreriella (Karrerulina) horrida Mjatliuk.

Pl.20, fig.6.

Karreriella horrida Mjatliuk 1970, pp.114-115, Pl.5, fig.9, Pl.33, figs.15-16c; Gradstein et al. 1988, pp.100-101, fig.2; Kaminski et al. 1988, p.196, Pl.9, figs.19-20.

Remarks.

Gradstein et al. (1988) noted this species in the early Late Palaeocene to more rarely in the Early Oligocene. Kaminski et al. (1988) noted this species in the Early Palaeocene, Danian (Zone P2 of Berggren 1969).

Karreriella (Karrerulina) conversa (Grzybowski).

Pl.20, fig.7a-b.

Gaudryina conversa Grzybowski 1901, p.224, Pl.8, figs.15-16.

Gaudryina apicularis Cushman 1911, p.69.

?Plectina conversa Jedlitschka, 1935, p.38, Pl.p.43, figs.1-2, 4, 8.

Karreriella apicularis (Cushman), Gradstein and Berggren 1981, p.263, Pl.4, figs.11-15.

Karreriella conversa (Grzybowski), Webb 1975, p.835, Pl.3, fig.12; Verdenius & Van Hinte 1983, P.196, Pl.7, fig.5; Gradstein et al. 1988, pp.100-101, fig.2; Kaminski et al. 1988, p.196, Pl.9, figs.17-18b.

Remarks.

Pl.20, fig.7a (?megalospheric, according to R.W. Jones, in press) shows an example of this species with a more distinct later biserial stage. Karreriella (Karrerulina) conversa (Grzybowski) has a terminal rather than interiomarginal aperture. Karreriella and Karrerulina Finlay differ from Plectina Marsson in lacking a dentate aperture. Jedlitschka (1935) noted P. conversa (non Grzybowski?) in the lower part of the Late Eocene, Czechoslovakia. Kaminski et al. (1988) noted this species in Late Cretaceous (Maastrichtian) through Eocene (Zone P8, Berggren 1969), Trinidad. Gradstein et al. (1988) noted this species in the North Sea Tertiary, in the Early Palaeocene through middle Middle Eocene.

Karreriella (Karrerulina) ?lenis (Grzybowski).

Pl.20, fig.8.

?Spiroplecta lenis Grzybowski 1896, Pl.9, figs.24-25.

Notes.

Small test, tapering in initial stage, and also in the later part.

Remarks.

Rare in wells in this study. Recorded by Grzybowski (1896) in the Lower Oligocene. Noted in this study in the Palaeocene.

GENUS: Martinotiella Cushman, 1933.

Martinotiella communis (d'Orbigny).

Pl.20, fig.9.

Clavulina communis d'Orbigny 1846, p.196, Pl.12, figs.1-2.

Martinotiella communis (d'Orbigny), Verdenius and van Hinte 1983, Pl.7, figs.13, 16-17.

?Martinotiella cylindrica of Gradstein et al. 1988, pp.100-101, fig.2.

Remarks.

Gradstein et al. (1988) noted this species (as M. cylindrica?) in the Late Oligocene to Middle Miocene. Noted by d'Orbigny (1846) in, for example, the Tertiary of the Vienna Basin.

FAMILY: TEXTULARIIDAE Ehrenberg, 1838.

SUBFAMILY: TEXTULARIINAE Ehrenberg, 1838.

GENUS: Textularia Defrance in de Blainville, 1824.

i. Textularia sp. Conical test. Flaring, chambers increasing rapidly in size as added. Broadly rounded periphery.

ii. T. chapmani Lalicker. Test roughly triangular in side and front views. Very compressed initial stage, last chambers inflated and not so compressed. Periphery broadly rounded near the apertural end, angular in initial stages.

Textularia sp.

Pl.21, fig.2a-b.

Notes.

Small, biserial, conical test. Finely agglutinated. Aperture a low interiomarginal slit at base of final chamber.

Remarks.

Rare, occurs in the London Clay Formation, Parliament Hill site, Early Eocene, Ypresian, Zone AB4.

Textularia chapmani Lalicker.

Pl.21, fig.3.

Textularia chapmani Lalicker 1935, p.13, Pl.2, figs.8(holotype)-9(paratype).

Remarks.

Rare in this study. Described by Lalicker (1935) from the Early Cretaceous, Gault. Only noted as a reworked species in the Southern North Sea, Well 49/9-1, 1288'SWS, earliest Oligocene/Late Eocene, Zone CB6.

SUBFAMILY: SIPHOTEXTULARIINAE Loeblich and Tappan, 1985.

GENUS: Siphotextularia Finlay, 1939.

Siphotextularia sp.

Pl.19, fig.3a-b.

Notes.

Small initial stage, gradually flaring. Rough wall, with perforations. Aperture near the base of the final chamber, with a small ?neck. Angular test.

Remarks.

Noted in this study in ?Middle-Late Eocene, Well 49/9-1, 1535'SWS, Zone NSB6a of King (1983).

FAMILY: PSEUDOGAUDRYNIDAE Loeblich and Tappan, 1985..

SUBFAMILY: PSEUDOGAUDRYNINAE Loeblich and Tappan, 1985.

GENUS: Clavulinoides Cushman, 1936, emend. Banner and Desai 1985.

C. anglicus (Cushman). Sutures in later uniserial stage often not horizontal. and chambers more inflated, not as compressed as in Clavulina parisiensis d'Orbigny.

Clavulinoides anglicus (Cushman).

Pl.20, fig.10, Pl.21, fig.1a-b.

Clavulina communis Sherborn and Chapman 1886, (non D'Orbigny), p.743 pl.15 Fig.1.

Pseudoclavulina anglica Cushman, 1936, p.18 pl.3 Fig.5a-b; Kaasschieter 1961, p.145, pl.1 Fig.29.

Clavulina anglica (Cushman) Murray et al. 1981, p.242, pl.8.1, Fig.3.

Notes.

Early part triserial, triangular in section with flat to concave sides. Uniserial, rounded, later portion. Round terminal aperture. Wall coarsely arenaceous, perforate.

Remarks.

Common in the London Clay, Parliament Hill site, and in the Southern North Sea Early Eocene. Large, well preserved examples were found. Wetherell's (1838) Fig.6 on his plate (see Text-Fig.4) is actually a broken form of the above. C. anglicus was also present in other slides from the Wetherell Collection (British Museum (Natural History) slide Reg. no. P9801 from Islington). Clavulinoides aspera (Cushman 1926) has, by some authors, been thought to be a senior synonym (R.W. Jones pers. comms.). However, although C. anglicus and Clavulinoides aspera look superficially similar due to their coarse wall texture P. anglica differs from C. aspera in having rounded chambers in the uniserial portion, while C. aspera has a triangular section throughout. C. anglicus is described from the London

Clay Eocene from Clapham, South-West London, from an excavation 100ft. above the base of the London Clay (Type Locality).

FAMILY: VALVULINIDAE Berthelin, 1880.

GENUS: Clavulina d'Orbigny.

C. parisiensis d'Orbigny. Compressed chambers in the uniserial stage with horizontal sutures.

Clavulina parisiensis d'Orbigny.

Clavulina parisiensis d'Orbigny 1826, p.268, modele no.66; Cushman 1937, p.18, Pl.2,. figs.22-26; Kaaschieter 1961, Pl.1, figs.27-28; Loeblich and Tappan 1988, p.182, Pl.200, figs.1-5.

Remarks.

Differs from Clavulinoides anglicus (Cushman) in having more compressed chambers in the uniserial stage, with sutures that are more perpendicular to the test wall. Often poorly preserved in the North Sea. Kaaschieter (1961) noted this species in the Middle Eocene, 'Lutetian'. It was recorded in this study in the early Late Palaeocene, Zone AB1.

3.3.3. Planktonic Foraminifera.

SUPERFAMILY: GLOBIGERINACEA Carpenter, Parker and Jones, 1862.

FAMILY: GLOBIGERINIDAE Carpenter, Parker and Jones, 1862.

SUBFAMILY: GLOBULIGERININAE Loeblich and Tappan, 1984.

GENUS: Globastica Blow 1979.

Notes.

Low to high trochospire, small tapering inner whorl. Shallow umbilicus. Primary aperture a low arch, axiointraumbilical to anterointraumbilical. Walls thin and microperforate, without pore-pits and inter-pore ridges. Surface covered in muricae. Variable development of sutural openings and bullae.

Globastica daubjergensis (Brönnimann).

Pl.21, fig.4a-e.

Globigerina daubjergensis Brönnimann 1953, p.340, fig.1; Troelsen 1957 (partim), p.128, pl.30, fig.2, (NOT pl.30, fig.1); Hofker 1962, pp.1068, 1070, fig.22a; Postuma 1971, p.148-149; Stainforth et al. 1975, p.181, fig.45.

NOT Globoconusa conusa Khalilov 1956, p.249, pl.5, fig.2.

Globoconusa daubjergensis (Brönnimann). Olsson 1970 (partim) (NOT Globoconusa conusa Khalilov), pp.598-601 (text-references only), pl.92, figs.2,6. (NOT pl.92 fig.5a-b); King 1983, p.12, 36; Toumarkine and Luterbacher 1985, p.106, fig.11, (6-7).

Globastica daubjergensis (Brönnimann). Blow 1979, pp.1235-1240, pl.74, fig.7-9, pl.256, fig.1-9, pl.257, fig.3-4.

Globigerina kozlowskii Brotzen and Pozaryska 1961, p.162, pl.1, figs.1-14, pl.2, figs.1-17, pl.3, 6 figs., pl.4, figs.5-6.

Globigerina kozlowskii Brotzen and Pozaryska, emend Moorkens 1971, pp.859-860, pl.3, fig.1a-d [topotype].

Notes.

Final whorl of 3 to 4 spherical to ovate chambers which rapidly increase in size. Sutures depressed and radial.

Remarks.

The type of *Globoconusa* Khalilov 1956 (that is *G. conusa* Khalilov) is different from *Globigerina daubjergensis* Bronnimann 1953 in that the test wall of *G. conusa* is "strongly thickened" (Khalilov 1956 p.249, Blow 1979 p.1232), and the test is much more conical and lacks an umbilicus. *Globoconusa* is referable to the superfamily Heterohelicacea. Loeblich and Tappan (1988, p.474) consider *Globastica* to be a junior synonym of *Globoconusa*, because they dispute Blow's (1979) identification of *conusa*, but they have not seen Khalilov's types.

Stratigraphical range.

Occurs sporadically in Blow's (1979) $P\alpha$, but commonly in Zone P1 (NSP1a/NSB1a, NP1 to base of NP3) to Zone P2 (NSP1b/NSB1a, NP3), Early Palaeocene Danian to ?early part of the Thanetian (s.l.).

SUBFAMILY: GLOBIGERININAE Carpenter, Parker and Jones, 1862.

GENUS: *Globigerina* d'Orbigny, 1826.

Notes.

Test surface spinose. Macroperforate. 3 to 5 chambers per whorl. Coiling usually trochospiral. Intraumbilical primary aperture, with no secondary ones. Periphery lobulate.

Globigerina ampliapertura Bolli.

Pl.21, fig.5.

Globigerina ampliapertura Bolli 1957, p.108, pl.22, figs.4-7; Hofker 1968, p.17, pl.7, fig.2; Blow 1969, p.315, 349, 382, pl.12, fig.6, 9-10; Stainforth *et al.* 1975, p.248 fig.102; Blow 1979, p.112, pl.12, fig.10; King 1983, p.11, 35, fig.4.

Globigerina ampliapertura ampliapertura Bolli. Blow and Banner 1962, pp.83, 130-131, pl.11, figs.A-D, pl.17, figs.C,H.

Globigerina (Globigerina) ampliapertura Bolli. Jenkins 1971, p.137, pl.15, figs.428-425.

Notes.

Very small umbilicus with an anterointraumbilical smooth-rimmed aperture. 4 chambers in final whorl. Surface with narrow pore-pits and knobbly spine-bases.

Remarks.

Closely resembles and intergrades with *"G." increbescens*. Most examples found are poorly preserved representatives of *G. ampliapertura*.

Stratigraphical range.

A useful index form, limited to the Late Eocene and early Oligocene. King (1983), notes this species in his NSP9 (Diatom sp.3 Zone). He points out that planktonic foraminifera commonly occur within this Zone, such as *G. ampliapertura*, but more studying is required to define their vertical distribution. Range according to Blow (1979) from P17 to P19/20 Zones.

Globigerina aff. *angulisuturalis* Bolli.

see *Globigerina ciperoensis angulisuturalis* Bolli 1957, p.109, pl.22, fig.11.

see *Globigerina angulisuturalis* Bolli. Blow and Banner 1962, p.84, pl.9, figs.Aa-Cc; Blow 1969, pp.219, 316, 379, pl.4-6, pl.12, figs.1-2; Stainforth *et al.* 1975, p.250, fig.104.

see *Globigerina concinna angulisuturalis* Bolli. Bandy 1964, p.8, 12.

aff. *Globigerina (Globigerina) ciperoensis angulisuturalis* Bolli. Jenkins 1971, p.143, pl.15, figs.448-450.

see *Globigerina (Globigerina) angulisuturalis* Bolli. Kennett and Srinivasan

1983, p.32, pl.5, figs.1-3.

Notes.

Umbilicus small. Low trochospiral coil. Anterointraumbilical aperture. Intercameral sutures of the last whorl weakly excavated. Surface hispid.

Remarks.

This is an intermediate form of G. angulisuturalis, developing along the G. officinalis Subbotina-G. anguliofficinalis Blow lineage. Its size and shape are correct for G. angulisuturalis, but the sutures are not so excavated.

Bolli (1957), originally referred to 3 subspecies; G. ciperoensis ciperoensis, G. ciperoensis angustiumbilicata, and G. ciperoensis angulisuturalis. However, the types of, G. ciperoensis angustiumbilicata Bolli are now known to be Tenuitellid, being microperforate and generically different from the other two taxa (Li Qianyu, 1987). G. ciperoensis ciperoensis was described on a typically advanced form, which had a wide umbilicus. G. angulisuturalis was also described on its typical form with deeply excavated sutures. There is also intergradation between the forms which have a broadening of the umbilicus and the 5 chambers which leads to G. ciperoensis, and the forms which show retention of a fairly narrow umbilicus which leads to G. angulisuturalis. The sutures in G. aff. angulisuturalis are neither very deeply excavated, nor is the umbilicus particularly small; it is within the plexus noted above.

Stratigraphical range.

Range of G. angulisuturalis s.str.: Zone P21 (Late Oligocene) of Blow 1969 (King's 1983 Zones NSP9/NSB8, partim, nannoplanton Zone NP24) to Zone N4 (Early Miocene, King's Zones NSP10/NSB9, nannoplankton Zone NN1). A useful index species. As this form is early in its development towards G.

angulisuturalis s.str. it is probably in the early part of *G. angulisuturalis* s.str. range. Rare in wells studied.

Globigerina ciperoensis Bolli.

Pl.21, figs.6-7.

Globigerina concinna Reuss. Nuttall 1932, p.29, pl.6, figs.9-11.

Globigerina ciperoensis Bolli 1954, pp.1-3, figs.3-4; Hofker 1968, pp.14-16, pl.6, fig.7, h-k; Stainforth *et al.* 1975, p.263, fig.111.

Globigerina ciperoensis ciperoensis Bolli. Bolli 1957, p.108, pl.22, fig.10.

Globigerina ouachitaensis ciperoensis (Bolli). Blow and Banner 1962, pp.90-91 fig.9, i-iii, pl.9, figs.E-G; Blow 1969, p.320, pl.1 figs.4-6; Berggren 1969, p.111.

Globigerina concinna ciperoensis Bolli. Bandy 1964, pp.8,12, fig.5.

Globigerina (Globigerina) ciperoensis ciperoensis Bolli. Jenkins 1971, p.145, pl.14, figs.411-413.

Globigerina (Globigerina) ciperoensis Bolli. Kennett and Srinivasan 1983, p.28, pl.4, figs.6-8.

Notes.

Low trochospiral coil, with 5 spherical chambers in the last whorl. Sutures radiate both sides, depressed, not excavated. Aperture axiointraumbilical. Surface hispid.

Remarks.

Differs from *Tenuitellinata angustiumbilicata* (Bolli) in being smaller, having a macroperforate wall, a larger umbilicus and no apertural lip. Differs from *G. angulisuturalis* Bolli which has excavated 'U'-shaped sutures, and a marked lip over the aperture.

Stratigraphical range.

Late Oligocene Zone P19 of Blow 1969 (NSP9/NSB7 partim, nannoplankton Zone NP22/23) to Earliest Miocene Zone N4 (King's NSP10/NSB9 partim, nannoplankton Zone NN1). Commonly occurs in Late Oligocene but rare in Early Miocene.

Globigerina eocaena Gumbel.

Pl.21, fig.8.

Globigerina eocaena Gumbel 1868, p.84, pl.2, fig.109a; Hagn 1956, p.170, pl.16, figs.1-2; Stainforth *et al.* 1975, pp.268-270 fig.115.

Globigerina (Subbotina) eocaena Gumbel. Hagn and Lindenburg 1966, pp.342-358, pl.1, figs.1-6.

Globigerina ouachitaensis (non Howe and Wallace). Bandy 1949, p.121, pl.23, fig.4a-c.

Globigerina pseudoeocaena var. *pseudoeocaena* Subbotina 1953, pl.4, fig.9, pl.5, figs.1-2,6; Pokorny 1960, pl.3, fig.3.

? *Globigerina yeguaensis* Weinzerl and Applin 1929, p.408, pl.43, fig.1; Bolli 1957, p.163, pl.35, figs.14?-15; Blow 1969, p.319, pl.3, figs.12-14.

? *Globigerina yeguaensis yeguaensis* Weinzerl and Applin. Blow and Banner 1962, pp.99,141-144, fig.13, fig.H-M.

? *Subbotina yeguaensis* (Weinzerl and Applin). Srinivasan 1968, p.149 pl.16 figs.1-3.

Notes.

4 subspherical inflated chambers in the last whorl, gradually increasing in size. Sutures depressed. Aperture with elongated lips (straight or slightly curved), mainly axioumbilical, has a slight tendency to become anterointraumbilical. Final chamber may have a bulla over the aperture. Surface cancellate.

Remarks.

Neotype of this species refigured by Hagn and Lindenburg (1966, paper in Russian). According to these authors there is a close connection or transition to *G. yeguaensis* Weinzerl and Applin. *G. yeguaensis* is morphologically very similar, but according to Hagn and Lindenburg differs because of a greater chamber size increase in the last whorl. These authors also suggest that *Globigerina corpulenta* Subbotina 1953, is closely related to *G. eocaena*, but differs in having a more conical spire, slightly embracing final chambers, together with irregularly shaped and normal bulla. Also closely related is *G. gortanii* (Borsetti) which has an even higher spire than *G. corpulenta* (see fig.4 in Hagn and Lindenburg, p.354).

Stainforth *et al.* (1975) regard *G. eocaena* as a standard form within the intergradational plexus of the "*G. linaperta* Finlay group" (see Stainforth *et al.* fig.128 p.292). They believe that the distinction between *G. yeguaensis* and *G. eocaena* is too tenuous to maintain, so the former is regarded as a subjective junior synonym.

In Hagn and Lindenburg's discussions concerning the generic status of this species they point out that *G. eocaena* could be placed into the genus *Catapsydrax* Bolli, Loeblich and Tappan, due to the presence of a bullate structure and accessory apertures in the umbilical area. However, Bandy (1949) called such end chambers "characteristics of doubtful species value". Hagn and Lindenburg argue that as the presence or absence of "bullae" is variable in *G. eocaena*, the genus *Catapsydrax* is not valid. I believe that the consistent presence of a bulla is of taxonomical value and therefore *Catapsydrax* is valid. But, it is uncertain as to whether *G. eocaena* belongs to this genus, as the bulla is not present in North Sea forms. It seems that the bullate structure in *G. eocaena* is not a true bulla.

Hagn and Lindenburg also refer G. eocaena to the "subgenus" Subbotina Brotzen and Pozaryska 1961, the type species of which is Globigerina triloculinoides Plummer. It can be differentiated from Globigerina by its smooth wall surface with no visible spine bases, but macropreforations which are clear. Many of the Subbotina species also have strong apertural lips. Regardless of the point of view expressed by Hagn and Lindenburg G. eocaena does not fit the characteristics of Subbotina, and it is distinguishable as a Globigerina.

Stratigraphical range.

This species occurs mainly in the middle and Upper Eocene. It also occurs in the early Oligocene. It has a cosmopolitan distribution (see Lindenburg, 1969).

Globigerina cf. falconensis Blow.

Pl.21, fig.9.

see Globigerina falconensis Blow 1959, p.177, pl.9, figs.40a-c, 41.

Remarks.

Similar in wall structure to Globorotaloides suteri Bolli. This is a very thick walled form similar to Zeaglobigerina of Kennett and Srinivasan (1983, p.42). Aperture rather slit-like, anterointraumbilical. Has a heavy lip, rather like typical Globigerina falconensis.

Blow (1969, pl.60, fig.1) illustrates a 'metatype' which has a very heavily cancellate wall, with a thick porticus-like lip over a low aperture. Examples from the North Sea have a fairly high aperture, shallowly depressed sutures, and are heavily calcified.

Stratigraphical range.

Zone N7 (Early Miocene) to Recent. Blow's original from the

Miocene. Range not proven.

Globigerina [*Subbotina*] *linaperta* Finlay.

Globigerina linaperta Finlay 1939, p.125, pl.13, figs.54-57; Stainforth *et al.* 1975, p.201, fig.63.

Globigerina ex. gr. *linaperta* Finlay. King 1983, p.36, pl.6, fig.4.

Notes.

Globular chambers, 3½ in final whorl. Low trochospire. Surface has well defined perforations on all chambers. Aperture a slightly twisted anteriointraumbilical arch, with a faint rim. Distinct, depressed sutures. Open, narrow, shallow umbilicus. Surface smooth, not spinose; because of this, this species is often referred to *Subbotina* Brotzen and Pozaryska, but Hemleben (verb. comm.) claims that spines are present although only in the umbilical apertural region; spinosity would require this species to be refered to *Globigerina* (see also notes on *G.* [*S.*] *triloculinoides*, and Appendix C).

Stratigraphical range.

From within P4 (M./Late Palaeocene, King's NSP3 NSB1b, nannoplankton Zones NP6-8)) to within Zone P16 (Late Eocene, NSP9/NSB6b, nannoplankton Zones NP19/20).

Globigerina [*Subbotina*] *triloculinoides* Plummer.

Pl.22, fig.1a-b.

Globigerina triloculinoides Plummer 1926, p.134, pl.8, fig.10a-c; Moorkens 1971, p.860, pl.4, fig.1a-d, fig.3a-b; Stainforth *et al.* 1975, p.234, fig.92; King 1983, pl.6, fig.6,7; Toumarkine and Luterbacher 1985, p.117, figs.19.1-2.

Notes.

3-3½ chambers in the final whorl. Trilobate equatorial outline.

Aperture anterointraumbilical, with lip.

Remarks.

G. triloculinoides is the type species for the genus *Subbotina* Brotzen and Pozaryska 1961. This genus has been regarded as being non-spinose, and as having a distinct porticus-like lip. However, *G. triloculinoides* does in fact have spine bases near the base of the last chamber, as shown by Hemleben at the meeting of the Palaeogene Planktonic project at B.P. Research Centre at Sunbury in August 1987. The presence of this porticus-like lip is not viable as a generic characteristic, as other species of *Globigerina* (for example, *G. falconensis* Blow 1959, Early Miocene to Recent) also possess a similar feature. The nature of the aperture is also a questionable basis for generic distinction as other examples of *Globigerina* (for example *G. ampliapertura* Bolli 1957, Late Eocene/Early Oligocene?) and *Eoglobigerina* (for example *E. trivialis* (Subbotina, 1953), Danian to Early Thanetian, Palaeocene), have similar apertures. The genus *Subbotina* needs further investigation.

Stratigraphical range.

Zone P1b (Early Paleocene, NSP1a/NSB1a, nannoplankton Zone NP2) to top of Zone P6 (E. Eocene, NSP4-5/NSB2-3, NP9-11), with some doubtful *G. triloculinoides* in the early part of P7 (after Blow, 1979). Stainforth *et al.* state that *G. triloculinoides* occurs only in the Paleocene. Blow (1979) placed *G. quadritriloculinoides* Khalilov 1956, into the synonymy of *G. triloculinoides triloculinoides* Plummer.

Globigerina officinalis Subbotina.

Globigerina officinalis Subbotina 1953, p.78, pl.11, fig.1-7: Blow and Banner 1962, p.88, fig.16, pl.9, fig.A-C; Blow 1969, p.320, pl.1, figs.1-3; Stainforth *et al.* 1975, p.211, fig.71.

Notes.

4 subglobular chambers in the last whorl. Low trochospiral coil. The low arched aperture is typically axiointraumbilical, but may become anterointraumbilical, bordered by a thin imperforate lip. Sutures radiate on the umbilical side and quite strongly depressed. Surface hispid. Densely perforated with strong spine bases, especially on the last formed chamber.

Remarks.

Found in London Clay as well as N. Sea samples.

Stratigraphical range.

G. officinalis ranges from Zone P13? (M. Eocene, NSP8/NSB5-6a, nannoplankton Zone NP16) to P22 (Late Oligocene, NSP9/NSB8, nannoplankton Zone NP25).

Globigerina praebulloides Blow subsp. occlusa Blow and Banner.

Pl.22, fig.2.

Globigerina cf. trilocularis d'Orbigny. Bolli 1957 (partim), (not G. trilocularis Deshayes 1832), p.110, pl.22, fig.9a-c (not fig.8a-c), pl.36, fig.3a-b.

Globigerina praebulloides Blow subsp. occlusa Blow and Banner 1962, p.93, pl.9u-w, fig.14(i-iii).

Notes.

Very small umbilicus, and very low aperture which lacks a lip or rim. 3 to 4 subglobular to ovoid chambers in the final whorl. Broadly rounded axial periphery. Strongly lobulate equatorial periphery. Distinct, broadly and deeply depressed sutures. Surface hispidocancellate.

Remarks.

The specimen chosen for the holotype of this species by Blow and Banner (1962) is not (according to Banner pers. comm.) typical G.

praebulloides *occlusa* as the name was subsequently used. *G.* *praebulloides* *occlusa* s. str. (that is the holotype form) is very rare, and occurs in the Eocene/Oligocene. The paratypes shown in Blow and Banner (1962) are not the same, having a different wall surface and even chamber shape.

G. *praebulloides* of Kennett and Srinivasan (1983, p.36, figs.1-3) is very similar to *G.* *praebulloides* *occlusa*. In the later the aperture becomes low and slit-like as in *Globigerinoides* *primordius* Blow and Banner and *Globigerinoides* *quadrilobatus* (d'Orbigny).

G. *praebulloides* *occlusa* differs from *G.* *praebulloides* *praebulloides* in having a smaller, shallower umbilicus, and a smaller, lower aperture without lip or rim.

Globigerina *praebulloides* Blow subsp. *praebulloides* Blow.

Pl.22, fig.3.

Globigerina *praebulloides* Blow 1959, pp.180-181.

Globigerina cf. *trilocularis* d'Orbigny. Bolli 1957 (partim), p.110, pl.22, fig.8a-c (not fig.9a-c).

Globigerina *praebulloides* Blow subsp. *praebulloides* Blow, emend. Blow and Banner 1962, pp.92-93, pl.9, figs.O-Q.

Notes.

Has a smaller umbilicus and lower, narrower aperture than its immediate descendent, *G.* *bulloides* d'Orbigny.

Stratigraphical *range.*

Upper Eocene, base of '*Porticulosphaera*' *semiinvoluta* (Keijzer) Zone (genus after Blow, 1979, P15 of Blow 1969, base of King's 1983 NSP9 and top of NSB6 Zones, equivalent to nannofossil Zones NP18-NP19), to the *Globorotalia* *cultrata* (d'Orbigny)/*Globigerina* *nepenthes* Todd Zones (N14 Middle

Miocene Zone of Blow 1969, NSP12? and NSB11 of King 1983, nannoplankton Zone NN7-10?).

Globigerina woodi Jenkins.

Globigerina woodi Jenkins 1960, p.352, pl.2, fig.2a-c.

Globigerina (Zeaglobigerina) woodi Jenkins. Kennett and Srinivasan 1983, p.43, pl.7, figs.4-6.

Notes.

4 chambers in the final whorl. Surface coarsely pitted with regular hexagonal perforation pits. Open umbilicus. Aperture axiointraumbilical, high arched, bordered by thick rim.

Remarks.

The specimens examined for this thesis tend to be higher spired than most typical *G. woodi*. Grading occurs between the subspecies *G. woodi woodi* and *G. woodi connecta*. Some forms noted from the North Sea have sutures similar to *G. woodi connecta*, in that they are not as deeply incised as *G. woodi woodi*, but, on the other hand, the aperture is as high as in *G. woodi woodi*. Some specimens do not have a particularly distinct apertural rim, as in *G. woodi connecta*.

Stratigraphical range.

Late Oligocene?/Early Miocene *Globorotalia kugleri* Bolli Zone (N4/top of P22 of Blow (1969), King's (1983) base of NSP10, base of NSB9 Zones, nannoplankton zone NN1) to Late Pliocene/Pleistocene *Globorotalia tosaensis* Takayanagi and Saito Zone (N21 of Blow 1969, King's NSP16, NSB15, nannoplankton Zone NN18).

GENUS: *Catapsydrax* Bolli, Loeblich and Tappan, 1957.

Notes.

Differs from *Globigerinita* Bronnimann 1951 in being macroperforate and spinose. The bulla may be an irregular feature, but in this genus every individual of a particular species, regardless of the size of the specimens, has a similar bulla, with approximately the same bullate apertures.

Catapsydrax unicavus unicavus Bolli, Loeblich and Tappan 1957.

Pl.22, fig.4.

Catapsydrax unicavus Bolli, Loeblich and Tappan 1957, p.37, pl.7, fig.9a-c; Blow 1959, p.204, pl.15, fig.94a-c.

Globigerinita unicava unicava (Bolli, Loeblich and Tappan). Blow and Banner 1962, pp.113-114, pl.14, figs.M,N.

Notes.

4 to 4½ chambers in final whorl. Dorsal side slightly more convex than ventral. Dorsal sutures depressed. Dorsal intercameral sutures slightly curved to subradial. Spiral suture lobulate. Ventral intercameral sutures subradial, deeply depressed. Ventral umbilicus broad and deep, almost entirely covered by weakly inflated bulla. Single narrow accessory aperture extends along margin of bulla, with weak lip (thin rim). Macroperforate surface with narrow pore-pits.

Stratigraphical range.

According to the type description *Catapsydrax* only occurs in beds younger than the Upper Eocene. Ranges from the *Globigerina ampliapertura* Zone P19/20 (NSP9, NSB7, NP22-24) into the *Globigerinita stainforthi* Zone N6 (NSP10/11 [partim], NSB9/10 [partim], NN3 [partim]).

Catapsydrax unicavus primitivus (Blow and Banner).

Catapsydrax unicavus Bolli, Loeblich and Tappan. Bolli 1957, p.166, pl.37, fig.7a-b.

Globigerinita unicava primitiva Blow and Banner 1962, p.114, pl.14, figs.J-L.

Notes.

4 chambers in last whorl. Dorsal intercameral sutures initially curved, become subradial between last two or three chambers. Ventral intercameral sutures weakly curved to subradial. Umbilicus covered by broad and inflated bulla. Aperture without rim or lip. Surface weakly hispid, macroperforate with narrow pore-pits.

Remarks.

C. unicavus primitivus differs from *C. unicavus unicavus* in having more strongly "vaulted ventral surfaces to the primary chambers" (Blow and Banner 1962, p.114). It also has a more inflated bulla and the later chambers are more 'depressed'.

Stratigraphical range.

According to Blow (1979) this species ranges from within ?Zone P13-P14 to within Zone N1 (=P20).

GENUS: *Globigerinoides* Cushman 1927.

Notes.

Wall macroperforate, spinose. Low to high trochospiral coil with globular to ovate chambers. Primary aperture intraumbilical, supplementary ones along the spiral suture as irregular slits.

Globigerinoides quadrilobatus trilobus (Reuss).

Pl.22, fig.5.

Globigerina triloba Reuss 1850, p.347, pl.47, fig.11; Banner and Blow 1965, p.20, pl.3, fig.8, pl.4, fig.16-8.

Globigerinoides triloba triloba (Reuss). Bolli 1957, p.112, pl.25, fig.2.

Globigerinoides quadrilobatus trilobus (Reuss). Blow and Banner 1962, p.137.

Globigerinoides quadrilobatus triloba (Reuss). Stainforth et al. 1975, p.310, fig.138; King 1983, p.36, pl.6, fig.7.

Notes.

Chambers rapidly enlarging, so that the last chamber is approximately equal in volume to the whole previous test. Sutures depressed. Coarse cancellate wall. 3 chambers visible on umbilical side, all chambers being symmetrical, subglobular. One supplementary aperture per chamber on spiral side.

Remarks.

Types of G. quadrilobatus trilobus have now been lost, therefore this name has been applied to a broad range of similar forms. Differs from G. quadrilobatus s.str. in having 3 not 4 chambers visible on umbilical side, and from the subspecies G. quadrilobatus sacculifer (Brady) in having regular development of adult chambers.

Stratigraphical range.

Zone N4 to Recent. Useful marker for Neogene and Quaternary.

GENUS: Globorotaloides Bolli 1957.

Notes.

Wall coarsely perforate, cancellate. Low trochospiral coil. 4 to 6 ovate to spherical chambers in the final whorl. Early part of test has anterointraumbilical-extraintraumbilical aperture, later chambers have intraumbilical aperture; each may be covered by a bulla-like chamber.

Globorotaloides suteri Bolli.

Pl.22, fig.6.

Globorotaloides suteri Bolli 1957, p.117, pl.27, figs.9a-13b; Blow and Banner 1962, p.122, pl.13, figs.N-P; Blow 1969, p.374; Berggren 1969, pp.130-131; Jenkins 1971, pp.189-190, pl.22, figs.646-648; Stainforth *et al.* 1975, pp.322-323, fig.146; Blow 1979, p.176; Kennett and Srinnivasan 1983, p.214, pl.53, figs.1,3-5; Bolli and Saunders 1985, p.190, figs.18.10,11.

?*Globigerina globularis* Batjes 1958 (non Roemer), pp.161-162, pl.11, figs.3,5.

Notes.

Depressed spiral sutures, curved to radiate. Umbilical sutures depressed and radial.

Remarks.

Globorotaloides differs from *Catapsydrax* Bolli, Loeblich and Tappan, in its wall, which is coarsely perforate but not spinose (*Catapsydrax* has a spinose wall), and in its initial coiling. The early growth stages of *Globorotaloides* have a *Neogloboquadrina*-like aperture (as noted in the above description). *Catapsydrax* is like a *Globigerina* throughout.

Several authors regard *Globorotaloides suteri* as a *Globoquadrina* Finlay, because the wall is similar and the latter has the same growth shift in apertural position as in *Globorotaloides suteri* (that is, in the latter the aperture is umbilical-extraumbilical in the early stage, later becoming intraumbilical). However, *G. suteri* has a bulla but no umbilical teeth (see Kennett and Srinivasan 1983, p.214, pl.53, figs.1, 3-5). *Globorotaloides variabilis* Bolli, the type species of the genus *Globorotaloides*, has a very Globorotalid form in its juvenile stage (see Kennett and Srinivasan 1983, *G. variabilis* pl.53, figs.2, 6-8). In the adult form the aperture is more intraumbilical, and the bulla is present. *G. variabilis* has less inflated early chambers, more curved sutures and more chambers than *G. suteri*.

Several of the forms observed from the North Sea did not possess a bulla, but had a reduced end chamber.

Stratigraphical range.

Long ranging, from mid-Eocene to Early Miocene. First described from the Oligocene, basal part of the Cipero Formation, Globigerina ampliapertura Bolli P19/20 Zone (NSP9/NSB7, approximately NP22/24). Most common and typical in that Zone. Ranges up to the Globigerinatella insueta Cushman and Stainforth Zone N7 of Blow 1969 (NSP11/NSB10 of King 1983, top of NN3 and NN4 nannoplankton Zones).

SUBFAMILY: SPHAEROIDINELLINAE Banner and Blow, 1959.

GENUS: Sphaeroidinellopsis Banner and Blow, 1959.

Notes.

Low trochospiral coil. 3 to 4 chambers in the final whorl. Broadly rounded periphery. Perforate wall. Surface covered by smooth cortex which reduces the external perforation-diameter and obscures them. Aperture intra-umbilical.

Sphaeroidinellopsis subdehiscens (Blow).

Pl.22, fig.7.

Sphaeroidinella dehiscens (non Parker and Jones). Stainforth 1948, p.124, pl.26, fig.20.

Sphaeroidinella dehiscens subdehiscens Blow 1959, p.195, pl.12, figs.71-72.

Sphaeroidinellopsis subdehiscens (Blow). Banner and Blow 1959, p.15, fig.5; Stainforth et al. 1975, p.410, fig.205; King 1983, pp.35-36, pl.6, fig.34.

Sphaeroidinellopsis subdehiscens subdehiscens (Blow). Blow 1969, p.338, pl.30, figs.3,6.

Sphaeroidinella subdehiscens Blow. Postuma 1971, pp.388-389.

Notes.

3 chambers in the last whorl of nearly equal size. Sutures of last whorl slightly depressed, distinct. Slit-like aperture, often obscured by thickened cortex.

Remarks.

Differs from S. seminulina (Schwager, 1866) in having 3, not 4 chambers in last whorl, and in having a thicker cortex.

Stratigraphical range.

King (1983) uses S. subdehiscens as a marker species for his NSP12 Zone Middle Miocene. Form ranges from M. Miocene to Late Miocene. According to Blow (1979), it ranges from N13 to N19.

SUBFAMILY: TENUITELLINAE Banner 1982, emend Li Qianyu 1987.

GENUS: Tenuitella Fleisher, 1974.

Notes.

Low to medium trochospire. Wall microperforate throughout and pustulate. Umbilicus small but open. Aperture anteriointraumbilical-extraumbilical, without bulla. Tenuitella differs in its microperforate wall from Globigerina which has a macroperforate one.

The tenuitellids have been largely ignored in biostratigraphy because of their small size, and inadequately defined systematics. It is only since the paper by Li Qianyu (1987) that it has been possible to study and record them. Li had few samples, so the stratigraphy of the species of this subfamily has yet to be assessed.

Tenuitella munda (Jenkins).

Pl.22, fig.8.

Globorotalia munda Jenkins 1966, pp.1121-1122, fig.14, nos.126-133.

Tenuitella munda (Jenkins), Li Qianyu 1987, p.310, pl.2, fig.13 (see fig.3: 7-9).

Notes.

Description emended by Li Qianyu (1987). Medium trochospire. 4 globular chambers in the final whorl. Small, open umbilicus. Aperture anterointraumbilical to extraumbilical. Microperforate wall.

Remarks.

Rare in wells studied. Examples of this species from the North Sea Tertiary had elongated chambers atypical of T. munda s.s., as in Li Qianyus figure 13, plate 2.

Stratigraphical range.

Recorded by Jenkins (1966) in the Early Oligocene, and the specimen figured by Li (1987) is from the Globigerina ampliapertura Zone. Either the age of this species must be extended, or this specimen (plate 22, fig.8) is reworked.

SUBFAMILY:GLOBIGERAPSINAE Blow, 1979.

GENUS: Globigerapsis Bolli, Loeblich & Tappan, 1957.

Notes.

Almost globular test. Trochospiral coil, becoming streptospiral in ontogeny. Final chamber envelops most or all of the umbilical side of the test. Macroperforate. Primary aperture umbilical, which may be covered by final chamber that has secondary apertures along the margin. Sutures distinct, depressed. Early coiling is acarininid and thus differs from the globigerine early coiling of all the Porticulosphaerinae.

Globigerapsis index index (Finlay).

Pl.22, fig.9.

Globigerinoides index Finlay 1939, p. 125, pl.14, figs.85-88; Hornibrook 1958, p.35, pl.1, figs.11-14.

Globigerinoides macrostoma Hagn 1956, pp.173-174, pl.16, fig.11a-b (holotype).

Globigerapsis index (Finlay). Bolli 1957, p.165, pl.36, figs.17-18 (not 14a-16); Blow and Banner 1962, pp.124-125, pl.15, figs.g-h; Blow 1979, p.132, pl.27, figs.1-2, pp.1141-1143, pl.174, figs.24,7-8, pl.181, fig.1, pl.183, fig.1-2, pl.186, figs.2-3, pl.192, fig.1.

Globigerinatheka (Globigerapsis) index index (Finlay). Jenkins 1971, pp.187-188, pl.22, figs.641-645.

Globigerinatheka index index (Finlay). Bolli 1972, p.124, figs.51-57, 63-64, pl.1, figs.1-4, 6-7; Toumarkine and Luterbacher 1985, p.142, figs.38.20-24.

Globigerinatheka index (Finlay). Stainforth *et al.* 1975, p.194, fig.56; King 1983, p.8, 11, pl.6, fig.6.

Notes.

Robust, thick, muricate wall. Deeply incised sutures. Adult test may have single large primary aperture with 2 to 3 secondary arched apertures on final chamber where it 'envelops' earlier test. Apertures usually not covered by bullae (see Toumarkine and Luterbacher, 1985 p.140).

Remarks.

Rare in North Sea sediments examined. Those specimens observed are usually without bullae.

Bolli (1972) states that as the presence or absence of a bulla varies from species to species (*Globigerapsis index* for example may or may not have a bulla, see Bolli 1972 fig.54 for non-bullate form, and fig.57 showing a bullate one).

Blow (1979, p.1133) states that in *Globigerapsis* there is "no single external primary aperture in adult forms, but multiple, arched sutural apertures occur". This is not the case in *Globigerapsis index*, which often has a single primary aperture plus multiple arched sutural openings. Blow's work was written before his death in 1972 and before the publication of Bolli's 1972 paper. Blow based the definition of his species mainly on the structure of the test wall as seen in the S.E.M. Loeblich and Tappan (1987, p.492) follow Blow in separating these genera "on the basis of the spinose wall of *Globigerinatheka*, and muricate one of *Globigerapsis*".

Globigerapsis index index differs from *G. index tropicalis* (Blow and Banner) in having thicker walls and more incised sutures. It has a lower spire than *G. index rubriformis* (Subbotina), (see Toumarkine and Luterbacher 1985, p.142). Blow (1979, pp.793-794, pl.27, figs.5-6, pl.198, figs.1-5) places *G. index tropicalis* into synonymy of "*Porticulosphaera*" *mexicana mexicana* (Cushman).

Stratigraphical range.

This species ranges from within the *Globigerinatheka subconglobata* (Shutskaya) Zone of Stainforth *et al.* (1975, p.62), Middle Eocene, to within the "*Porticulosphaera*" *semiinvoluta* (Keijzer) Zone, Late Eocene. According to Blow (1979) ranges from P10 to P?17. Occurs in NSP8 of King (1983), NSB5 (partim) to NSB6a. Approximately nannoplankton zone NP16.

FAMILY: GLOBIGERINIDAE Carpenter, Parker and Jones.

SUBFAMILY: HASTIGERININAE Bolli, Loeblich and Tappan, 1957.

GENUS: *Pseudohastigerina* Banner and Blow, 1959.

Notes.

Adult chambers planispiral, biumbilicate. Sutures radial, straight to slightly curved. Periphery may be narrowly to broadly rounded. Aperture equatorial, at base of final chamber, low arch with distinct lip. Wall macroperforate.

Pseudohastigerina wilcoxensis (Cushman and Ponton).

Pl.22, fig.10.

Nonion wilcoxensis Cushman and Ponton 1932, p.64, pl.8, fig.11.

Hastigerina eocenica Berggren 1960, pp.85-91, pl.5, figs.1-2, pl.10, fig.2.

Pseudohastigerina wilcoxensis (Cushman and Ponton). Berggren, Olsson and Reyment 1967 (partim?, see Blow 1979), pp.278-280, fig.2-6; Stainforth *et al.* 1975, p.243, fig.99; Blow 1979, pp.1193-8, pl.252, figs.1-4; King 1983, p.12, pl.6, figs.32-33 (plus figs.30-31?).

Notes.

6/7 chambers in the final whorl, which increase regularly in size. Broadly rounded periphery. Radial to slightly curved sutures. Planispire often slightly assymetric and pseudotrochospiral.

Remarks.

This species is generally larger than *P. micra* (Cole) and is less inflated, has more radial intercameral sutures, has more umbilically inflated chambers, and has better separated less closely appressed and less closely-set chambers. The two species are linked by intermediate forms. King's interpretation of *P. micra* (1983, pl.6, figs.30-31) is more akin to *P. wilcoxensis.*

Loeblich and Tappan (1964, p.C665, and 1987, pp.485-486) regard *Pseudohastigerina* as a junior synonym of *Globanomalina* Haque 1956, but they do not distingiush between the adult planispirality and macroperforations of the former, and the trochospirality and microperforations of the latter.

Stratigraphical range.

Late Paleocene into Middle Eocene, Stainforth *et al*'s *Globorotalia* pseudomenardii Bolli Zone (P4, NSP3/NSB1b, NP6-8) to Globorotalia lehneri Cushman and Jarvis Zone (P12, top of NSP7 base of NSP8, part of NSB6, top of NP15 base of NP16). In King 1983 the top of his NSP7 Zone, is defined by the highest occurence of his P. micra (see King 1983, p.11) equivalent in age to P10-middle of P12, and the bottom two thirds of King's benthonic Zone NSB5, Middle Eocene.

SUBFAMILY: EOGLOBIGERININAE Blow, 1979.

GENUS: Globanomalina Haque 1956.

Notes.

Low trochospiral test. Aperture extraumbilical-umbilical, a low arch with a distinct lip. Periphery rounded to subacute in side view. Surface microperforate, with weak pore-pits but no pustules, muricae or spines.

"Globanomalina" compressa (Plummer).

Pl.22, fig.11.

Globigerina compressa Plummer 1926 (1927), p.135, pl.8, fig.11.

Globigerina compressa var. compressa Plummer. Subbotina 1953, pp.55-56, pl.2, figs.4-5.

Globorotalia compressa (Plummer). Bolli 1957a, p.77, pl.20, figs.21-23; Postuma 1971, pp.186-187; Stainforth et al. 1975, p.178, fig.43; King 1983, p.12, pl.6, figs.8-10.

Globorotalia (Turborotalia) compressa compressa (Plummer). Blow 1979, pp.1062-1064, pl.75, figs.10-11, pl.248.

Planorotalites compressa (Plummer). Tourmarkine and Luterbacher 1985, p.107, fig.12.1-2.

Notes.

Very compressed form; periphery rounded-subangular. Umbilical side flat to slightly convex, spiral side wholly evolute and flat. Spiral suture often distinct. 4 to 5 ovate chambers in last whorl which increase rapidly in size. Umbilicus shallow, wide. Depressed sutures, slightly curved on spiral side, radiate on umbilical.

Remarks.

Loeblich and Tappan (1964, p.C668) regard Planorotalites Morozova 1957 as a junior synonym of Globorotalia. However, Globorotalia is a strictly Neogene form which is carinate, and has a "lensiform trochospiral test" (Banner 1982, p.220). Planorotalites is a Palaeogene form, has an acute periphery, is carinate, and may be pustulate. The type of Planorotalites (Globorotalia pseudoscitula Glaessner) is macroperforate: this middle Eocene species has microperforate homeomorphs in the Palaeocene (eg. "P." pseudomenardii Bolli) to which G. compressa s.s. is phylogenetically related. However, Globanomalina has a rounded periphery, is non-carinate, with rare pustules only around the aperture. The species 'compressa' is neither a Globorotalia or a "Planorotalites" (which I regard as a separate and distinct genera), and is only tentatively placed into Globanomalina as it posseses a macroperforate, not microperforate wall. This later genus forms part of the Eoglobigerina Morozova to Pseudohastigerina Banner and Blow evolutionary lineage. "G." compressa differs from compressa s.s. in having a less angular peripheral margin, and larger perforations.

Stratigraphical range.

Occurs with examples of "G." pseudobulloides (Plummer) in King's (1983) NSP1 (nannoplankton zones P1-3) Early to 'Middle' Palaeocene Zone. Stainforth et al. (1975) record this species from their "G." pseudobulloides Zone (Middle Early Palaeocene) to their Globorotalia angulata (White) Zone

(Middle Middle Palaeocene). According to Blow (1979) ranges from P1 to P3.

North Sea forms often appear to be crushed.

"*Globanomalina*" *pseudobulloides* (Plummer).

Pl.22, fig.12a-c.

Globigerina pseudobulloides Plummer 1926 (1927), p.33, pl.8, fig.9.

Globigerina compressa var. *pseudobulloides* Plummer. Subbotina 1953, pp.55-57, pl.2, figs.7, 11-14.

Globorotalia pseudobulloides (Plummer). Bolli 1957, p.73, pl.17, figs.19-21; Stainforth *et al.* 1975, p.216, fig.76; King 1983, p.12, pl.6, figs.22,28.

Globorotalia (Turborotalia) pseudobulloides (Plummer). Blow 1979, p.1096, pl.75, fig.2 [hypotype], pl.248, figs.6-8 [topotypes].

Notes.

5 spherical to ovate chambers in final whorl. Lobate, rounded periphery. Spiral sutures radiate, umbilcal ones radiate to curved Spiral side slightly more flattened than umbilical. Umbilicus narrow, open. Aperture umbilical to extraumbilical.

Remarks.

Examples in the North Sea often poorly preserved, often suffering from 'recrystallisation' of calcite (see Pl.22, fig.12b).

Differs from *G. compressa* (Plummer) s.s. in being less compressed, with a broader more lobulate periphery. *G. compressa* also differs in its smoother wall surface. "*G.*" *pseudobulloides* differs from *Globorotalia uncinata* Bolli in having spherical and not subangular chambers in the early part of the last whorl. *Globanomalina* is essentially a microperforate genus (Banner pers. comm.) and the specimens from the North Sea of *compressa* and *peudobulloides* were both macroperforate.

Stratigraphical range.

An accepted zonal index for Early and Middle Palaeocene (P1 to P3 of Blow, 1979). Marker for King's (1983) NSP1 Zone which is defined by the highest occurence of "G." pseudobulloides. Range as for G. compressa s.s.

"Globanomalina" varianta (Subbotina).

Pl.22 fig.13.

Globigerina varianta Subbotina 1953 (partim) p.63, Pl.3, figs.5a-c (only).

NOT Globorotalia varianta (Subbotina), Loeblich and Tappan 1957, p.196, Pl.44, figs.1a-2b, Pl.45, figs.4a-c.

Globorotalia (Turborotalia) varianta (Subbotina), Blow 1979, p.1114-1115, Pl.71, fig.1 (hypotype).

Notes.

Less 'pitted' wall than 'G'. pseudobulloides (Plummer), more radially elongated chambers, and more tightly coiled test.

Remarks.

Rare in this study. Two specimens noted. Most of the figured paratypes of "G." varianta Subbotina 1953, Blow (1979) regarded as ecophenotypes of "G." pseudobulloides (Plummer). However, the holotype (Subbotina 1953, Pl.3, fig.5a-c) differs from pseudobulloides by having "a more tightly coiled earlier test" and shows "some tendency to produce rather radially elongated chambers" (Blow op. cit., p.1115) in its later stages.

Stratigraphical range.

This species was noted in Well 29/10-1, in the Early Palaeocene, Danian, Zones PK1b, CB2. Blow (1979) recorded this species in the ?lower part of the Danian, from Denmark, and from his Subzone P1b to within Zone P3.

Globanomalina danica (Bang).

Pl.22 fig.14.

Globigerina danica Bang 1969, p.58 and 61, pl.1, figs.1a-2c.

Globorotalia (Turborotalia) danica (Bang), Blow 1979, p.1069-1071, pl.254, figs.5-10.

Notes.

$4\frac{1}{2}$-$5\frac{1}{2}$? chambers in last whorl. The chambers are inflated, subglobular in dorsal view, not closely appressed or very embracing. Small, open umbilicus. Interiomarginal, umbilical-extraumbilical aperture, with apertural lip. Thin wall, smooth to finely hispid.

Remarks.

Only two specimens noted in this study. Fig.14, Pl.22 was identified as this species by Dr I. Bang. A true *Globanomalina* with a microperforate wall.

Stratigraphical range.

G. danica was noted in the Early Palaeocene, Danian, Zones PK1b and CB2, in Well 29/10-1. Blow (1979) noted this species in the Danian of Denmark, from Zones P1 (Subzone P1b) to P2.

GENUS: *Eoglobigerina* Morozova 1959.

Notes.

Simple 'flattish' trochospiral test, small apertural system. Aperture with portici that are less strongly developed than those seen in *Globigerina* [*Subbotina*, Brotzen and Pozaryska]. 4-$4\frac{1}{2}$ chambers in the final whorl. Wall 'pitted', with inter-pore ridges.

i. *E. trivialis* (Subbotina). Aperture centrally placed within the umbilical depression.

Eoglobigerina trivialis (Subbotina).

Pl.23, fig.1.

Globigerina trivialis Subbotina 1953 (*partim*), p.64, Pl.4, figs.4a-c, figs.6a-7c.

Eoglobigerina trivialis (Subbotina), Blow 1979, p.1224-1228, Pl.65, figs.1-3, Pl.66, figs.4 & 7, Pl.69, fig.9, Pl.70, fig.8, Pl.74, figs.3 & 5, Pl.79, figs.1-2.

Notes.

4 chambers in the final whorl. Distinct portical structure. Small, open and deep umbilicus, sharply defined, and low arched aperture. Inflated subglobular chambers, slowly enlarging as added, closely set. Wall typically coarsely cancellate, "coarsely porous [and] pitted" (Blow 1979, p.1225).

Stratigraphical range.

Blow (1979) noted this species in the Early Palaeocene, ?basal Danian, Zone Pα, to within the earlier Thanetian, Zone P3. Noted in this study in, for example, well 29/10-1, Early Palaeocene, Danian, Zones PK1b, CB2.

Eoglobigerina cf. *trivialis* (Subbotina).

Pl.23, fig.2.

see *Globigerina trivialis* Subbotina 1953, p.64, Pl.4, figs.4a-c, 6a-c, 7a-c.

Remarks.

This species was noted as cf. *trivialis* because of its poor presevation (the aperture is often obscurred), and more elongated chambers than *trivialis* s.s.

Stratigraphical range.

This species was noted in the Early Palaeocene in this study, for example in well 29/10-1, Danian, Zone PK1a.

Eoglobigerina aff. *trivialis* (Subbotina) *sensu* Blow.

see *Globigerina* *trivialis* Subbotina 1953 (*partim*), p.64, Pl.4, figs.4a-c, figs.6a-7c. NOT Pl.4, figs.5a-c. NOT Pl.4, figs.8a-c.

Eoglobigerina aff. *trivialis* (Subbotina), Blow 1979, p.1228-1229, Pl.69, fig.8.

Remarks.

This species is the same as Blows (1979) aff. *trivialis* form; it has a more strongly pronounced initial spire than *trivialis* s.s.

Stratigraphical range.

Blow (1979) noted this species in the Early Palaeocene, his Zones $P\alpha$-1, Danian.

Eoglobigerina *eobulloides* *simplicissima* Blow.

Eoglobigerina *eobulloides* *simplicissima* Blow 1979, p.1217-1224 , Pl.55, figs.1 (holotype), 2-4, Pl.57, figs.3-4, Pl.60, figs.2-3, Pl.70, figs.5-6, 9-10, Pl.73, figs.1-3, 8-9.

Notes.

Low trochospiral test, small (Blows 1979 holotype had a maximium diameter of 0.152mm), with 4 chambers in the last whorl. The chambers are inflated in dorsal view, embracing and slightly appressed. Open umbilicus, deep. Aperture arched, confined to the umbilicus, with thin porticus. Wall perforate.

Remarks.

Rare in wells in this study. Differs from *E.* *trivialis* (Subbotina) in having a more asymetrically placed, and more widely open 'apertural system', and does not possess a cancellate wall.

Stratigraphical range.

Blow (1979) noted this species in his Zone $P\alpha$, Early Palaeocene,

?basal Danian. A marker species for Zone PK1a, Early Palaeocene, Danian, in this study, for example in Well 29/10-1, 9080'-9110'.

SUBFAMILY: TRUNCOROTALOIDINAE Loeblich and Tappan, 1961.

GENUS: Acarinina Subbotina, 1953.

Notes.

The primary aperture is intraumbilical-extraumbilical in position and, or, direction. Rounded to bluntly subangular peripheral margin, without carina. Muricae developed over the whole surface, although strongest around the umbilicus.

Acarinina aff. pentacamerata (Subbotina).

Pl.23, fig.4.

see Globorotalia crassa (d'Orbigny) var. pentacamerata Subbotina 1936, p.11, 14, 16, Pl.3, figs.7-9 (nomen nudum). Considered as validated in Subbotina 1947, p.128, Pl.7, figs.12-17, Pl.9, figs.24-26.

see Globorotalia (Acarinina) pentacamerata Subbotina, Blow 1979, p.939-941, Pl.135, fig.5.

Notes.

5-6 chambers in the final whorl. Globorotalid aperture.

Remarks.

The species referred to as A. aff. pentacamerata (Subbotina) in this study differs from A. pentacamerata s.s. in having more globular chambers, a more convex spiral side, more depressed sutures on the umbilical side, and a less angular periphery. Only noted in the Southern North Sea in this study.

Stratigraphical range.

Blow (1979) noted this species from the base of his Subzone P8a, to Zone P9, later Early Eocene. Recorded in this study in Well 49/19-1, 1230'DC, earliest Early Eocene, Zone PK6 (marker species for that Zone). This species was described from the Early Eocene of the Caucasus.

SUBFAMILY: GLOBOROTALIINAE Cushman, 1927.

GENUS: Neogloboquadrina Bandy, Frerichs and Vincent, 1967.

Notes.

Trochospiral test. 4 to 6 subglobular to globular chambers in the final whorl. Depressed radial sutures. Rounded periphery. Wall cancellate. Aperture umbilical to extraumbilical with distinct lip.

Remarks.

Cifelli (1982) noted that there were a lot of Globigerine-like forms in the Oligocene/Early Miocene (such as 'G'. opima) which have an intra-extraumbilical aperture, that is, they are Globorotalid in that respect, but have nothing else in common with Globorotalia, the type species of which is G. tumida (Brady) and which is quite unlike Globigerina. G. tumida has a smooth wall, compressed chambers, an acute angular profile and well formed keel. 'G'. opima and its associated forms have rounded peripheries, with a spinose cancellate wall texture. The type description for Globorotalia by Cushman (1927) is unfortunately ambiguous in that the main difference recognised between Globigerina and Globorotalia was the spiral side being flat in the later. Cushman and Bermudez (1949) tried to rectify this ambiguity in that they defined broad morphological limits of Globorotalia by dividing it into three subgenera. These are: Globorotalia s.str. type species G. tumida; Truncorotalia type species G. truncatulinoides (d'Orbigny) which has sharply conical umbilical sides; and Turborotalia, type species G. centralis Cushman and Bermudez (now regarded by some authors [e.g. Cifelli, 1982] as a junior synonym of G. cerroazulensis). In the last subgenus, Cushman and Bermudez included smooth and coarse walled forms. It is widely used as a genus and subgenus, but problems arise in deciding what should be included into it. Angularity of profiles may vary considerably among species, and therefore a clear distinction from *Globorotalia* is difficult. Blow (1969) placed sharp limits on *Globorotalia* including only keeled species, the remaining globorotalids he placed into *Turborotalia*. *'G'*. *opima* agrees with the original descriptions of both *Globorotalia* and *Turborotalia*, but does not agree with their type species. *T*. *centralis* Cushman and Bermudez has a smooth wall, as seen in true, Neogene *Globorotalia*; the related *T*. *cerrazulensis* has a subangular profile, not the subrounded one of Oligocene and later turborotalids. Therefore, the genus *Paragloborotalia* was proposed by Cifelli (1982) for forms similar to *'G'*. *opima*, that is, species which had a cancellate wall texture, and were spinose. The pore ridges of *Paragloborotalia* are sharply angular. Cifelli regarded *Neogloboquadrina* as a valid genus but not applicable to the *'G'*. *opima* forms. He pointed out that although *Neogloboquadrina* had a cancellate wall, like *'G'*. *opima*, it was generally far less spinose, and the ridges develop independently of the spine bases and are less angular. He regarded *Paragloborotalia* as an ancestor to *Neogloboquadrina*. Loeblich and Tappan (1988, pp.476-477) also regard the latter as being distinct from the former, based on wall structure and on apertural characteristics. One could include many *'G'*. *opima*-like forms in *Neogloboquadrina*, as do Kennett and Srinivasan (1983), or into *Paragloborotalia*. However, I would argue that as *Neogloboqaudrina* has so much in common with *Paragloborotalia*, that the latter should be seen as the phylogenetically earliest 'end-member' of the former. The two "genera" cannot always be distingiushed in practice. So *Paragloborotalia* Cifelli 1982 should be regarded as a junior synonym of *Neogloboquadrina* Bandy, Frerichs and Vincent 1967.

Neogloboquadrina continuosa Blow.

Pl.23, fig.5.

Globorotalia opima Bolli subsp. continuosa Blow 1959, p.218, pl.19, fig.125a-c.

Neogloboquadrina continuosa (Blow). Kennett and Srinivasan 1983, p.192, pl.47, figs.3-5.

Globorotalia continuosa Blow. Bolli and Saunders 1985, p.206, fig.26.8-14.

Remarks.

N. continuosa is an 'intermediate' form between 'G'. opima Bolli s.l. and the Neogloboquadrina acostaensis (Blow) complex. It has deeply depressed intercameral sutures (like N. acostaensis and N. mayeri) but only 4 chambers per whorl (as in N. opima s.l.).

Bolli and Saunders (1982) considered 'G'. opima continuosa as a 4 chambered variant of "Globorotalia" mayeri, but as the former is a stratigraphically useful taxon it is more sensible to keep it separate.

Stratigraphical range.

Early Miocene Zone N4b (NSP10/NSB9, NN1) to Late Miocene Zone N16 (NSP13-14/NSB12-14, NN10/11). Tropical to cool subtropical.

Neogloboquadrina aff. increbescens (Bandy).

see Globigerina increbescens Bandy 1949, p.120, pl.23, figs.3a-c.

Notes.

3½ chambers (slowly enlarging, moderately embracing) in the final whorl. Sutures distinct, depressed. Aperture with no obvious rim or lip. Thick walled, uniformly and coarsely perforate.

Remarks.

Differs from N. increbescens in having no obvious apertural rim or lip. In N. increbescens the aperture extends to the periphery and around the margin. In the above the aperture is more restricted to the umbilical region, and does not actually reach the periphery. N. increbescens also has 4 chambers in each whorl, while the above has only 3 in the final whorl.

Neogloboquadrina mayeri (Cushman).

Pl.23, fig.6.

Globorotalia mayeri Cushman and Ellisor 1939, p.11, pl.2, fig.4a-c; Bolli 1957, p.118, pl.28, fig.4; Postuma 1971, pp.333-333; Bolli and Saunders 1982, pp.41-46, pl.1, figs.7-18 [holotype refigured]; Bolli and Saunders 1985, pp.203-206, fig.26.31-43.

Globorotalia (Turborotalia) mayeri Cushman and Ellisor. Blow and Banner 1962, p.131, 133; Blow 1969, pl.3, figs.7-9 [holotype refigured].

Globorotalia (Jenkinsella) mayeri Cushman and Ellisor. Kennett and Srinivasan 1983, p.174, pl.43, figs.4-6.

Globorotalia (Turborotalia) mayeri mayeri Cushman and Ellisor. Jenkins 1971, pp.119-126, pl.11, figs.297-302.

Globorotalia siakensis Leroy 1939, pp.39-40, pl.3, figs.30-31; Postuma 1971, pp.359-360; Bolli and Saunders 1982, pp.41-46, pl.1, figs.1-6.

Globorotalia (Turborotalia) siakensis Leroy. Berggren 1963, p.471; Blow 1969, p.351, 356, pl.10, figs.7-9 [holotype refigured], pl.34, figs.4-5.

Globorotalia (Jenkinsella) siakensis Leroy. Kennett and Srinivasan 1983, p.172, pl.42, figs.6-8.

Notes.

Wall coarsely perforate, smooth to hispid surface. 5/6 chambers in last whorl. Sutures radial on umbilical side and slightly curved to radial on spiral side.

Remarks.

N. mayeri was originally thought to differ from N. siakensis in having distinctly curved intercameral spiral sutures, a less lobate equatorial periphery, and less separated chambers (according to Blow, 1969); compared with the more radial sutures and more strongly lobate periphery in N. siakensis. Bolli and Saunders (1982) have re-examined the holotype of N. mayeri and illustrations of the holotype of N. siakensis, and examined specimens of this 'plexus' from Java and Trinidad. They have shown that the sutures of the holotype of N. mayeri are much less curved than in Blow's (1969) illustration, and closer to Cushman and Ellisor's original figure. N. mayeri has priority over N. siakensis as it was published in March 1939. No month is given in 1939 in the publication of N. siakensis. The last day of 1939 must be taken as the valid date of publication for the latter, according to Bolli and Saunders (1982, p.47), and Article 21 of the I.C.Z.N.

Loeblich and Tappan (1988, pp.476-477) place Globorotalia (Jenkinsella) Kennett and Srinivasan (1983), type species Globorotalia siakensis Leroy, into synonymy with the genus Paragloborotalia.

Stratigraphical range.

N4a latest Oligocene to the top of N14 Middle Miocene, according to Kennett and Srinivason (1983).

GENUS: Globorotalia Cushman, 1927.

Notes.

Lenticular, trochospiral form. Finely, but macroperforate wall, compressed chambers, an acute angular profile and well formed keel. Aperture umbilical-extraumbilical, arched, with distinct lip.

Globorotalia scitula (Brady) subsp. praescitula Blow.

Pl.23, fig.7a-b.

Globorotalia scitula (Brady) subsp. *praescitula* Blow 1959, p.221, pl.19, fig.128a-c.

Globorotalia (Globoconella) praescitula Blow. Kennett and Srinivasan 1983, p.108, pl.24, fig.1, pl.25, figs.4-6.

Globorotalia scitula praescitula Blow. Bolli and Saunders 1985, p.217, fig.31.6.

Remarks.

The criterion normally used for identification of this species is the acuteness of the periphery of the test, and the development of an imperforate area ("carina" or keel) around the periphery. In *G. scitula* (Brady) s.str. (see Kennett and Srinivasan 1983, p.134, pl.31, figs.1, 3-5), the rate of spiral opening is much greater than in *G. scitula praescitula*, and unlike the latter keels develop on the early chambers of the former. Stainforth *et al.* (1975, p.313), place *G. scitula praescitula* into synonymy with *G. scitula*. They noted that the pesence of a member of the *G. scitula* group is a reliable indicator of post-Oligocene age.

Stratigraphical range.

Early Miocene *Catapstdrax dissimilis* (Cushman and Bermudez) Zone (N5, NSP10/NSB9 in part, NN2) to Middle Miocene *Globorotalia peripheroronda* Blow and Banner-*peripheroacuta* Blow and Banner overlap Zone (N9-10, NSP11/NSB10 in part, top of Zone NN5). Temperate to tropical. *G. scitula* was noted in this thesis with *G. scitula praescitula* in Early Miocene sediments.

FAMILY: PLANOMALINIDAE Bolli, Loeblich and Tappan, 1957.

SUBFAMILY: PLANOMALININAE Bolli, Loeblich and Tappan, 1957.

GENUS: *Biglobigerinella* Lalicker 1948.

Notes.

Planispiral coil. Biumbilicate, with narrow umbilici. Test has few globular chambers per whorl, depressed sutures, and rounded periphery. Wall perforate, muricate and pitted. Doubling of final chambers may occur, with equatorial arch aperture divided into two openings.

Biglobigerinella cf. Biglobigerinella aspera (Ehrenberg).

Pl.23, fig.3.

cf. Phanerostomum asperum Ehrenberg 1854, p.23, pl.30, fig.26b (?26a, pl.32 Group 1, fig.24, pl.32, Group 2 fig.42).

cf. Nonionina escheri Kaufmann 1865, p.198, Text-fig.110a-e.

cf. Globigerinelloides asper (Ehrenberg). Masters 1980, p.96, fig.1, pl.1, fig.1-5.

Remarks.

This is a reworked Upper Cretaceous foraminifer.

Masters (1980) referred to the species 'aspera' as belonging to the genus Globigerinelloides Cushman and Ten Dam 1948. However, this genus has many chambers per whorl and broad umbilici, and is only known from the Aptian, although it may have its homeomorphs in the Albian. Biglobigerinella is a Late Cenomanian/Turonian to Maastrichtian form, and has a different wall structure, chamber shape and number, umbilical characteristics, and even portical shapes and dimensions. Doubling only occurs in the last chambers of some species, and is not common. The above species belongs to Biglobigerinella, not Globigerinelloides.

SUPERFAMILY: HETEROHELICACEA Cushman 1937.

FAMILY: GUEMBELITRIDAE Montanaro Gallitelli 1957.

GENUS: Globoconusa Khalilov 1956.

Notes.

For full description and discussions of genus see Blow (1979, p.1385).

Globoconusa conusa Khalilov.

Pl.23, fig.8.

Globoconusa conusa Khalilov 1956, p.249, pl.5, figs.2a-c; Blow 1979, p.1386-1387, Pl.257, figs.10-11.

NOT Globoconusa daubjergensis (Brönnimann), of authors (as synonymised with conusa Khalilov, see Blow 1979, p.1386).

Remarks.

See discussions under Globastica daubjergensis (Brönnimann) p.192, this study.

Stratigraphical range.

Blow (1979) noted this species in his Subzone P1b to Zone P2, it is a Palaeocene species, Danian to earlier Thanetian. Blows (op. cit.) illustrated example of this species (Pl.257, figs.10-11) comes from the Thanet Sands at Reculver, Kent, England. The specimen was, according to Blow, probably derived from Danian equivalents. Loeblich and Tappan 1988 dispute the identification of this form, and regard Globastica as a junior synonym of Globoconusa.

Comments on London Clay Planktonic Testate Protozoa.

The Planktonic Foraminifera.

According to King (1981, p117) the planktonic foraminifera first occur in his Division A3, but the first common occurrence is at the base of Division B (Wright's 'planktonic datum'). This is coincident with the development of the NRA fauna mentioned earlier. This, according to King, suggests depths of over 200 metres. However, in all the samples processed planktonic foraminifera were not very common, being always less than 10 percent of the foraminiferid fauna. In more silty samples the planktonic species are often either extremely rare or absent.

The planktonic foraminiferid genera and species are often very small and include *Globigerina* [*Subbotina*] *linaperta*, *G. officinalis*, *G.* [*Subbotina*] *triloculinoides*, *Catapsydrax*, and *Neogloboquadrina* (="*Paragloborotalia*"). Small *Globigerina* spp. occur throughout the London Clay Formation according to King.

Williams (1971) placed the planktonic foraminifera into 2 main groups. Group 1 was said to consist of "*Globigerina bulloides*/ *G. triloculinoides*". These species have 3 to 3 chambers per whorl, and the surface is 'pitted'. There is a large apertural arch with lip. In this group there is some variation; those that have a closer affinity to "*G. triloculinoides*", have deep sutures, with 3 chambers per whorl. Those forms in Group 1 that have a closer affinity to "*G. linaperta*" have 3 chambers per whorl, shallow sutures, with the last suture occupying less than ½ the test. All the chambers are quite compressed. These forms are very similar to *G.* [*Subbotina*] *linaperta*. Williams noted that this group occurs throughout his 'Middle' London Clay. *G. bulloides* is of course, Neogene and does not occur in the London Clay.

Globigerina Group 2 consists of *G.* sp. cf. *G. varianta* Subbotina. This group, which again has some morphological variations in its members, has 4/5 hispid chambers per whorl. The tests are high spired with apertural lip. Only a few examples were picked from the London Clay that I could assign to Group 2, and these were always broken. William's suggested that this Group was particularly abundant in Middle London Clay offshore sections. As the Hampstead Heath samples are of a shallower nature it is not surprising that examples of Group 2 were rarely found.

Reworked, and partly dissolved, Upper Cretaceous planktonic foraminifera were picked from the British Library samples, for example, *Biglobigerinella* cf. *Biglobigerinella aspera*.

Radiolaria.

'Cenosphaera' sp.

Pl.23, fig.9.

Remarks.

Abundant numbers of Cenosphaera sp. (large spherical Radiolaria) were used in this study to mark Zone PK5, late Early Eocene.

Cenodiscus lenticularis (Grzybowski).

Pl.23, fig.10a-b.

Reophax lenticularis Grzybowski 1896, pl.8, fig.22.

"Reophax" lenticularis Grzybowski. Geroch 1960, p.137 , pl.2, figs.7-11.

Cenosphaera lenticularis (Grzybowski). Jones G.D., 1988, p.149, pl.2, fig.7.

Remarks.

Geroch (1960) noted this species in the Cretaceous-Palaeogene. G.D. Jones (1988) noted this species in the Late Palaeocene, Viking Graben Region, North Sea. It was used in this study to mark Zone PK2, early Late Palaeocene.

Diatoms.

Coscinodiscus sp.1 of Bartenstein et al.

Coscinodiscus sp.1, Bartenstein et al., H., 1962, p.357, pl.2, figs.18-19; Jacque and Thouvenin 1975, p.462, pl.2, figs.A-E; King 1983, p.20, pl.1, figs.1-2.

Remarks.

This species was used in this study as a marker species for Zone PK3, Late Palaeocene-Early Eocene. A characteristic species of Kings (1983) Zone NSP4.

Coscinodiscus sp. 2 of Bartenstein et al.

Pl.23, fig.11.

Coscinodiscus sp.2, Bartenstein et al., H., 1962, p.358, pl.52, fig.20; Jacque & Thouvenin 1975, p.462, pl.2, Fig.F: King 1983, p.20, pl.1, fig.3.

Remarks.

Occurs at British Library site, London Clay Formation. Large, pyritised. Preservation poor. Also common in lings NSP4 Zone, Late Palaeocene-Early Eocene.

Diatom sp.3 of King.

Pl.23, fig.12.

Diatom sp.3, King 1983, p.20, pl.1, fig4.

Remarks.

This species was noted by King (1983) in his NSP9 Zone, Oligocene.

Microplankton.

The London Clay samples surprisingly yielded very large well preserved dinoflagellates, which were picked out of samples that were processed for foraminifera.

Hystrichosphaeridium tubiferum (Ehrenberg, 1838).

Remarks.

Found in the 75 m sieve fractions in small numbers. Well preserved, these specimens could quite easily be picked with a brush.

Comments on London Clay Radiolaria, Diatoms and Microplankton.

A few large Radiolaria (Cenosphaera) were found in the Hampstead Heath samples, and were always pyritised. Also observed, in the British

Library samples, were pyritised diatoms. According to King (1981) large diatoms belonging to the species *Coscinodiscus* sp. 1 and sp. 2, occur in Divisions A to B. However, the above mentioned diatoms were found together with partly dissolved examples of *Biglobigerinella* which indicates some inclusion of Upper Cretaceous material into unweathered Tertiary beds.

The organic-walled microfossils have been examined by J. Goodall (U.C.L.), and he noted the presence of for example, *Apectodinium paniculata*, *Wetzeliella lunaris*, and *W. astra* s. l., from the British Library samples. (This corresponds to the *W. astra* zone; no specimens of *W. meckelfeldensis* were found). These samples gave dates of NP10, which supports the dates suggested by the presence of large *Coscinodiscus* sp. 2 as mentioned previously. The Parliament Hill samples belong to the *Dracodinium similis* zone, suggested by the presence of *D. similis*, *D. solida*, *Wetzeliella articulata* and *W. lunaris*. This corresponds to nannoplankton zone NP11.

Large, well preserved *Hystrichosphaeridium tubiferum* were picked from material prepared for foraminifera. This species, unfortunately, has a long stratigraphic range, but gives a pre-mid Eocene date.

Hystrichosphaeridea were first recorded from the London Clay by E.W. Wetherell (not N.T. Wetherell) in 1892.

CHAPTER 4. FORAMINIFERAL BIOSTRATIGRAPHY.

King (1983) introduced a microfaunal zonal scheme for the Cenozoic of the North Sea, based on benthonic (NSB zones) and planktonic foraminifera (NSP Zones, which included diatoms, Bolboforma and radiolaria). Most of King's (1983) zones were based on the 'tops' or FDOs (or LADs) of selected species, as most of the samples examined were ditch-cuttings (as in this study). However, events such as major faunal 'turnover' were taken into account in his scheme. King (1989) took into account acmes of certain species and LDOs (FADs). The use of assemblage zones, according to King (1989), in the Tertiary North Sea Basin, is not practicable due to major lateral biofacies changes. The NSP and NSB zones of King (1983, 1989) can be followed quite clearly in the outer sublittoral and epibathyal (upper bathyal) environments in the North Sea Tertiary Basin, and in the shallower water inner "sublittoral" (neritic) environments such as the London Clay Formation in the London Basin.

In the deeper waters of the central parts of the Central North Sea, in the 'Rhabdammina-biofacies' the NSB and NSP zones are only of very limited use. Hence, King (1989, see figs.4-6b), set up a scheme based on agglutinated foraminifera (NCAs or non-calcareous agglutinants) that can be used in such environments. These are called NSA (North Sea agglutinant) zones.

The biostratigraphical scheme applied in this study uses calcareous benthic foraminifera (CB Zones 1-15), agglutinated benthic species (AB Zones 1-11b), and calcareous planktonic forms (PK 1a-13). This scheme is shown in the PK, AB, and CB rangecharts (see Enclosures and Appendix B) and a combined scheme is shown in figure 9. King's (1983, 1989) Zonation is correlated with the zones established in this study. The CB zones are of greater use in the inner sublittoral biofacies of King (1983), that is the Southern North Sea, and towards the edges of the Central North Sea.

The CB zones can also be applied to the inner sublittoral-outer sublittoral epibathyal biofacies of King (1983).

(1) THE CB ZONES.

CB1:- Early Palaeocene, Danian, Tappanina selmensis Zone:- The nominate taxon is recorded in this study from well 49/9-1 (2698' SWS). It occurs in chalks probably belonging to the Ekofisk Formation. It corresponds to Stewart's (1987) stratigraphic sequence 1. King (1983) uses Tappanina selmensis to mark his Zone NSB1a. Many of the species occurring in his NSB1b zone are missing from this zone . They include Stensioina beccariiformis, and Spiroplectammina spectabilis. The nominate taxon was recorded from the Thanet Formation, Thanetian, by Murray et al. (1981). The base of this zone is marked by an abrupt change in the Sonic velocity and Gamma ray logs. There is also an abrupt faunal change. The underlying Late Cretaceous species are represented by Stensioina pommerana, Gyroidinoides nitida, Valvalabamina, and Gaudryina cretacea.

CB2:- early Late Palaeocene, Stensioina beccariiformis Zone:- Contains common to few examples of the nominate taxon. Also recorded from this interval is Spiroplectammina spectabilis form B, the nominate taxon for the S. spectabilis form B zone, AB2, Late Palaeocene. Stensioina beccariiformis also occurs with examples of Osangularia expansa, O. corderiana, Anomalinoides danica, rare Lenticulina multiformis, and Nodosaria torsicostata, plus Clavulina parisiensis. Corresponds to King's (1983)

NSB1b Early Late Palaeocene zone. Considerable reworking and mixing of sediments occurs in this interval.

CB3:- Early Eocene, *Turrilina brevispira* Zone:- This zone was rarely observed in the North Sea wells in this study. Many of the forms that are recorded at this level are agglutinated. For examples, *Clavulinoides anglicus*, *Gaudryina hiltermanni*, and *Spiroplectammina spectabilis* form A. *Bulimina* sp. of King (1983) also occurs within this zone. This zone corresponds to King's (*op. cit.*) NSB3 *Gaudryina hiltermanni* Zone, early Early Eocene, and the base of his NSB4 "*Cyclammina*" *amplectens* Zone, late Early Eocene. *Acarinina* aff. *pentacamerata* and *Pseudohastigerina wilcoxensis* are also recorded from this zone, as is *Globigerina* [*Subbotina*] *linaperta* (NSP5 of King (*op. cit.*)). Rare *Turrilina brevispira* was noted from the London Clay, Ypresian, E. Eocene. This zone corresponds to Gradstein *et al.*'s (1988) "*Subbotina patagonica*" Zone, (P6b-P8 of Blow, 1979). Rare *T. brevispira* is also noted to occur in the base of King's NSB4 Zone.

CB4:- Late Early/early Middle Eocene, *Eponides karsteni* Zone:- This zone is only found in the Southern North Sea wells studied. The nominate taxon often occurs in high numbers (few (3-5) specimens to common (6-21)). King (1983) noted *Eponides karsteni* in the base of his NSB5 *Planulina palmerae* (=*P. costata*) Zone, early Middle Eocene. He points out that *E. karsteni* may be used in the future to define a subzone of his NSB5 Zone. In this study this species is used to define a zone (King (1989) uses it to define his 1989 Zone NSB5a). *Eponides schreibersi* (=*E. karsteni* in this study) was recorded by Doppert (1975) from his FH1 *Nummulites*-*Eponides* Subzone, Late

Eocene. In the North Sea this species has its FDO earlier in the Middle Eocene.

CB5:- Middle Eocene, Planulina costata Zone:- The nominate taxon is most common in the Southern North Sea, but also noted in the Central parts. The FDO of Spiroplectammina spectabilis form A occurs within this zone. The top of this zone is defined by the highest occurrence of the nominate taxon. According to King (1983) this species is restricted to the outer sublittoral-epibathyal biofacies. This was not found to be the case, because it was noted in the Central North Sea bathyal facies, wells 14/29-1 and 21/11-1. According to van Morkhoven et al. (1986) P. costata was primarily an upper and middle bathyal species, although it ranged from outer neritic (less than 100m) to lower bathyal depths.

CB6:- Late Middle-Late Eocene, Brizalina cookei Zone:- Zone defined by FDO of nominate taxon (see King, 1983). Few (3-5) specimens to common (6-21) in the Southern North Sea (well 49/9-1). Associated species include Percultazonaria wetherellii, Uvigerina jacksonensis and Angulogerina germanica.

CB7:- Latest Late Eocene-Early Oligocene, Rotaliatina bulimoides Zone:- Defined by FDO of nominate taxon. Index form widely distributed. Associated calcareous benthic species are Turrilina alsatica, and Gyroidina soldanii mamillata. Agglutinated forms in this zone are Dorothia seigliei, Adercotryma agterbergi, Reticulophragmoides sp. 5 of Gradstein and Kaminski (1989), and rare Reticulophragmoides jarvisi (see Gradstein and Kaminski (op. cit.). Sabellovoluta humboldti was also noted in this interval (King

(1989)). This zone can be split into two parts. This zone is equivalent to King's (1983) NSB7 Zone.

CB7a:- Latest Late Eocene-early Early Oligocene, Cassidulina carapitana Subzone:- Defined by FDO of the nominate taxon. In this study this zone was only noted in the Central North Sea (for example in well 14/29-1, 1880' DC).

CB7b:- Late Early Oligocene, Rotaliatina bulimoides Subzone:- Defined by the FDO of nominate taxon above the occurrence of Cassidulina carapitana.

CB8:- Early Late Oligocene, Asterigerina guerichi acme Zone:- Defined by the FDO of common to abundant nominate taxon. This zone was noted only in the Central N. Sea (wells 14/29-1 and 21/11-1, for example).

CB9:- Late Oligocene-Early Miocene, Sigmomorphina regularis Zone:- Defined by the FDO of the nominate taxon. Equivalent to NSB9/10 of King (1983). The nominate species is rare in most of the wells studied; its FDO was below the occurrence of Plectofrondicularia seminuda (see CB10) in this study (well 29/10-1 for example).

CB10:- Early Miocene, Plectofrondicularia seminuda Zone:- Defined by the FDO of the nominate taxon. P. seminuda is rarely common. Spirosigmoilinella compressa also occurs in this zone. Corresponds to King's (1983) NSB9 P. seminuda -"Silicosigmoilina sp." Zone.

CB11:- Early Miocene, Asterigerina guerichi FDO Zone:- This zone is defined by the FDO of the nominate taxon. This species occurs in few (2 to 5 specimens) numbers in this zone. This species is not common until the CB8 Zone, early Late Oligocene.

CB12:- Early Miocene, Stainforthia schriebersiana Zone:- The top of this zone is defined by the FDO of the nominate taxon. This zone is often difficult to recognise. Rare S. schriebersiana may occur in the Middle to Early Pliocene (NSB11-14 of King, 1983). This species is rare in the Central N. Sea basin. The highest occurrence of Turrilina alsatica is within this zone (King, 1989).

CB13:- Early-Middle Miocene, Asterigerina staeschei Zone:- Defined by the top occurrence (FDO) of the nominate taxon. Associated species include Elphidium inflatum (FDO at the top of this zone). Corresponds to Zone NSB11 A. staeschei Zone of King (1983).

CB14:- early Late Miocene, Siphonina reticulata Zone:- Defined by the FDO of the nominate taxon. This zone is distinctive when present. Corresponds to NSB12b, Uvigerina sp. cf. hemmooriensis Subzone, of King (1983).

CB15:- Late Miocene, Bulimina elongata Zone:- Defined on the FDO of the nominate taxon. This species is very common throughout the N. Sea basin. It ranges from NSB13a, Middle Miocene, to NSB8a Late Oligocene (King's (1983) zones). Associated forms are Uvigerina pygmaea, Pseudononion boueanus, and Nodosaria konincki. Caved later Miocene and Pliocene species are common in this and the underlying zone. Reworked species are also common.

(2) THE AB ZONES.

AB zones are of greater use in the deeper bathyal regions of the Central North Sea.

AB1:- Late Palaeocene, Clavulina parisiensis/Clavulinoides anglicus Zone:- This is generally a very thin zone. In well 14/29-1 this zone is approximately 109' thick, in 21/30-1 this interval is approximately 137' thick. This zone is at the very base of the Late Palaeocene, and occurs within Stewart's (1987) depositional sequence 2. This sequence in its upper part, according to Stewart (op cit.) has a "chaotic" seismic character. It is split by Stewart (op. cit.) into 3 lithostratigraphical units. The lower unit is a debris-flow deposit including reworked Cretaceous and Early Danian Chalk (sub-sequence 2A). The overlying unit (2B) is a submarine-fan sandstone which shows a Late Danian to earliest Thanetian fauna. This is overlain by a hemipelagic mudstone in the early Thanetian (Zone 2C), which is often approximately 60'-100' thick according to Stewart (op. cit.). The zone 2B probably contains the Clavulina parisiensis Zone AB1. This zone occurs in 3 of the 8 wells in this study, although it is difficult to define in 1 of these wells, 29/10-1. This species is often poorly preserved, with only the initial part being noted. Clavulinoides anglicus is a useful Eocene form, and is very similar to Palaeocene forms noted in the Central North Sea. However, the Palaeocene forms are generally more irregular in their chamber arrangement.

AB2:- Late Palaeocene, Spiroplectammina spectabilis form B Zone:- This is the Palaeocene form of this species. The Eocene form differs from the Palaeocene one by having a more compressed cross-section (see taxonomic comments Ch.3.3.2). This species occurs in high numbers within this zone, and is often abundant. This zone is equivalent to Gradstein *et al.*'s (1988) *Reticulophragmium paupera*-*Trochammina ruthvenmurrayi* Zone. This zone is P3-P4 in age, King's NSP2-NSB1, early Late Palaeocene. Common species include *R. paupera*, *T. ruthvenmurrayi*, *Ammodiscus planus*, *A. cretaceus*, *Cyclammina* cf. *garcilassoi*, *Rzehakina minima*, *Karreriella (Karrerulina) conversa*, *Reticulophragmoides jarvisi*, *Praecystammina globigerinaeformis* and *Cystammina pauciloculata*. The agglutinated species are common to abundant in this zone. This zone occurs throughout the Central North Sea region, and is within Stewart's (1987) stratigraphic sequence's 3 to 6. Sequence 3 (of Stewart, *op. cit.*) consists mostly of a submarine-fan sandstone of the Andrew Fan. It is characterised on electric logs by a relatively high sonic velocity. Sequence 4 (of Stewart, *op. cit.*) is a thin regionally restricted deposit. It consists of a tuffaceous sandstone and mudstone, with a low to very low Gamma ray response and fast Sonic. Sequence 5 (of Stewart, *op. cit.*) is restricted to the Moray Firth and Viking Graben regions, while sequence 6 is often thin and widely distributed. The latter lithofacies is of a mudstone with carbonaceous siltstone. All these depositional sequences are within Stewart's (*op. cit.*) "*Bolivinopsis*" *spectabilis* Zone.

AB3:- Late Palaeocene, Sparsely Microfossiliferous Interval:- Very few species and low numbers of foraminifera were noted at this level. It is defined on the highest occurrence of agglutinated foraminifera below the overlying planktonic *Coscinodiscus* sp.1 Zone PK2.

AB4:- Early Eocene, *Gaudryina hiltermanni* Zone:- This zone is found in the Southern North Sea wells in this study, 49/9-1 and 49/19-1, and in the London Clay, Ypresian samples from Hampstead Heath in the London Basin.

Many of the G. hiltermanni forms were juveniles. Other agglutinated forms noted in this zone include Clavulinoides anglicus s.s., rare Dorothia eocenica, plus examples of the Eocene form of Spiroplectammina spectabilis (form A). Calcareous benthics are discussed under CB zones (equivalent to CB3). See also discussions of PK4 which is equivalent in age.

AB5:- Early Eocene, Spiroplectammina navarroana Zone:- S. navarroana in the North Sea was noted by King (1983) as more common in the base of his Zone NSB4, Late Early Eocene (as "Textularia plummerae"). This species was only commonly encountered in the more Northerly wells in this study, and in the Norwegian well 25/10-1. This zone represents a restricted marine environment, possibly a regression (Stewart, 1987). Globigerina [Subbotina] linaperta is often common at this level. Acarinina aff. pentacamerata is also noted in this zone. This zone correlates to NSB4 (pars.) of King (op. cit.), and his NSP5 Zone; P8a to P9 of Blow (1979), and Stewart's (op. cit.) stratigraphic sequence 10. The upper boundary of Stewart's (1987) sequence is marked by a major regional unconformity. It comprises a lower lithostratigraphic unit of reddish-brown mudstone overlain by a pale grey mudstone. Both units have low sonic velocities and a higher gamma-ray response than the overlying Eocene mudstone of the Hordaland Group. S. navarroana occurs within Gradstein et al.'s (1988) Subbotina patagonica Zone, Ypresian, Early Eocene P6b-P8 (NSB3 of King op. cit.).

AB6:- Early Middle Eocene, Reticulophragmium amplectens Zone:- This zone is found throughout the whole of the North Sea, both South and North. It is based on the top occurrence (FDO) of the nominate species, and its abundant occurrence. Corresponds to the Actinomid Radiolaria Zone (Cenosphaera sp.).

Water depths estimated at 200-700m (?), restricted marine, but more open than in the underlying zone (R.W. Jones, unpub.). Corresponds to NSB4/5 of King (1983) according to Gradstein et al. (1988).

AB7:- Early Middle Eocene, Reticulophragmoides jarvisi acme Zone:- This nominate species occurs in high numbers just above the R. amplectens Zone. It is particularly notable in well 29/10-1, in the Central Graben of the Central North Sea. R. jarvisi ranges from the Late Palaeocene (P4) to the Early Oligocene (Dorothia seigliei AB10, Rotaliatina bulimoides Zone CB7). It is a bathyal form (Gradstein and Kaminski, 1989).

AB8:- Middle Middle Eocene, Spiroplectammina spectabilis form A Zone:- The top of this zone is marked by the FDO of the nominate taxon. It marks a restricted marine environment (R.W. Jones, unpub.). It also contains Spiroplectinella wilcoxensis. It corresponds to NSB5 of King (1983). The nominate taxon is the same as King's (op. cit.) "Spiroplectammina aff. spectabilis".

AB9:- Late Eocene, Karreriella (Karrerulina) conversa Zone:- This zone is defined by the FDO of Karreriella (Karrerulina) conversa. It represents an unstable substrate, with reducing conditions according to R.W. Jones (unpub.). Other forms that occur within this zone, are Brizalina cookei (FDO), and rare Globigerina [Subbotina] linaperta (FDO).

AB10:- Early Oligocene/earliest Late Oligocene, Dorothia seigliei Zone:- This species is common in the Early Oligocene, but may occur in the earliest Late Oligocene in certain parts of the North Sea (21/30-1 in this study). The type locality for this species is in blocks 29 and 30 (Gradstein and Kaminski, 1989). Associated species include *Adercotryma agterbergi*, *Reticulophragmoides* sp.5, and rare *R. jarvisi*. Also associated with the nominate taxon is *Rotaliatina bulimoides* (marking Zone CB7), and *Gyroidina soldanii mamillata*. This zone is often very thick in Central North Sea wells. It correlates with King's (1983) NSB7 Zone.

AB11a:- Late Oligocene, *Spirosigmoilinella compressa* acme Zone:- This zone is marked by the top occurrence of common to abundant *S. compressa*. Associated species are *Globigerina officinalis*, *Globigerina ampliapertura*, and *G.* aff. *angulisuturalis* and *G. ciperoensis*. The zone correlates to Zones P20-22 of Blow (1979). It was possibly a restricted marine environment (R.W. Jones, unpub.).

AB11:- Late Oligocene-Early Miocene, *Spirosigmoilinella compressa* Zone:- The top of this zone is marked by the FDO of *S. compressa*. AB11 correlates to P20-N4 of Blow (1979), NSB8/9 and NSP9/10 of King (1983).

(3) THE PK ZONES.

The planktonic zonation includes the ranges of planktonic foraminifera, radiolaria, and diatoms.

PK1:- Danian (Early Palaeocene), Danian Planktonics Zone:- The top of this zone is defined by the FDO of *Eoglobigerina trivialis*, *Globastica daubjergensis*, and "*Globanomalina*" aff. *compressa*. This zone corresponds to Gradstein *et al.*'s (1988) *Subbotina pseudobulloides* Zone and to Blow's (1979) P1-P2 Zones. Corrseponds to Zone NSP1 of King (*op. cit.*). Zone PK1 can be subdivided into 2 subzones.

PK1a:- Early Danian, *Eoglogigerina eobulloides simplicissima* Subzone:- Defined by the FDO of the nominate taxon. Other forms associated include *Eoglobigerina* aff. *trivialis*. This zone occurs within Chalk facies eroded from the margins of the basin, the stratigraphic sequence 1 of Stewart (1987) (Ekofisk Formation). There is a seismic event at the base of this zone which represents the Cretaceous/Tertiary boundary. *Tappanina selmensis* occurs in this Zone.

PK1b:- Late Danian, "*Globanomalina*" *compressa*-*Eoglobigerina trivialis* Subzone:- This zone is defined by the FDO of *E. trivialis*. "*G.*" *compressa* also generally occurs first at this level, although it has been noted rarely in AB1 and PK2. This zone corresponds to the base of Stewart's (1987) stratigraphic sequence 2, Maureen Formation, debris flow with reworked Cretaceous and Danian material. There is a distinct unconformity at the base of this zone. *Globastica daubjergenis* was recorded, often poorly preserved. Water depths were probably greater than 200-500m.

PK2:- Thanetian, Late Palaeocene, Spongodiscid Radiolarian Zone, *Cenodiscus lenticularis* :- Defined by the abundant FDO of the nominate taxon. Recorded in most wells studied in the Central N. Sea. Corresponds to Zone NSP2 'Large Radiolaria' Zone of King (1983). This corresponds to stratigraphic sequence 2C of Stewart (1987), a hemipelagic mudstone 20-30m thick, of Early Thanetian age. This represents a 'highstand' sea level position. This is equivalent to his *Cenodiscus* sp. biozone. The top occurrences of "*Globanomalina*" *pseudobulloides*, "*G.*" *compressa*, and *Globigerina [Subbotina] triloculinoides* are within this zone.

PK3:- Late Palaeocene-Early Eocene, *Coscinodiscus* sp.1 Zone:- Defined by the FDO of the nominate taxon. Samples from this interval are usually barren of foraminifera. Other species of diatoms include *Coscinodiscus* sp.2 of Bartenstein *et al*. (1962) (recorded in the London Clay, Ypresian) and rare *Triceratum* spp.. This biozone corresponds with Stewart's (1987) stratigraphic sequence 9, Balder and Sele formations. The Balder formation provides a distinctive seismic event at the top of this zone. Equivalent to King's (1983) NSP4 Zone.

PK4:- Ypresian, Early Eocene, *Globigerina* *[Subbotina]* *linaperta* acme Zone:- Defined by the occurrence of common to abundant numbers of the nominate taxon. Associated species include *Turrilina brevispira*. The London Clay examined from Parliament Hill, Hampstead Heath, belongs to this zone. This interval represents a 'highstand' sea level of Stewart (1987), the lower part of his stratigraphic sequence 10, a reddish-brown mudstone characterised by low sonic velocities and a higher gamma ray response than in the overlying Hordaland formation. It corresponds approximately to King's (1983) NSP5, "*Globigerina* sp. ex. gr. *linaperta*" Zone, P6b-P7 of Blow (1979). Gradstein *et al*. (1988) correlate their *Subbotina patagonica* (= *G.* [*Subbotina*] *linaperta* in this study) Zone to Blow's (*op. cit*.) P6b to P8 Zones. According to the latter authors the end of their *S. patagonica* peak occurs at the NP11/12 nannoplankton zone boundary. The species noted from this interval are often stained red. Associated benthic species include *Clavulinoides anglicus*, *Gaudryina hiltermanni* and *Osangularia plummerae*. Equivalent to Zone AB4.

PK5:- Late Early Eocene, Actinomid Radiolarian Zone (Cenosphaera sp.):- This zone is defined by the FDO of large (according to King (1983) 150-300 microns) spherical radiolaria, usually pyritised. These radiolaria are often locally abundant. This zone is not always easily defined in the Central N. Sea. Corresponds to King's (op. cit.) NSP6 Zone, and his NSB4 Zone. Similar forms are noted in the London Clay in this study.

PK6:- Early Middle Eocene, Acarinina aff. pentacamerata Zone:- Defined by the FDO of this species.

PK7:- Early Middle Eocene, Pseudohastigerina wilcoxensis Zone:- This zone is defined by the FDO of the nominate taxon. It was only recognised in the Southern North Sea (well 49/19-1, 1200',1260'). It corresponds to King's (1983) NSP7 Pseudohastigerina micra Zone, base of NSB5, but P. micra was not noted in any of the wells studied. King (1989) records Pseudohastigerina spp. in his NSP7 Zone (equivalent to his 1989 NSB5a Zone (CB4 in this study), while he also records P. wilcoxensis s.s. in his NSP5b Zone Middle Eocene, top of his "Subbotina" linaperta Zone, Early Eocene. In this study, P. wilcoxensis occurred within the Eponides karsteni Zone (CB4) in well 49/19-1.

PK8:- Late Eocene, Globigerapsis index index Zone:- This top of this zone is defined by the FDO of the nominate taxon. Common Globigerina [Subbotina] linaperta is recorded in this interval (King, 1983). The zone correlates with King's (1989) NSP8c Zone.

PK9:- Early-Late Oligocene, Globigerina ampliapertura Zone:- This zone is defined by the FDO of the nominate taxon. This species was recorded by King (1983) from his NSP9 Zone, Early-Late Oligocene. G. ampliapertura ranges from P17 (Late Eocene) to P19/20 (Early Oligocene) of Blow (1979). The FDO of this species is within Blow's (op. cit.) Globigerina ampliapertura Zone.

PK10:- Late Oligocene-?Early Miocene, Globigerina ciperoensis Zone:- Zone defined by the FDO of the nominate taxon. The type level of this species is in the Lower Oligocene, Cipero Formation, Trinidad (Bolli (1954)). According to Blow (1979) Globigerina ciperoensis ranges from P19/20 (Early Oligocene) to P22 (Late Oligocene), G. ciperoensis Zone, and possibly into Zone N4 (the very earliest Early Miocene). Stainforth et al. (1975, p. 263) note that when G. ciperoensis is present in "its usual abundance, it is a reliable guide to Oligocene age even though records exist of its occurrence in Early Miocene beds".

PK11:- Late Oligocene-Early Miocene, Globigerina aff. angulisuturalis Zone:- This zone is defined by the FDO of the nominate taxon. Bolli (1957) noted that the type level for G. angulisuturalis s.s. was within the lower part of the Cipero Formation, Trinidad, in his "Globorotalia opima opima" Zone, Oligocene. Blow (1979) records this species from P21 (Late Oligocene) to Zone N4 (early Early Miocene).

PK12:- Early Miocene, Globorotalia praescitula Zone:- This zone is defined by the FDO of the nominate taxon. Blow (1959) noted that the type level of this species is within the Early Miocene, Tocuyo formation, lower part of the "Globigerinatella insueta Zone s.l., Globigerinatella insueta/

Globigerinoides trilobus subzone" (Ellis and Messina, supplement for 1963, no.2). This species ranges (according to Blow (1959), see also Ellis and Messina, op. cit.) from the Early Miocene, Aquitanian (*Catapsydrax stainforthi* Zone of the Tocuyo formation)) to the late Early Miocene, Burdigalian (*Globorotalia peripheroronda* Zone of the Pozon Formation). King (1983) records *Globorotalia praescitula* in his NSP11 Zone, Early to early Middle Miocene (equivalent to his NSB10 Zone).

PK13:- Middle Miocene, *Globigerinoides quadrilobatus trilobus* Zone:- The top of this zone is defined by the FDO of the nominate taxon, which has its worlwide FAD late in planktonic Zone N4, and which survives in subtropical/tropical modern oceans. The FDO of this taxon in the North Sea Miocene marks the appearance of oceanic plankton at that horizon. King (1983) records this species from the Middle Miocene, his NSP12 Zone (to NSP11). Stainforth *et al*. (1975) record *G. quadrilobatus trilobus* from Early Miocene (*Catapsydrax dissimilis* Zone) through Middle Miocene and younger sediments.

CHAPTER 5. DESCRIPTIONS OF INVESTIGATED SITES.

5.1. Well Descriptions.

Abbreviations used in this section are:-

FDO= First Downhole Occurrence.

LDO= Last Downhole Occurrence.

LCO= Last Common Occurrence.

LAD= Last Appearance Datum.

FAD= First Appearance Datum.

SWS= Side Wall Sample (= SWC, Side wall Core).

DC = Ditch-Cuttings.

Well Description. (See Enclosure No.1).

Well 14/29-1. Northern part of the Central North Sea.
95 samples were examined from this well, from depths 1580', to 6510'. 24 of these proved to be barren. These sediments range in age from earliest Miocene/Late Oligocene, P20-N4, to the Palaeogene, Danian P1.
105 benthic species were noted in this well, together with 15 planktonic forms, 2 species of radiolaria, and one form of diatom.
Distinct breaks in the faunal content of the samples were noted at 1760', 2360', 2480', 4280', and at 5770'. Most of the samples were ditch-cuttings.

1580' Late Oligocene-Early Miocene, P20-N4 of Blow (1979), AB11:- A poorly defined fauna stratigraphically. Contains Asterigerina staeschi with subordinate numbers of A. guerichi. The planktonic forms noted are Globigerina officinalis, and Globigerina praebulloides s.l.. The former species occurs in the Spirosimoilinella compressa zone (N4-P20). Gradstein (1988) regarded 'G. officinalis gr.' as a marker species for the Late Oligocene. The higher numbers of A. staeschi is probably due to caving. Other common benthonic species at this level are Nonion compressum, and Bulimina elongata. This appears to confirm the theory that A. staeschi has caved down this well.

1640-1670' Late Oligocene, P22 of Blow (1979), PK10:- Lower numbers of A. staeschi were noted at this level, with increased numbers of A. guerichi. More planktonic forms noted, examples being Globigerina aff. angulisuturalis, Globigerina aff. ciperoensis, and Globigerina praebulloides praebulloides. Stainforth et al. recognised Globigerina ciperoensis as a marker species in the later part of the Oligocene. This suggests zone P22 of Blow (1969,1970). The existence of G. aff. angulisuturalis confirms this age.

1760' late Early to early Late Oligocene, NSB8a, P19-20, CB8, PK9:- Globigerina aff. angulisuturalis occurs in this sample, together with Neogloboquadrina continuosa. Globigerina ampliapertura also occurs here which indicates a 'middle' Oligocene age. Benthonic forms are present in greater numbers and diversity, useful forms include increased numbers of Asterigerina guerichi (which gives this zone its CB8 age) and Pseudononion boueanus. Also noted were examples of Melonis affine, Plectofrondicularia seminuda, plus Sigmomorphina regularis. The FDO of P. seminuda is a marker for Zone CB10 (Early Miocene), while the FDO of S. regularis is a marker for Zone CB9 (also Early Miocene) (King, 1983, 1989). The FAD's of the latter two species is in the Late Early to Late Oligocene. This increase in diversity and numbers corresponds with a rise in the Gamma ray log values.

1761'-1820' late Early to Late Oligocene, NSB7b-8:- Poor fauna, with low diversity and numbers. Contains S. regularis, and P. seminuda. No planktonics.

1880' Early Oligocene, NSB7a, CB7a:- Poor fauna, again with low diversity and numbers. However, contains *Cassidulina carapitana*, which ranges from NSB6a to NSB7a. This sample also contained *A. guerichi*.

1940' Barren.

2000' Late Eocene to Early Oligocene, ?NSB6:- Slight increase in numbers and diversity. Contains *Nodosaria minor*, and *Lenticulina cultrata* s.l. (sensu Shell U.K. Expro.), together with *Lenticulina* cf. *pseudovortex*. The former two species are regarded by Shell as Eocene to Earliest Oligocene forms. *L.* cf. *pseudovortex* was noted in the London Clay, in this study, and by Kaaschieter (1961) in Eocene sediments..

2080'-2120':- 2080' barren. At 2120' there is a limited fauna of caved species, low diversity (just 3 species, *Pseudononion boueanus*, *Sigmomorphina regularis* and *Cibicides pseudoungerianus*), and low numbers.

2180'-2240' Late Eocene, NSB6:- Increasing numbers and diversity of benthics. No planktonic forms. *Lenticulina cultrata* s.s. present, plus *Lenticulina gutticostata*, *Lenticulina calcar*, and *Nodosaria minor*.

2300'-2360' Middle Eocene, *Planulina costata* Zone, NSB5, CB5, PK6:- 2300' shows the top part of this zone. Includes the first appearance of *Planulina costata*, and also contains *Spiroplectinella excolata*. At 2360' *Acarinina* aff. *pentacamerata* first appears downhole, suggesting that this is the lower part of zone NSB5, planktonic Zone PK6. Also within this zone there is the first occurence downhole of *Percultazonaria wetherellii*, *Heterolepa mexicanus*, and

Spiroplectinella wilcoxensis. *H. mexicanus* supposedly ranges from P16, Late Eocene, to N5 Early Miocene (van Morkhoven *et al.*, 1986). However, this form appeared in North Sea wells in this study at older levels, usually from the Middle Eocene upwards. Also present were examples of *Anomalinoides capitatus* which ranges from Late Palaeocene (P6a) to Early Oligocene (P19-20?) (van Morkhoven *et al.* (1986)).

2420' ?Middle Eocene, ?NSB5. ?CB5:- Contains *Uvigerina* sp.1, a marker species for the Middle-Late Eocene. Also contains *Dentalina megalopolitana*, and *L. cultrata* s.s.

2480' Early-Middle Eocene, NSB3-5, AB4:- Contains *Anomalinoides semicribratus* (range Middle Eocene (P12), to Middle Miocene (N12)). Transitional forms between *A. semicribratus* and *A. capitatus* occur within the Middle to late Eocene (P9-11) in the North Sea. Such forms exist in this sample. More agglutinateed forms occur at this level. Examples include *Clavulinoides anglicus* (NSB3), *Saccammina sphaerica*, and *Rhabdammina excelsa*.

2540' Barren.

2590'-2930' ?Early Eocene, NSB3?:- Poor faunal diversity, low numbers. *C. anglicus* occurs at 2590'. 2630'-2690' contains *Trochammina subvesicularis*, plus *Rhabdammina excelsa*. At 2750' *Spiroplectinella deperdita* was noted. *S. excolata* was noted at 2930'.

2930'-4130' Late Palaeocene, Sparsely microfossiliferous interval, NSB2/P6, AB3:- Most samples completely barren, with occasional specimens of *R. excelsa*.

4220'-5810' Late Palaeocene, NSB1-2/P4-5,, *Spiroplectammina spectabilis* Form B Zone, AB2:- Abundant agglutinated forms. First occurence of *Reticulophragmium paupera* at 4220'. Increase in numbers and diversity of agglutinated foraminifera at 4340'. At this level have the first downhole occurences of *Thalmannammina walteri* , *Trochammina ruthvenmurrayi*, *S. spectabilis* form B, *Trochammina globigeriniformis*, *Cribrostomoides sublobosus*, *Karreriella (Karrerulina) conversa*, *Ammodiscus cretaceus*, *Cyclammina* cf. *garcillassoi*, various *Rhabdammina* and *Dendrophyra* species, etc.. *Rhabdammina excelsa* was very common in these samples. Also present in 4340' was *Cystammina pauciloculata*. See Enc. no.1 for full species list.

5810'-5990' Late Palaeocene, NSB1b/NSP2/>P3, Spongodiscid Radiolaria Zone, PK2, CB2:- Contains examples of *Cenodiscus lenticularis*. Also contains the above agglutinated assemblage. At 5870' (D.C.) *Stensioina beccariiformis* was recorded indicating the top of the calcareous benthonic Zone CB2 (FDO early Late Palaeocene). This form is normally more dominant in the underlying *Clavulinoides anglicus/Clavulina parisiensis* Zone. Also noted at 5928' (SWS) was *Marssonella oxycona*. This species occurs in low numbers in this zone. Planktonic species were noted at 5990', in small numbers. These were "*Globanomalina*" *pseudobulloides*, and "*Globanomalina*" *compressa*. These forms often first appear in the basal part of this zone.

5991'-6100' Late Palaeocene, NSB1b/P3, Clavulina parisiensis/ Clavulinoides anglicus Zone, AB1, CB2:- Contains examples of the nominate taxon, plus an influx of calcareous benthic forms such as Osangularia sp.1. Other calcareous benthics were at 6051' (SWS) Eponides lunata, Alabamina solnasensis, Cibicides voltziana, and Bulimina denticulata. Also observed examples of Stensioina beccariiformis at 6050' (DC). This confirms the CB2 age of these sediments (early Late Palaeocene-Early Palaeocene). Cenodiscus sp.1 was also observed at 6051', with minor amounts of C. lenticularis at 6050' (caved?)." Globanomalina" pseudobulloides and Globigerina [Subbotina] triloculinoides occur within this zone, but without "Globanomalina" compressa.

6101'-6469' Early Palaeocene, NSB1a/P2/?NP4, Danian Planktonics Zone, PK1?:- The upper boundary of this zone is indistinct if only the foraminiferal evidence is examined, as the sampling space is very wide. Next sample after 6100' is 6170'. However, the geophysical log data indicate a major lithological break at 6100' (approx.). This is shown on the lithological section of Enclosure no.1 as an influx of chalk. "Globanomalina" pseudobulloides was recorded from 6170', 6290'and 6410'. Stensioina beccariiformis also occured in this interval.

6470'-6510' Early Palaeocene, Danian Planktonics Zone, NSB1a/P1, Eoglobigerina eobuloides simplicissima subzone, PK1a, CB2:- Includes "G." pseudobulloides in greater numbers, plus "Globanomalina" varianta, Eoglobigerina eobulloides simplicisima, and "G." compressa at 6470'. Also observed were Mantanzia varians which is generally more common in the basal part of the Danian (see Gradstein et al. (1988), Doppert and Neele (1983, as "Textulariella" varians)).

Marssonella oxycona occurs here, plus *Quadrimorphina allomorphinoides*, and *Cibicidoides* aff. *dayi*. *Cibicidoides dayi* s.s. ranges from the Late Cretaceous (Campanian) to the Late Paleocene (P5) (van Morkhoven *et al*. (1986). *Stensioina beccariiformis* was also noted in this interval.

Well 21/11-1. Central part of the Central North Sea. (See Enclosure No.2A-B). The samples from this well were mostly ditch-cuttings, with few SWS. Age of sediments examined range from Pleistocene (starting at 0940') to ?Cretaceous (at 5450'-5500').

2130'-2229' Early Pliocene :- *Cibicides pseudoungerianus*, *C. grossus*, *Melonis affine*, *Bulimina marginata*, *Buccella frigida*, *Cassidulina laevigata*, *Loxostomoides lammersi*, and *Sigmoilopsis schlumbergeri* were recorded. Much of this assemblage is made up of Pliocene and Pleistocene forms typical of Dopperts (1975) Upper Pliocene FA Zone (FA 2 subzone containing *Buccella* and *Cassidulina*). the FDO of *C. grossus* is in the Late Pliocene (NSB15b), the FDO of *C. pseudoungerianus* is in the Late Pliocene-Early Pliocene (NSB15a), while *L. lammersi*'s FDO is in the Early Pliocene (base of NSB15a) (King, (1983)).

Reworked calcareous benthic species include rare *Bulimina elongata* (FDO in the Late Miocene, (NSB13b of King (1983)), and rare *Heterolopa dutemplei peelensis* (FDO in the Middle Miocene NSB10 of King (*op. cit*.)). The planktonic species were rare to few in occurence, and most were reworked. Examples were *Neogloboqaudrina continuosa*, *Catapsydrax unicavus primitivus*, *Globigerina praebulloibes praebulloides*, and *Globorotaloides suteri*. The top occurrence of *Catapsydrax unicavus* is at the top of the *C. stainforthi* Zone (see Stainforth *et al*. (1975)), N6 of Blow (1969,1970), Early Miocene. This form is long ranging, being recorded from Eocene to Miocene beds. According to Stainforth *et al.* (*op. cit.*) members of the *"G". opima* group died out in the top Oligocene. Kennett and Srinivasan (1983) noted that *Neogloboquadrina continuosa* ranged from the Early Miocene N4b, into the base of the Late Miocene (Zone N16). *Globigerina praebulloides* ranges from the Late Eocene to the Late Miocene (after Kennett and Srinivasan (*op. cit.*)). *Globorotaloides suteri* was recorded by Bolli (1957c) from Trinidad, and reported its range as being from the Middle Eocene (*"Porticulosphaera" mexicana* Zone) to the Early Miocene (*Globigerinatella insueta* Zone, N8 according to Kennett and Srinivasan *op. cit.*). At 2190' one example of *Orbulina universa* was recorded, which ranges from the earliest Middle Miocene Zone N9 to the Recent. This specimen was poorly preserved so may have been reworked.

2230'-2265' early Middle-early Late Miocene, NSB13:- The age of this interval is based upon the FDO of *Uvigerina venusta* (common at 2250' DC, this species FDO is at the top of King's (1989) NSB13b Zone, noted as *U. venusta saxonica*, earliest Early Pliocene to Late Miocene, while it's LDO is in his NSB13a Zone, Early Late Miocene); and the FDO of *Stainfothia schriebersiana* at 2250' (marker species for Zone CB12, Early to early Middle Miocene, see King, 1989). The bulk of the calcareous benthic association remained the same as the interval above (2130'-2229'), but with fewer numbers of specimens and lower diversity. The planktonic foraminifera recorded in this interval include *Dentoglobigerina venezuelana*. This species is unfortunately a very long-ranging form, known from the Middle Eocene to the Early Pliocene. The existence of abundant *Pseudononion boueanus* and The calcareous nannofossils indicate an age of older than Middle Miocene from 2230' to 2250', although the assemblage noted was very poorly preserved. From 2248' the nannofossils indicate an Early Miocene age (*teste* LTG.ms).

Caved species include rare *Monspielensina pseudotepida* at 2265' (SWS) and *Loxostomoides lammersi*. One species of reworked planktonic foraminifera was noted in this interval, rare *Globigerina ampliapertura*. This species ranges from the Late Eocene to the Early Oligocene.

2310' Early Miocene, PK11?:- At 2310' an influx of planktonic species was noted together with some new calcareous benthic species, such as *Elphidium inflatum*. The LAD of *E. inflatum* occurs (according to Letsch and Sissingh (1983)) at the base of the Middle Miocene. The planktonic species include *Globigerina praebulloides praebulloides*, *G. praebulloides occlusa*, *Globorotaloides suteri* (P20-N8 of Blow (1979)), *Dentoglobigerina venezuelana*, and members of the *Globigerina yeguaensis-pseudovenezuelana* group. Rare *Globigerina ciperoensis* occurred here, plus *Globigerina* cf. *falconensis*. *G. ciperoensis* is a Late Oligocene (P19) to Earliest Miocene (N4B) marker species. Only one specimen noted at this level. *G. falconensis* s.s. is along ranging form, recorded from the Early Miocene N7 to the Pleistocene. From 2270'-2430' the nannofossils indicate an age of NN1, earliest Early Miocene, based on the occurence of *Sphenolithus conicus* (*teste* LTG.ms).

One species of caved planktonic foraminifera was recorded, *Orbulina universa* (N9 to Recent).

2370'-2430' Early Miocene, CB13, PK11:- At 2370' *Asterigerina staeschi* was noted. This suggests that this may be within Letsch and Sissingh's (1983) *A. staeschi* FT6 Zone, Early Miocene. Also noted were *Dentalina mucronata*, *Uvigerina macrocarinata*, *Karreriella (Karreriella) siphonella* (FDO), and *Heterolopa dutemplei peelensis* (FDO). *Karreriella (Karreriella) siphonella*'s FDO is in the Early Miocene according to King (1989, Zone NSA10). Heterolepa dutemplei peelensis' FDO is in Zone NSB10 of King (1983), Early-Early Middle Miocene. The planktonics increased in numbers and diversity at 2370'. More Globigerina ciperoensis were noted. New species include Chiloguembelina sp.1, Globigerina aff. angulisuturalis (rare), and Tenuitella munda. G. angulisuturalis is used as an index fossil for recognising the latest Oligocene N2 to N4A (Kennett and Srinivasan (1983)), although it occurs in the Early Miocene according to Blow (1979). T. munda ranges from Zone P20-P21, Early Oligocene (Li Qianyu, 1987), although it was also noted in the Early Pliocene (2000'DC) in this well. The Miocene/Oligocene boundary was recognised at 2430'-2450' by using nannofossil data (teste LTG.ms).

Reworked planktonic species include few Globigerina officinalis and rare G. ampliapertura. The FDO of the former species is in Late Oligocene sediments, within the G. ciperoensis Zone (see Fig.16, in Stainforth et al., (1975)). G. ampliapertura's FDO is also within the Late Oligocene (King (1983)).

2451'-2550' Late Oligocene, NP24/25:- The foraminifera in this interval do not provide any useful marker species. However, the nannofossils indicate that from 2451' to 2810' a Late Oligocene nannofossil assemblage exists. The marker forms are Chiasmolithus altus, Reticulofenestra scissura and H. recta, in association with Zygrhablithus bijugatus and Cyclicargolithus abisectus (teste LTG.ms).

2610'-2669' Early Late Oligocene, NSB8a, CB8:- Asterigerina guerichi noted. This form is abundant to common in Zone NSB8a of King (1983), Early Late

Oligocene. Letsch and Sissingh (1983) point out that this species dies out at the top Oligocene (Chattian).

2670'-2790' Middle Oligocene, NSB7, *Rotaliatina bulimoides* Zone, CB7, AB10:- *Sabellovoluta humboldti* recorded at 2670'. *Rotaliatina bulimoides* was also noted here confirming the age for this interval. *R. bulimoides* FDO is at the top of the Middle Oligocene, and LDO is at the base of the Middle Oligocene. *Spiroplectinella carinata* was noted at 2790'. This species is typically found in Oligocene sediments (see Doppert and Neele (1983), FE and FF Zones, Late Oligocene to Early Oligocene) .

2810'-3089' Late Eocene, CB6?:- At 2810' *Percultazonaria wetherellii* was recorded, one specimen only. At 2820' *Asterigerina bartoniana* was recorded. *P. wetherellii* is a marker species for the Late Eocene (King (1989)) as *Vaginulinopsis decorata*), while *A. bartoniana* is used by Doppert (1975,1980) as a marker for his *Scutuloris oblongus*-*Asterigerina bartoniana* assemblage FG Zone, Rupelian, Early Oligocene. However, Murray *et al.* (1981) note this species as ranging from Middle to Late Eocene, while Doppert and Neele (1983) noted this species as common in their FH Zone (Upper to Middle Eocene). At 2850' *Stilostomella adolphina*, and *Anomalinoides acuta* (FH1-2 Zones of Doppert and Neele (1983), Late-Middle and Middle-Early Eocene) was recorded, which typically occur in Eocene sediments in this study. At 2910' *Nodosaria minor* was recorded, which is another Eocene species (also noted in the London Clay (Ypresian), E. Eocene, and in the FH1-2 Zones of Doppert and Neele (op. cit.), Late-Middle and Middle-Early Eocene). *Percultazonaria* sp.1, a smoother form of *P. wetherellii* was recorded at 2970' which suggests a Late Eocene age. More new species, again typical Eocene forms, were noted at

3002', for example; *Nodosaria consobrina*, *Cibicides westi* (both noted from the London Clay, in this study, the latter recorded by Doppert and Neele (1983) in their FH1 (base of) to FH2 Zones, the former by Bowen (1954) from the London Clay Formation), *Lenticulina cultrata* s.s. (again recorded by Doppert and Neele (op. cit.) from FH Zones Late Middle to Middle Early Eocene), together with some agglutinated forms such as *Haplophragmoides*, *Glomospira gordialis* and *Rhabdammina discreta* gr. The interval 2810'-3089' is dated as Late Eocene NP19/20 by the nannofossil assemblage, which includes *Ismolithus recurvus* and *Lanternithus minutus* (*teste* LTG.ms).

Reworked species include, at 2850', *Cassidulina carapitana* (FDO). This species is recorded in the Early Oligocene NSB7a of King (1989). Large numbers of caved *Spiroplectinella carinata* were also noted at 2850'.

3090'-3160' Late Eocene NSP8, P15-17, PK8:- The age of this interval was based upon the occurence of the planktonic index form *Globigerapsis index index*, a marker for King's (1983) NSP8 (Late Middle Eocene) Zone, NSP8c Zone of King (1989), Late Eocene. Gradstein *et al.* (1988) used *G. index index* as a marker for the Late Eocene P15-17 (Blow, 1979) in the Central North Sea and Viking Graben regions. King's (1983) zonation is based on neritic faunal assemblages. (As this well is in the Central North Sea it would appear that Gradstein *et al.*'s (1988) zonation and King's (1989) updated zonation are the most relevant and accurate here). Benthics include *Angulogerina germanica* which ranges from NSB6b Late Eocene to NSB5 Middle Eocene (rare in the latter, King (1983)). At 3090' rare *Spiroplectinella wilcoxensis* noted (recorded by Willems (1986) from the Ieper Formation, Early Eocene), together with *P. wetherellii* aff. (Late Eocene/Early Oligocene) *Karreriella (?Meidamonella) mexicana*, and *Turrilina alsatica* (FDO). The latter species is generally regarded as a marker for the Lower Oligocene, although it does also occur in Late Eocene (NSB6) sediments (King (1983)). The LDO of *T. alsatica* at 3150' suggests the end of Zone NSB6 (Late Eocene), unless specimens are caved, which is very possible (caving is always a problem).

Reworked species include, at 3150', *Alabamina obtusa* (rare). This species is also found in London Clay sediments (Ypresian), (see Murray *et al.* (1981)).

3170'- 3210' Middle Eocene NSB5, *Planulina costata* Zone, CB5:- *Planulina costata* occurs at 3170', and marks King's (1983) NSB5 Zone. According to King *P. costata* only occurs in the outer sublittoral-epibathyal biofacies. However, it is found in this study in very small numbers in the Central North Sea deeper-water biofacies. This species forms the upper part of Gradstein *et al.*'s (1988) *Reticulophragmium amplectens* Zone. *Cibicidoides eocaenus* also occurs with *Cibicides sulzensis*, which are typically Eocene species. *C. eocaenus* was recorded by King (1989) from the Late to Early Eocene (as *Cibicidoides eocaenus*), while van Morkhoven *et al.* (1986) note that it's stratigraphic range is from the Early Eocene (P6b of Blow (1979)) through Late Oligocene (P22 of Blow (op. cit.). At 3180' *Siphonina* sp.1 recorded, a Late Eocene/Middle Eocene form in this study. *Dentalina multilineata* recorded at 3200' (FDO). This is also noted in E. Eocene (Ypresian) London Clay sediments from the Euston Centre site. *Spiroplectinella deperdita*, a Late Eocene form, occurs at 3210', which was recorded by Doppert (1975) in his FH1 *Nummulites-Eponides* Subzone, Upper Eocene (also noted by Willems (1983) from the Early Eocene). Agglutinated forms, such as, *Recurvoides* sp.1, and *Haplophragmoides* spp. were recorded in this interval. Rare *Globigerina* [*Subbotina*] *linaperta* was recorded from 3210'. This species occurs in low numbers as high as King's (1983) NSP8 Zone NSB6a Middle Eocene.

3211'-3449' Middle Eocene?:- Contains common Rhabdammina gr. discreta, which is part of King's (op. cit) Rhabdammina biofacies. No useful index species occur in this interval.

Caved Bulimina alsatica was recorded in this interval. This is an Oligocene form (Doppert and Neele (1983)). From 3201'-3450' there is an abundant assemblage of caved Late Eocene calcareous nannofossils in a section otherwise barren of nannoplankton (teste LTG.ms).

3450'-3569' Early Eocene-Middle Eocene, AB4?:- At 3450' Haplophragmoides aff. kirki was noted. H. kirki s.s. is found in Early Middle Eocene/Early Eocene and Late Palaeocene sediments (Gardstein et al. (1988)). This species also occured with Repmanina charoides. There is a major lithological break at 3450' indicated by peaks in the Gamma Ray and Sonic (BCSL) logs. At 3510' Cibicidoides eocaenus occurs, typically an Early to Late Eocene form in the North Sea Tertiary (King (1989)), common in the London Clay (Ypresian).

From 3451'-3500' there is an abundant assemblage of caved Late Eocene calcareous nannofossils. From 3501'-3630' the samples were completely barren of nannofossils (teste LTG.ms).

3570'- 3770' Early Eocene-Late Palaeocene, NSP4, NSB2, Coscinodiscus sp.1 Zone, PK3:- Contains the nominate taxon for this zone. Also contains some agglutinated species that are typically Early Eocene, for example, Haplophragmoides kirki s.s. (Gradstein et al. (1988)). This zone is often barren of foraminifera, but low numbers of species were recorded at 3570', 3750' and at 3770'. At 3770' 1 specimen of *Spiroplectammina spectabilis* was noted. Below 3630' *Coscinodiscus* spp. were recorded; at 3770' this species was more common than *Coscinodiscus* sp.1 This sample could be within Stewart's (1987) *Coscinodiscus* spp. Zone Late Palaeocene, Thanetian. Also at 3750' rare *Osangularia* gr. *corderiana* was recorded. This species typically occurs in the Late Palaeocene, Thanetian (well 29/7-1 this study, 8318', 29/10-1, 8580'), in the Early Palaeocene, Danian (21/30-1 this study, 6890'), and Late Cretaceous sediments (Hart *et al.* (1981)). 3631'-3770' contained a limited assemblage of caved calcareous nannofossils (*teste* LTG.ms).

3790'- 4889' Late Palaeocene, NSB2, Thanetian, Sparsely microfossiliferous interval, AB3:- Low species diversity. Contains mostly agglutinated forms, such as very common *Rhabdammina discreta*, *Thalmannammina walteri* (the latter species to 3890'), and *Cyclammina* cf. *garcillasoi*. This species is common in the uppermost part of Gradstein *et al.*'s (1988) *Trochammina ruthvenmurrayi*- *Reticulophragmium paupera* Zone Late Palaeocene NSB1 of King (1983), although it does occur above the latter Zone in the earliest Early Eocene according to Gradstein *et al.* (*op. cit.*). The interval 3771' to 4859' contained only caved species of nannofossils (*teste* LTG.ms).

4890'- 5190' 'Middle'/Late Palaeocene, NSB1, Thanetian, *Spiroplectammina spectabilis* form B Zone, AB2:- Top occurence of common nominate taxon. Abundant agglutinants. Other forms noted at this level are; *Ammodiscus cretaceus*, *Spiroplectammina navarroana*, *Karreriella* (*Karrerulina*) *conversa*, common *Trochammina globigeriniformis*, *Reticulophragmoides jarvisi*, *Marssonella oxycona*, *Repmanina charoides*, *Reticulophragmium paupera*, *Haplophragmoides walteri*, and various species of *Dendrophyra*, *Bathysiphon*, *Rhabdammina* and

Glomospira. *Rzehakina minima* was also noted in this interval, plus *Spiroplectammina biformis*. At 5070' *Trochammina ruthvenmurrayi* was recorded. This zone is approximately equivalent to Gradstein *et al.*'s (1988) *T. ruthvenmurrayi*-*R. paupera* Zone Late Palaeocene, NSB1 of King (1983). The interval 4860'-5219' was barren of nannofossils (*teste* LTG.ms).

5200'- 5306' early Late Palaeocene, NSP2 NSB1b, Early Thanetian, Spongodiscid Radiolaria Zone (*Cenodiscus lenticularis*), PK2, CB2:- The nominate taxon occurs at 5234' together with abundant "*Globanomalina*" aff. *pseudobulloides*. The planktonic foraminifera noted in this interval also included *Globigerina [Subbotina] triloculinoides*, and "*Globanomalina*" *pseudobulloides*. "*G.*" *pseudobulloides* and *Globigerina [Subbotina] triloculinoides* top in this zone (R.W. Jones, unpub.). *Cenodiscus* spp. also occurred within this zone. At 5219' *Stensioina beccariiformis* was noted. This species ranges from the Late Cretaceous (Santonian) through Late Palaeocene (P5 of Blow (1979)), according to van Morkhoven *et al.* (1986). King (1983) recorded *S. beccariiformis*' FDO in the Late Palaeocene NSB1b Zone; this species is used in this study to mark the early Late Palaeocene-Early Palaeocene CB2 Zone. Calcareous benthics include *Cibicidoides dayi*, *Cibicidoides velascoensis*, *Dentalina eocenica*, and various examples of *Dentalina* spp.. The stratigraphic range of *Cibicidoides dayi* was recorded by van Morkhoven *et al.* (op. cit.) as being from the Late Cretaceous (Campanian) through to Late Palaeocene (P5 of Blow (*op. cit.*)). King (1989) records this species in the Early Late Palaeocene (1989, NSB1b Zone). The stratigraphic range of *Cibicidoides velascoensis* was also noted by van Morkhoven *et al.* (*op. cit.*) from the Late Cretaceous (Campanian) through to Late Palaeocene (P5 of Blow (*op. cit.*)). King (1989) records this species (as *Anomalinoides* *velascoensis*) from the Early Late Palaeocene (1989, NSB1b Zone). At 5305' *Anomalinoides danica* was recorded. This species was noted by Doppert and Neele (1983), as '*Gavelinella*' *danica*, in his FK Zone, Palaeocene (Montian). Van Morkhoven *et al.* (1986) recorded this species (as *Anomalinoides rubiginosus*) from the Late Cretaceous (Campanian) through to the Late Palaeocene (P5 of Blow, 1979). From 5220' there is a diverse and abundant calcareous nannofossil assemblage. The abundance of large *Neochiastozygus perfectus* in association with a high percentage of *Chiasmolithus edentulus*, indicates the presence of the *N. perfectus* Zone (van Heck and Prins (1987)), which marks the top of the Early Palaeocene (Zone NP4) and the top of the Danian (*teste* LTG.ms).

Reworked species include rare *Globastica daubjergensis*, *Eoglobigerina trivilais*, and "*Globanomalina*" *compressa*. Reworked calcareous benthics were also recorded, for example *Gyroidinoides nitida* at 5305'. This species is recorded by Sliter (1974) from the Late Cretaceous (Campanian and Maastrichtian) of DSDP Leg 39 Site 335.

5306'- 5490' E. Palaeocene, P1/2 (Blow, 1979), NSB1a, Danian Planktonics Zone, PK1, CB2 (pars.):- Contains common "*Globanomalina*" *pseudobulloides*. Also contains *Eoglobigerina trivialis*, *E.* aff. *trivialis*, *Pseudotextularia* sp. and "*Globanomalina*" *compressa*. The presence of the latter species suggests Zone P1a to P2 of Blow (1979), Danian-?basal Thanetian. *Eoglobigerina trivialis* ranges from P.a Danian to within the basal part of P3, earliest Thanetian (Blow, 1979). In this study (in for example wells 21/30-1 6850' and 29/10-1 9060') the latter species occurs only within the Danian. The base of Zone CB2 occurs in this interval. The marker species for that Zone (*Stensioina beccariiformis*) was recorded down to 5430'. The Gamma Ray and Sonic (BCSL) logs show a distinct break in the lithology at 5306'. From 5306' to 5490' Danian Chalk exists in this well. The interval 5311'-5490' was either barren of calcareous nannofossils, or contained only reworked Cretaceous forms (teste LTG.ms).

WELL 21/30-1. Central part of the Central North Sea. (See Enclosure No.3). 90 samples were examined from 3490' to 6890'. 157 benthic species were noted, 74 of which were agglutinated ones. 20 species of planktonic foraminifera were noted, plus 1 species of radiolaria, and examples of the diatom genus Coscinodiscus. 6 samples were barren.

3490'-3649' Late? Miocene NSB13a, CB15:- The age of this interval is determined by the FDO of Bulimina elongata. Also noted were Cassidulina pliocarinata and Cibicides pseudoungerianus. Planktonic species are first recorded at 3550'. These are; Globigerina praebulloides praebulloides (common), Catapsydrax spp. (common), and G. praebulloides s.l. (common). G. praebulloides was said to range from the Late Eocene (Globigerapsis semiinvoluta Zone) to the Middle Miocene (Globorotalia cultrata-Globigerina nepenthes) Zone by Blow and Banner (1962); but Kennett and Srinivasan (1983) noted this species as frequent in the Middle and Late Miocene, but more common in the Late Oligocene-Early Miocene in DSDP wells. The interval 3551'-4088' was dated using calcareous nannofossils as Middle to Late Miocene based partly on Reticulofenestra pseudoumbilicus. Late Miocene to Pliocene nannoplankton species were also noted at this level (teste LTG.ms).

Caved species are common in this interval. At 3490' Sigmoilopsis schlumbergeri was recorded, plus Elphidium excavatum, Loxostomoides lammersi, Monspielensina pseudotepida, Bulimina gibba, Cassidulina *laevagate*, and *C. crassa*. This assemblage has many of the characteristics of the Early Pliocene NSB14 Zone. For example, it contains that Zone's nominate taxon, *Monspielensina pseudotepida*. Other forms typical of that Zone are included in the above list. They include *C. pliocarinata*, *L. lammersi*, *S. schlumbergeri*, *C. laevigata*. *C. crassa* and *E. excavatum* are more common in or above NSB14. *C. grossus* was also recorded at this level. This is a Late Pliocene NSB15 species, and examples here are caved. Reworked species include *Heterolepa dutemplei peelensis* (early Middle Miocene age, NSB10, examples are only comon in 3490'), and *Heterolepa dutemplei praecinctus*. *H. dutemplei praecinctus* is an Early Oligocene sub-species. There has been considerable reworking of older material into this interval. Rare *Turrilina alsatica* was noted at 3610' SWS. This is a reworked Late Oligocene specimen.

3650'-3729' Late Middle Miocene, NSB12a, *Siphonina reticulata* Zone, CB14:- This Zone is defined by the FDO of *Siphonina reticulata*, which was noted at 3650' SWS, abundant. King (1983) records this species FDO in the Early Late Miocene (NSB12b). At 3670' *Svratkina perlata* was recorded. This species was recorded by Hughes (1981) from Late Middle Oligocene material with *Rotaliatina bulimoides*. However, Shell Expro. U.K. have noted this species in Northern North Sea wells from Late Eocene to Late Miocene (FDO) sediments. *Neogloboquadrina continuosa* was recorded at 3670', with *Globigerinoides quadrilobatus trilobus* and *Orbulina* sp. *G. quadrilobatus* ranges according to Kennett and Srinivasan (1983) from the E. Miocene Zone N4b to Pleistocene Zone N22. King (1983) noted this species in his NSP12 Zone Late Middle Miocene, base of NSB12a. *Orbulina* spp. are recorded from basal Middle Miocene times upwards (Kennett and Srinivasan (*op. cit.*).

Reworked species include abundant Angulogerina gracilis. A. gracilis s.s. is an Early Miocene and Oligocene species. At 3650' rare Globigerina ampliapertura was noted. G. ampliapertura is an Oligocene species recorded by King (1983) from his NSP9 Zone; Blow (1979) records this species from his P17 to P19-20 Zone, Early Oligocene. Globigerina aff. angulisuturalis was also noted in this interval; G. angulisuturalis s.s. ranges from Zone N2 to Zone N4a (latest Oligocene), after Kennett and Srinivasan (op. cit.).

3730'-4329' late Early to Middle Miocene, NSB10-11, Asterigerina staeschi Zone, CB13, PK12?:- The top of this Zone is defined by the FDO of A. staeschi (rare in this well at 3730'). This species is common at 3880', and abundant at 4270'. A. staeschi's FDO is in King's (1983, 1989) NSB11 Zone, in Early Middle Miocene sediments. Globorotalia scitula was recorded at 4210' to 4330'; this is an earliest Middle Miocene (Zone N9 of Blow, 1979) to Recent species (Kennett and Srinivasan, 1983), and is used to mark Zone PK12 in this study. At 4270', specimens of Globigerina aff. angulisuturalis were noted; this was a latest Oligocene species according to Kennett and Srinivasan (1983)). However, in this study this species is also recorded in Early Miocene sediments, and is used to mark the PK11 Zone below the occurrence of Globorotalia scitula-G. praescitula (PK12 Zone), from 4330'-4810' in this well. The interval 4089'-4369' was dated on calcareous nannofossils as being Late Early Miocene, NN3 and NN4 zones of Martini (1971) (teste LTG.ms).

Reworked Gyroidina soldanii mamillata (few) was recorded at 3730'. This is an Early Oligocene species (King (op. cit.)). At 3910' Percultazonaria aff. wetherellii was noted, a species usually found in E. Oligocene material. Considerable reworking appears to have taken place at this level.

4330'-4579' Early Miocene-Late Oligocene, NSB8-9, *Spirosimoilinella compressa* Zone, AB11:- The top of this Zone is defined by the FDO of the nominate taxon (rare at 4330'). This species has its FDO usually within the Early Miocene, although it has been recorded by Gradstein *et al.* (1988) from Middle Miocene sediments. It is generally common to abundant in Late Oligocene sediments. Planktonics include *Globigerina woodi* (rare). This species ranges, according to Kennett and Srinivasan (1983) from the Late Oligocene (*Globorotalia kugleri* Zone) to the Late Pliocene (*Globorotalia tosaensis* Zone). 4370'-4474' E. Miocene dated by nannoplankton, equivalent to NN3 of Martini (1971), as was 4475'-4486', Zone NN2. A poor nannoplankton assemblage was noted from 4487'-4600'?, and tentatively dated as E. Miocene (*teste* LTG.ms).

4580'-5079' early Late Oligocene, NSB8a, *Asterigerina guerichi* Zone, CB8:- FDO of *A. guerichi* (common). *A. guerichi* is first recorded by King (1983) from his NSB9 E. Miocene Zone. However, he uses it as an index species for his NSB8a early Late Oligocene when it commonly occurs. *Spirosigmoilinella compresssa* common from 4880' suggesting Oligocene age sediments. At 4700' *Reticulophragmium rotundidorsata* (rare), *Stilostomella spinescens* (rare), and *Lenticulina calcar* (few) were recorded. *R. rotundidorsata* is recorded by Gradstein *et al.* (1988) as being rare in Early Miocene to Late Oligocene sediments. *S. spinescens* was recorded by Ulleberg (1974) from Oligocene sediments. At 4810' *Gyroidina soldanii mamillata* was recorded, confirming the NSB8a age for this interval. *Reticulophragmium placenta* common at 4640' (FDO); this species is generally only common in the Oligocene although it has been recorded from Early and Middle Miocene sediments (Gradstein *et al.* (*op. cit.*)). At 4700' *Ammodiscus latus* was recorded. This species is recorded by Gradstein *et al.* (*op. cit.*) from the Early Oligocene and Late Eocene. It has been noted in this study from later Oligocene material. *G.* aff. *angulisuturalis* occurs at 4810' (Zones N2 to N4a, Latest Oligocene, Kennett and Srinivasan, 1983, and marker for PK11 Late Oligocene-Early Miocene). 4601'?-5201' were barren of nannofossils (*teste* LTG.ms).

5080'-5201' ?Late Oligocene:- At 5080' *Reticulophragmoides* sp.5 of Gradstein and Kaminski (1989) was recorded. This species was noted by Gradstein and Kaminski (*op. cit.*) from the Oligocene of the Central North Sea. Also present at this level was *Dorothia* aff. *seigliei*, another Oligocene (?Late) form.

Caved *Asterigerina staeschi* and *A. guerichi* were also noted.

5202'-5899' earliest Late Oligocene to Early Oligocene, NSB7, *Dorothia seigliei-Rotaliatina bulimoides* Zone, CB7, AB10:- *Ammodiscus latus* was noted plus common *Spirosigmoilinella compressa*. At 5202' *Dorothia seigliei* s.s. was noted, plus *Reticulophragmoides jarvisi*. *Adercotryma agterbergi* was noted at 5220'. These three species are indicative of the *D. seigliei* Zone (Gradstein and Kaminski (1989)). At 5700' *Rotaliatina bulimoides* was recorded confirming the NSB7 Early Oligocene age of these sediments (King, 1983, 1989). *Reophax* spp. and tubular agglutinants were recorded at this level. Planktonic species include *Globigerina* cf. *officinalis* (rare) recorded at 5080'. Nannofossils in the interval 5202'-5420' indicate a Late Oligocene age, Zones NP24-25 of Martini (1971) (*teste* LTG.ms). There appears to be a conflict of ages between the calcareous nannofossil dates and the foraminiferal evidence, at this level. The interval noted as Late Oligocene NP24 to NP25 by L. Gallagher, would be dated as Early Oligocene by their foraminiferal fauna. This E. Oligocene date is based upon the occurence of *Dorothia siegliei* s.s., and *Reticulophragmoides jarvisi* at 5202', with *Gyroidina soldanii mamillata* (a marker for Zone CB7, Early Oligocene) at 5220'. *D. seigliei* and *Adercotryma agterbergi* were recorded throughout this interval. These species are typically E. Oligocene in age according to Gradstein and Kaminski (1989). It may be that they do in fact range up into the Late Oligocene. '*Karreriella siphonella*' of Verdenius and van Hinte (1983), which is the same as *D. seigliei*, was recorded by them in Oligocene and Early Miocene material. However, *A. agterbergi* and *R. jarvisi* have only been noted from E. Oligocene sediments. *G. soldanii mamillata* was first recorded (FDO) at the base of NSB8a, earliest Late Oligocene by King (1983, 1989).

5900'-6378' Early-Middle Eocene, NSB4, *Reticulophragmium amplectens* Zone, AB6:- Contains the FDO of *R. amplectens*. Also contains *Reticulophragmoides jarvisi*. At 6067' *Ammomarginulina macrospira* was noted, plus *Spiroplectinella wilcoxensis* and *Karreriella (Karrerulina) conversa*. *A. macrospira* is commonly found in Early Eocene sediments according to Gradstein *et al.* (1988) (as *Ammobaculites* aff. *polythalmus*), while Gradstein and Kaminski (1989) note it from the Palaeocene through Late Eocene. *Karreriella (Karrerulina) conversa* is a Middle Eocene to Palaeocene form (Gradstein *et al.* (*op. cit.*)). *Spiroplectammina spectabilis* form A was recorded at 6107' with *R. amplectens*. At 6210' *Karreriella (Karrerulina) conversa*, *Karreriella (Karrerulina) horrida*, *Haplophragmoides kirki*, *Praecystammina globigerinaeformis*, and examples of *Reophax*, *Glomospira*, and *Dendrophyra* species were noted. *Karreriella (Karrerulina) horrida* is an Early Oligocene (rare) to Late Palaeocene species (more common) (Gradstein *et al.* (*op. cit.*)).

According to Gradstein *et al.* (*op. cit.*), *Haplophragmoides kirki* is an Early Eocene form, while *Praecystammina globigerinaeformis* is an early Early Eocene form.

Reworked Palaeocene *Trochammina ruthvenmurrayi* was recorded at 6362' (noted in King's (1989) NSB1, NSA1 Zones).

6379'-6442' Early Eocene/Late Palaeocene, NSP4, *Coscinodiscus* sp.1 Zone, PK3:- Zone defined by FDO of nominate taxon, plus *Coscinodiscus* spp..

6443'-6689' Late Palaeocene, NSB2, Sparsely microfossiliferous interval, AB3:- Logs indicate Balder formation from 6440'-6477'. 6443', 6454', and 6620' were barren.

6690'-6711' Late Palaeocene, Thanetian, NSB1b, *Spiroplectammina spectabilis* form B and Spongodiscid Radiolaria Zone, AB2, PK2?, CB2:- Contains abundant *S. spectabilis* form B. No Radiolaria, but FDO's of *Globigerina [Subbotina] triloculinoides* and "*Globanomalina*" *pseudobulloides* in this interval. The latter two species are typically found firstly (FDO's) in the *Cenodiscus lenticularis*, NSP2 Zone (wells 49/9-1, 21/11-1 for example). *Eoglobigerina* cf. *trivialis* was also noted at this level. *Stensioina beccariiformis* (few) was also recorded in this interval (6690'-6900'), together with *Nuttallides truempyi* (rare). *S. beccariiformis* often tops within (or just above) the *Clavulina parisiensis*/ *Clavulinoides anglicus* Zone, just below the *S. spectabilis* form B Zone (wells 21/30-1, 14/29-1 for examples); it is a marker species for the CB2 Zone, early Late Palaeocene-Early Palaeocene. Van Morkhoven *et al.* (1986) record *S. beccariiformis* from the Late Cretaceous (Santonian) through Late Palaeocene (P5), and noted that it was a bathyal and abyssal species.

Nuttallides truempyi (rare) ranges according to van Morkhoven et al. (op. cit.) from the Late Cretaceous (Campanian) through Late Eocene (P17). The latter authors regarded this as predominantly a lower bathyal abyssal taxon. Berggren and Aubert (1983) estimated an upper depth limit of approximately 500-600m for N. truempyi.

Caved Trochammina subvesicularis (rare) was noted in this interval. T. aff. subvesicularis was recorded by King (1989) from the Late-Middle Eocene. Hanzlikova (1955) described T. subvesicularis s.s. from Early Eocene sediments (type level, Palaeogene).

6712'-6849' Early Late Palaeocene, NSB1b?, P3 of Blow (1979), Clavulina parisiensis/Clavulinoides anglicus Zone, AB1, still PK2? and CB2:- Contains a few examples of the nominate taxon (FDO). Other forms noted include Dorothia beloides, a Late Palaeocene form (recorded from the Lizard Springs Formation by Kaminski et al. (1988)). At 6732' Rzehakina minima (rare) was recorded, plus Nonion spp., Osangularia expansa and Pullenia quaternaria. R. minima has it's FDO in the Late Palaeocene (rare in the later part of the Late Palaeocene) (Gradstein et al. (1988)). Osangularia expansa first occured (FDO) in King's (1983) NSB1b Zone, early Late Palaeocene. Pullenia quaternaria was recorded by Doppert and Neele (1983) from the very earliest Early Eocene (their FI Zone) to the Palaeocene (their FJ Zone. Montian). The planktonic species include abundant Guembelina spp., plus Eoglobigerina cf. trivialis (few) and "Globanomalina" pseudobulloides (common at 6770').

Reworked Cretaceous Biglobigerinella aspera (few) noted in this interval.

6850'-6890' Early Palaeocene, NSB1a, NSP1, Danian Planktonics Zone, PK1b:- Common "Globanomalina" compressa, Eoglobigerina trivialis s.s., and abundant *Globigerina [Subbotina] triloculinoides*. "*Globanomalina*" aff. *compressa* and *Eoglobigerina trivialis* indicate that this interval is within the Danian Planktonics Zone, P2, Blow (1979). A few examples of *Clavulina parisiensis* were recorded at 6850' SWS with "*Globanomalina*" *compressa*. *Osangularia corderiana* were noted at 6890', again, generally an NSB1 species, Early to early Late Palaeocene (wells 29/7-1, 29/10-1 for examples). *O. corderiana* was noted by Hart *et al.* (1981) from the Late Cretaceous. A lithological break occurs at 6900' according to the Completion Log, and the Gamma Ray and Sonic data. This is believed to be the Cretaceous/Tertiary boundary.

Caved Cretaceous *Gavelinella* was noted at this level.

Well 29/7-1. Central North Sea, Central Graben. (See Enclosure No.4). Well contains 29 species of benthic foraminifera, with 6 species of planktonic foraminifera. It also contains ostracods, 2 species of radiolaria, and diatoms. 20 samples were examined, 2 were barren. The age of sediments ranges from Early Paleocene (Danian) to Eocene. All samples were side-wall samples.

7000' (SWS) Barren.

7100'-7500' Late Eocene, *Karreriella (Karrerulina) conversa* Zone, AB9:- Latter species common in this interval, together with *Rhabdammina discreta*. At 7200' *Reticulophragmium rotundidorsata*, *Haplophragmoides walteri*, and rare *Reticulophragmoides jarvisi* occur.

Reworked *Spiroplectammina spectabilis* form A was noted at 7100' (rare).

7500'-7751' Early-Middle Eocene, NSB3-5, AB6:- The numbers of Karreriella (Karrerulina) conversa increased at 7500'. Also at this level examples of Reticulophragmium amplectens were noted indicating zone NSB4 of King (1983), and Zone AB6 (Early-early Middle Eocene) in this study. Radiolarians Cenodiscus spp. were also recovered. Praecystammina globigerinaeformis were found at 7500' suggesting an earliest Eocene age for these sediments.

7751'-7901' Early Eocene, NSB3, AB6:- Contains Haplophragmoides walteri, Karreriella (Karrerulina) conversa, plus Reticulophragmium amplectens and most notably Cyclammina cf. garcillassoi (at 7751'). This assemblage suggests an earliest Eocene age. 7901' barren.

7901'-8030':- 8001' contained Spiroplectammina spectabilis form A, suggesting an Early Eocene age. Calcareous nannofossil evidence confirms this age, indicating zone NP12 of Martini. This nannofossil assemblage correlates well with those seen in the London Clay (teste LTG.ms).

8040'-8120' Earliest Eocene-Late Palaeocene, NSB2-3:- Balder formation, ash marker (based on log information). No Coscinodiscus forms noted because of large sample gap here. Samples processed for nannofossils were barren (LTG.).

8120'-8149' Late Palaeocene, NSB2, Sparsely microfossiliferous interval, AB3.

8150'-8318' Early Late Palaeocene, NSB1b:- Contains a generally poorly diverse fauna and low numbers of specimens. One notable feature is the presence of reworked Cretaceous calcareous benthonic forms (contamination?), together with Guembelina spp.. Also noted were Gavelinella sp., and Gyroidina sp.. Age based upon the FDO of *Osangularia cordieriana* at 8318', which in this study often occurs in the Late and Early Palaeocene (wells 29/7-1, 21/30-1, and 29/10-1).

8400' Late Palaeocene, NSB1b, P3, NSP2, Spongodiscid Radiolaria Zone, PK2:- Contains *Cenodiscus lenticularis*.

8450'-8500' Early Late Palaeocene, NSB1b, basal part, CB2?:- Samples contain agglutinated forms, such as *Rhabdammina excelsa*. Also present at 8490' is *Alabamina solnasensis*, described by Brotzen (1948) from the Palaeocene of Sweden (this species may be limited in it's occurrence to Zone CB2).

8500'-8541' ?Early-early Late Palaeocene Palaeocene, NSB1, CB2:- *Cibicidoides velascoensis* (a marker species for Zone CB2) occurs at 8500' together with *Eponides plummerae*. *C. velascoensis* ranges from the Late Cretaceous (Campanian) through Palaeocene (P5 of Blow, 1979), while King (1989) records this species (as *Anomalinoides velascoensis*) in the early Late Palaeocene, 1989 Zone NSB1b. At 8540' the nannofossil *Chiasmolithus inconspicuous* occurs, together with *Prinsius bisulcus*, indicating the age here as the base of Zone NP4. From 8501'-8540' the sediments were dated as Zone NS18 (*teste* LTG.ms).

8541'-8620' Early Palaeocene, P2, NSB1a, Danian Planktonics Zone, "*Globanomalina*" *compressa*- *Eoglobigerina trivialis* Subzone, PK1b:- At 8600' *Eoglobigerina* cf. *trivialis* and "*Globanomalina*" aff. *pseudobulloides* occurs suggesting a later Danian age. "*Globanomalina*" *compressa* occurs at 8620' re-inforcing this age. Calcareous nannofossil data suggests Zone NP3 (upper part) and Zone NS19 (8541'-8570'), this is based upon the existence of

Prinsius martinii and members of the Chiasmolithus inconspicuous/danicus group (and the absence of Chiasmolithus edentulus) (teste LTG.ms).

WELL 29/10-1. Central North Sea Central Graben. (See Enclosure No.5A-B). Samples were examined from 1410' to 9110'. However, samples were only logged from 4810' to 9110'. The total number of samples logged was 86. 167 benthic species were recorded, approximately 80 of which were agglutinated benthic forms. 42 planktonic species were recorded, together with 4 species of Bolboforma, 3 species of diatoms, and 2 species of radiolaria. Most of the samples were ditch-cuttings, so caving was a problem in this well.

4810'-5509' Spirosigmoilinella compressa Zone, early Middle Miocene, AB11b:- This Zone is based on the FDO of Spirosigmoilinella compressa. The benthic assemblage includes Siphonina reticulata, Cibicides pseudoungerianus, and Karreriella (Meidamonella) bradyi. Planktonics include Neogloboqaudrina continuosa and Globigerina praebulloides praebulloides. The planktonic species indicate an early Middle Miocene age. G. praebulloides praebulloides (according to Banner and Blow, 1962) ranges from the Late Eocene to the Middle Miocene; Kennett and Srinivasan (1983) record G. praebulloides from the Late Eocene ("Porticulosphaera" semiinvoluta Zone) to the Middle Miocene (Globorotalia cultrata-Globigerina nepenthes Zone); they also state that this species is common in the Late Oligocene and Early Miocene in DSDP sequences, and is infrequent in the Middle and Late Miocene. Kennett and Srinivasan (op. cit.) record Neogloboquadrina continuosa from the Early Miocene (Zone N4b of Blow, 1979) through to Late Miocene (Zone N16 of Blow (op. cit.)). Cibicides pseudoungerianus ranges from the late Late Miocene, down into the Middle Eocene. The calcareous nannofossils present in this interval suggest Zone NN6, Middle Miocene, Zone NS3 from 4801'-5530' (*teste* LTG.ms).

The *Bolboforma* species present in this interval suggest a Late Miocene age. Examples are *B. spiralis*, *B. laevis* and *B. clodiusi*. These are probably caved. Caved foraminifera include *Sigmoilopsis schlumbergeri*, *Loxostomum lammersi*, *Uvigerina venusta deurnensis*, *Cassidulina laevigata*, and *Bulimina elongata subulata*. *B. elongata subulata* is, according to Shell Expro. U.K., a Pliocene-Pleistocene species. "*Uvigerina hosiusi deurnensis*" ranges (according to Doppert, 1980) from the late Middle Miocene to the late Late Miocene (this is the same as *U. venusta deurnensis* as recorded here in this well). Reworked? examples of *Karreriella (Karreriella) siphonella* were present in this interval. *Karreriella (Karreriella) siphonella* was recorded by King (1989) as present in his NSA9 *Spirosigmoilinella* sp.A Zone, Early Miocene. This species may be reworked, but it is likely that its stratigraphic range extends up into the early Middle Miocene.

5510'-5700 Early-early Middle Miocene, CB12 (from 5510'-5530'):- The age of this interval is based on; the FDO of *Asterigerina staeschi*, the occurrence of *Spirosigmoilinella compressa*, the FDO of *Stainforthia schriebersiana* (marker species for the CB12 Zone, LDO in this well at 5530'), and certain planktonic species. Letsch and Sissingh (1983) use *S. schriebersiana* as a marker for their Late Oligocene *Stainforthia schriebersiana* Subzone, in their *Turrilina alsatica* Zone. *S. schriebersiana* is recorded by Doppert (1980) from early Middle Miocene sediments, but it is not common until the early Early Miocene-Late Oligocene. *Asterigerina staeschi* is recorded by Doppert (1980) from Middle Miocene sediments and is used as a marker species in his Middle Miocene *A. staeschi-Uvigerina tenuipustulata* FD Zone. However, Letsch and Sissingh (1983) use *A. staeschi* as a marker species for Early Miocene sediments. The planktonic species includes *Globigerinoides quadrilobatus trilobus* "*Globigerinella*" *obesa*, and *Globigerina praebulloides praebulloides*. "*Globigerinella*" *obesa* is not a useful marker species in this interval as it ranges from the Late Oligocene (P22) to the Recent (Kennett and Srinivasan, 1983). Stainforth *et al.* (1975) record *Globigerinoides quadrilobatus trilobus* from sediments younger than Early Miocene (*Catapsydrax dissimilis* Zone) but Kennett and Srinivasan (*op. cit.*) record *G. quadrilobatus* from basal Early Miocene N4 through to Recent. King (1983) used the latter species as a marker for the top of his NSP12 Zone, late Middle Miocene. It ranges down into the top of his NSP11 Zone Early to early Middle Miocene. Blow and Banner (1962) recorded *G. praebulloides praebulloides* from Late Eocene to the Middle Miocene (see also comments in interval above (4810'-5509') concerning the range of this species). At 5530' *Globorotaloides suteri* was noted (ranges from the Middle Eocene *Porticulosphaera mexicana* Zone to the Early Miocene *Globigerinatella insueta* Zone, according to Bolli (1957a,1957b), see also Kennett and Srinivasan (*op. cit.*)). *Globorotalia scitula* was also recorded at 5530', which ranges from the Middle Miocene Zone N9 to the Recent (see Kennett and Srinivasan (op cit.)). The calcareous nannofossils suggest an age of Early-early Middle Miocene NN5 from 5531' to 5610' (Zone NS4), and Early Miocene NN4 from 5611-5790' (Zone NS5) (*teste* LTG.ms).

Dentalina mucronata was recorded in this interval. This is a Late Miocene to late Middle Miocene species (it is probably caved here).

5701'-5880' late Early Miocene, PK12 (at 5810'):- The age of this interval is based upon the nannofossil data, the general benthonic foraminferal assemblage, and the planktonic foraminifera present. The benthonic foraminiferal assemblage includes *Asterigerina staeschi*, *Nodosaria longiscata*, *Cibicides ungerianus*, *Spirosigmoilinella compressa*, *Reticulophragmium placenta*, *Angulogerina* gr. *gracilis*, *Martinotiella communis* and *Bulimina elongata*. *Asterigerina staeschi* tops (FDO) in the late Middle Miocene, but is still commonly found in Early Miocene sediments. *Bulimina elongata* is commonly found, according to Doppert (1980), in Middle and late Early Miocene. He noted that *Angulogerina gracilis* occurs in the earliest Middle Miocene, but is more common in the Early Miocene-Late Oligocene. The first occurrence of *Reticulophragmium placenta* is commonly within the earliest Early Miocene, although it has been noted from late Early and ?Middle Miocene sediments (Gradstein *et al.*, 1988, Verdenius and van Hinte, 1986). *Spirosigmoilinella compressa* is more commonly found in the earliest Early Miocene-Late Oligocene (King (1989) as *Spirosigmoilinella* sp.A). This assemblage still belongs in Letsch and Sissingh's (1983) *Asterigerina staeschei* FT6 Zone. This corresponds to the *Rotalia*-*Trifarina* FE1 subzone of Doppert (1975,1980), and de Meuter and Laga's (1977) *Trifarina gracilis rugulosa*-*Elphidium ungeri* assemblage Zone, Early Miocene. The planktonic foraminiferal species includes *Globorotalia scitula*, common *Globorotalia praescitula* (at 5810'), *Neogloboquadrina* gr. *continuosa*, *Globigerina woodi*, and common *G.* aff. *angulisuturalis*. *Globorotalia praescitula* ranges, according to Kennett and Srinivasan (1983), from the Early Eocene Zone N5 to early Middle Miocene Zone N9. King records *G. praescitula* in the top of his NSP11 Zone, Early Middle Miocene. *G. scitula* is recorded by Kennett and Srinivasan (*op. cit.*) as occurring in Middle Miocene N9 to Recent material. Both *G. scitula* and *G. praescitula* are used in this study to mark Zone PK12 Early Miocene. *G. woodi* is unfortunately a very long ranging species, noted in the Late Oligocene (N4A *Globorotalia kugleri* Zone) to the Late Pliocene (N21 *Globorotalia* *tosaensis* Zone). Members of the *N. continuosa* group range up into the Early Miocene. *Globigerina angulisuturalis* s.s. is generally regarded as a marker species for the Late Oligocene N2 to N4A (Kennett and Srinivasan (*op. cit.*)). In the North Sea *G.* aff. *angulisuturalis* appears to range up into the Earliest Miocene. The calcareous nannofossils suggest a late Early Miocene NN4 age (NS5) until 5790', while from 5791'-5880' a middle Early Miocene NN3 age was indicated (NS6) (*teste* LTG.ms). The boundaries of this interval are difficult to determine because of the wide sampling spaces at this level.

> Caved *Sigmoilopsis schlumbergeri*. Increased numbers of *Bolboforma clodiusi* at 5800' and 5810' suggest a Late Middle Miocene age (Zone NSP13 of King (1983)), but these are probably cave. Other caved species in this interval were *Oridorsalis umbonatus* and *Pullenia bulloides*. *O. umbonatus* was noted by Doppert (1980) in his FC (Late Miocene) and FD (Middle Miocene) Zones. *P. bulloides* was noted in Doppert's (*op. cit.*) FB (Early Pliocene) to FD (Middle Miocene) Zones.

5881'-6180' Early Miocene NSB9/Late Oligocene FE Zone (Doppert 1975,1980)

Asterigerina guerichi FDO Zone, CB11, CB10, PK10:- This Zone is based on the FDO of *Asterigerina guerichi* (King, 1983), at 6000'; the occurrence of the marker species for Zone PK10 (Late Oligocene-Early Miocene, *Globigerina ciperoensis* Zone), and the calcareous nannofossil data. Increased numbers of *Reticulophragmium placenta* and *Spirosigmoilinella compressa* noted within this interval. Other benthic species included *Martinotiella communis*, *Cibicides pseudoungerianus*, *Uvigerina macrocarinata*, *Bulimina elongata*, *Glomospira gordialis*, *Angulogerina gracilis* s.s., *Ammodoscus latus*, occasional *Asterigerina staeschi*, and *Asterigerina guerichi*. *A. guerichi* was first recorded by Doppert (1980) from the Earliest Middle Miocene (base of his FD Zone), although it was more common in his Early Miocene/Late Oligocene (FE2 Zone), and it was most common in his Late Oligocene (FE3 *Asterigerina* Zone). *Plectofrondicularia seminuda* a marker species for Zone CB10 was noted at 6100'. The FDO of this species was recorded by King (1983, 1989) in the Early Miocene Zone NSB9. *A. latus* occurs in Late Oligocene and Early Miocene sediments (Gradstein *et al.* (1988)). At 6100' there is an increase in the number of agglutinated species in the assemblage; examples include *Glomospira serpens*, *Haplophragmoides walteri*, *Reophax pilulifer* and *Repmanina charoides*. These are generally common in Oligocene and older strata, although they have all been recorded rarely in the Miocene. The planktonic foraminiferal species include *Globigerina* aff. *angulisuturalis*, *G. woodi*, *Globorotalia praescitula*, *Globigerinoides quadrilobatus trilobus* and *Globigerina ciperoensis*. *G. ciperoensis* is a valuable index species for the Late Oligocene, although it is also more rarely found in the earliest Early Miocene (Zone N4B). *G. ciperoensis* is ancestral to *G. angulisuturalis* s.s., and according to Kennett and Srinivasan (1983) there is a complete gradation between these species within Zone P21. Such intermediates are common in the North Sea in the Late Oligocene-Early Miocene. Both *G. ciperoensis* and *Globigerinoides trilobus* are noted by Doppert (*op. cit.*) as occuring in high frequencies in his Early Miocene- ?Late Oligocene FE1 Zone. The calcareous nannofossil assemblage from 5881'-6180' indicates an Early Miocene NN2 age (NS7), although significant amounts of reworked species were noted (*teste* LTG.ms).

Caved species include *Pullenia bulloides* and *Oridorsalis umbonatus*. Reworked species include, at 6100', *Bulimina alsatica*. This occurred in Doppert and Neele's (1983) Middle Oligocene FF Zone. Caved planktonic species included *Neogloboquadrina continuosa*.

6181'-6359' Late-'Middle' Oligocene NSB8, *Spirosimoilinella compressa* acme Zone, AB11a, CB9:- This Zone is based on the FDO of common *Spirosigmoilinella compressa* (from 6210'); and the presence of *Sigmomorphina regularis* (at 6210' only), which occurs in Doppert's (1980) FE zone, Early Miocene-Upper Oligocene, and in the top of his FF *Rotaliatina bulimoides-Cibicides ungerianus* Zone, Middle Oligocene. *S. regularis* marks the CB9 Zone in this study, Late Oligocene. At 6210' *Stilostomella spinescens* was recorded. Ulleberg (1974) records this species from the Oligocene (Viborg Formation in Denmark). Doppert and Neele (1983) recorded "*Nodosaria*" *spinescens* from Middle Oligocene sediments. *Eratidus foliaceus* was also noted at this level, this again indicates sediments of Oligocene age. From 6181'-7000' the nannofossil assemblage indicates an age of NP24/25 Late Oligocene (NS8) (*teste* LTG.ms)

6360'- 7609' Early Oligocene *Rotaliatina bulimoides- Dorothia seiglae* Zone (plus early Late Oligocene, base of *Spirosimoilinella compressa* Zone 6360'-6660'), AB10, base of AB11a?, CB7, PK9 (from 6710'):- Contains *Reticulophragmoides* sp.5 of Gradstein and Kaminski (1989) FDO 6360'; this species reportedly occurs in their *D. seigliei* Zone; however, *D. seigliei* was not recorded until 7210', while *R. bulimoides* was noted at 7360'. *Gyroidina soldanii mamillata* was also noted at 7360'; both the latter species indicate Zone CB7 (7360'-7610', Early Oligocene). *Cassidulina carapitana* was noted at 6660'; this calcareous benthic foraminifer marks the top of King's (1983) NSB7a Early Oligocene Zone, and the CB7a Zone in this study (Early Oligocene). *Reticulophragmoides jarvisi* was recorded at 6610' together with *Turrilina alsatica*. *R. jarvisi* is again indicative of Early Oligocene sediments. *T. alsatica* was used by Gradstein and Kaminski (1989) in the Labrador/Grand

Banks region to mark the Early Oligocene. King (1983) used this species in the North Sea to indicate Oligocene sediments (FDO in the Late Oligocene). *Reticulophragmium acutidorsata* (of Verdenius and van Hinte 1983 = *R. placenta*) was noted at 6460'. *Adercotryma agterbergi*, again an Early Oligocene species according to Gradstein and Kaminski (1989), was noted from 6660'. Agglutinated species were far more common in Oligocene sediments in this well than in the overlying Miocene. *Rhabdammina* gr. *discreta* was common from 6510'. *Haplophragmoides walteri* is common from 6360' while *Repmanina charoides* was common from 6940'. The planktonic foraminifera include; *Globigerina* aff. *angulisuturalis* (from 6610'-7080'), *Globigerina officinalis* (6610'-7360'), *Globorotaloides suteri* (6710'-6760'), *Globigerina ampliapertura* (6710'-7010'), *G. praebulloides occlusa* (7010'), *G. praebulloides leroyi* (6850'), *G. angiporoides* (7010'), and *G. ouachitaensis* (6850'-7030'). King (1983) records *G. ampliapertura* from his NSP9 Zone, Early to early Late Oligocene, and is used to mark Zone PK9 in this study. Blow (1979) used *G. ampliapertura* as a marker species in the Early Oligocene, P19 (range P17? to P19/20). *G. officinalis* was noted by Gradstein *et al.* (1988) from the Early Miocene/Late Oligocene. Gradstein and Kaminski (1989) use "*G.* ex gr. *officinalis*" as a marker form in the Central North Sea for the Late Oligocene. Both these taxa are reportedly common in the overlying *Spirosigmoilinella compressa* Zone (Late Oligocene-Early Miocene). They were not recorded in this well in the top part of the *S. compressa* Zone, but only from what could be its base. Blow (1979) recorded *Globigerina angiporoides* from the Middle Eocene (P10), to the early Late Oligocene (P21). Blow (*op. cit.*) noted *G. ouachitaensis* from the late Middle Eocene P15 to early Late Oligocene (P21). Diatom sp.3 of King (1983) was recorded at 7030'. This species indicates Oligocene sediments. *Cenosphaera* spp. occurs throughout much of this interval together with *Coscinodiscus* spp. The calcareous nannofossils indicate an age of NP21/22, Early Oligocene (Zone NS10) from 7001'-7744' (*teste* LTG.ms) .

Reworked (contamination?) *Ammomarginulina macrospira* was recorded at 6360' and 6610', while reworked? *Spiroplectammina navarroana* was recorded at 6460'. *A. macrospira* is a late Middle Eocene marker species, while *S. navarroana* is an Early Eocene index form. The occurrence of these species suggests that considerable reworking of older sediments has occurred in this well at this level, thus blurring the biostratigraphical resolution. Caved? species include *Neogloboquadrina* gr. *continuosa* (6610').

7610'-7739' Middle-Late Eocene?, AB8?:- At 7610' *Spiroplectinella wilcoxensis* was noted. This species was recorded by Willems (198~~6~~) from the Ieper Formation, Belgium, Early Eocene. *Spirosigmoilinella* sp.1 also from this level confirms the Eocene age of these sediments. The occurrence of *Nodellum velascoense* at 7610' also suggests an Eocene age. Kaminski *et al.* (1988) noted this species from the Ypresian, Early Eocene to the Maastrichtian, Late Cretaceous. Planktonic forms include *Globigerina praebulloides praebulloides* and *G. ouachiatensis*. *G. ouachiatensis* ranges from the late Middle Eocene P15 to early Late Oligocene (P21) (Kennett and Srinivasan, 1983). *G. praebulloides praebuloides* ranges from the Upper Eocene to the Middle Miocene (Blow and Banner, 1962).

1983 in Ref

Not in Ref.

Caved species include *Globigerina* aff. *angulisuturalis* (Oligocene, see Kennett and Srinivasan (*op. cit.*), type level in the Oligocene Cipero Formation and ranges from the "*Globorotalia opima opima* Zone" to the overlying "*Globigerina ciperoensis ciperoensis* Zone", according to Bolli (1957). Caved *Globigerina ampliapertura* and *G. officinalis* were also noted in this interval. *G. officinalis* was noted by Subbotina (1953) from the Lower Oligocene. *G. ampliapertura* is an Oligocene form (King, 1983).

7740'-7779' early Middle Eocene, *Reticulophragmoides jarvisi* Zone, AB7, Actinomid Radiolaria (*Cenosphaera*) Zone (from 7740'-8010'), PK5:- This interval is defined by the FDO of common *Reticulophragmoides jarvisi*. At 7750' (SWS) *Dorothia seiglae* was recorded, plus common *R. jarvisi* (also common at 7740'), very abundant *Rhabdammina* *discreta*, and rare *Spirosigmoilinella compressa*. *R. jarvisi* appears to occur as a flood of forms above the *Reticulophragmium amplectens* Zone. It is similar in outline to *R. amplectens*, but differs in possessing limbate sutures and an umbilical tube (Gradstein and Kaminski, 1989). Also noted were examples of *Cenosphaera* sp. marking Zone PK5.

Caved species (at 7740' DC) included *Globigerina officinalis*, *G. ouachitaensis*, *G.* aff. *angulisuturalis*, and *G. praebulloides praebulloides* (see above interval, 7610'-7739', for ranges of these species).

7780'-8339' Early-Early Middle Eocene, NSB4 of King (1983) *Reticulophragmium amplectens*-Actinomid Radiolaria (*Cenosphaera*) Zone (from 7740'-8010'), PK5, AB6:- Contains *R. amplectens*, plus common *Cenosphaera* spp.. Common *R. amplectens* was regarded by King (*op. cit.*) as marking his Early Eocene NSB4 "*Cyclammina*" *amplectens* Zone. He also records this species from his NSB5 *Planulina palmerae* (=*P. costata* in this study, see also King, 1989) early Middle Eocene Zone in low numbers. Gradstein *et al.* (1988) regard this species as a Middle (-Late) Eocene marker, while R.W. Jones (unpub.) regarded this species as an early Middle Eocene marker. In this study *R. amplectens* is regarded as an early Middle Eocene form. *Cyclammina* cf. *garcillassoi* was also noted from this interval. This species was regarded by Gradstein *et al.* (*op. cit.*) as a constituent of their *Trochammina ruthvenmurrayi*-*Reticulophragmium paupera* Late Palaeocene (Selandian) Zone. Also at 7780' rare *Globigerina* [*Subbotina*] *linaperta* was recorded. This is regarded as a marker species for the Early Eocene when it occurs in large numbers.

8360'-8400' Early Eocene-Late Palaeocene, NSP4-5, *Globigerina* [*Subbotina*] *linaperta* acme Zone?/*Coscinodiscus* sp.1 Zone, PK3 and PK4?:- No *Coscinodiscus* sp.1 noted, but logs indicate the Balder formation, which is equivalent in age. Also in this interval are increased numbers of *Globigerina* [*Subbotina*] *linaperta* at 8360'-8390' (caved?). 8400' barren.

8401'-8499' Late Palaeocene, NSB2, Sparsely microfossiliferous interval, AB3:- Contains mostly tubular agglutinated species at 8460', while *Haplophragmoides* spp. are dominant at 8450' and 8490'.

8500'-8579' Late Palaeocene, NSB1b, *Spiroplectammina spectabilis* form B Zone, AB2:- Contains common nominate taxon. Other forms noted include *Repmanina charoides*, *Reticulophragmium amplectens* (rare), common *Praecystammina globigerinaeformis*, few-common *Haplophragmoides kirki*, and *Karreriella* (*Karrerulina*) *conversa*.

8580'-8699' Late Palaeocene, Thanetian, NSB1b/NSP2, PK2?, CB2:- This interval is defined by the FDO of "*Globanomalina*" *pseudobulloides*, *Globigerina* [*Subbotina*] *triloculinoides* (rare), and *Eoglobigerina* cf. *trivialis* (noted at 8610', rare). The FDO of these species is usually within the Spongiodiscid Radiolaria Zone PK2 (wells 14/29-1, 49/9-1 for example, and R.W. Jones (unpub.)). The completion log indicates a melange type sediment (the Maureen Formation) from 8400' to 9080'. Thus any biostratigraphical subdivision of these sediments is tentative. Benthic foraminifera include Spiroplectammina spectabilis (common), Rhabdammina discreta (abundant), Haplophragmoides walteri (few-common), Repmanina charoides (few-common), Recurvoides walteri (few-common), Ammodiscus cretaceus (few-common), Cyclammina cf. garcilassoi (few), Trochammina ruthvenmurrayi (few) and Ammodiscus planus (few-common). Most of the aforementioned agglutinated species are a common constituent in Palaeocene assemblages (in Gradstein et al.'s (1988) Trochammina ruthvenmurrayi-Reticulophragmium paupera Zone early Late Palaeocene, and in the flysch-type agglutinated foraminiferal assemblages from Trinidad examined by Kaminski et al. (1988)). The calcareous benthic species include Osangularia corderiana (few-common), and Stensioina beccariiformis (few-common). The latter species (which is used to define Zone CB2, 8590'-9090' in this well) ranges from the Late Cretaceous (Santonian) through Late Palaeocene (P5 of Blow, 1979) (see van Morkhoven et al. (1986)). O. corderiana occurs in the Palaeocene in wells 29/7-1 and 21/30-1 while Hart et al. (1981) records this as a Late Cretaceous species (Campanian to Early Maastrichtian).

Reworked? "Globanomalina" compressa and Eoglobigerina aff. trivialis (rare, FDO) were also recorded in this interval. The mixture of 'older' species, for example "G." cf. compressa and E. aff. trivialis (these indicate P2 of Blow (1979) and Zone PK1, well 29/7-1 for example) with 'younger' forms, such as "Globanomalina" pseudobulloides (which occurs in Zone PK2 in this study, wells 14/29-1 and 49/9-1), indicates that considerable reworking of underlying material has taken place at this level.

8700'-9079' Early Palaeocene, Danian Planktonics Zone, PK1b, CB2:- FDO of *Globastica daubjergensis*, confirming the Maureen Formation age, P2 Zone of Blow (1979). At 8950' *Globoconusa conusa* was noted. This species ranges according to Blow (1979) from Danian to Early Late Palaeocene, Pa to P3. *Eoglobigerina* cf. *trivialis* was common at 8700'. At 8800' one example of *Cenodiscus lenticularis* was found. From 9010' *Cenodiscus* spp. were commonly recorded. From 8700' *Guembelina* spp. were common. The benthic species include; *Spiroplectammina spectabilis*, rare *Clavulinoides anglicus*/*Clavulina parisiensis* at 8700' (usually indicative of the overlying *Clavulina parisiensis*/ *Clavulinoides anglicus* AB1 Zone, basal Late Palaeocene, Thanetian), *Eponides plummerae*, *Cibicidoides hyaphalus*, *C. dayi*, *Nodosaria torsicostata*, and *Marssonella oxycona*. *C. hyaphalus* ranges from the Late Cretaceous (Late Maastrichtian) through Late Palaeocene (P5 of Blow (1979)), while *C. dayi* ranges from the Late Cretaceous (Campanian) through Late Palaeocene (P5 of Blow (*op. cit.*)), according to van Morkhoven *et al.* (1986). King (1989) records *C. dayi* in his NSB1b Zone (1989), early Late Palaeocene. The latter two species are common in Zone CB2. *Nodosaria torsicostata* was recorded by King (1983) in his NSB1 Zone, FDO in the early Late Palaeocene. The calcareous nannofossils indicated a Danian age NP4 (Zone NS18), from 8701'-9110' (*teste* LTG.ms)

Reworked species include *Biglobigerinella aspera*, *Gaudryina cretacea* and reworked Late Cretaceus *Stensioina pommerana* (Hart *et al.* (1981) record *S. pommerana* from the Early Campanian to the Maastrichtian, while van Morkhoven *et al.* (1986) records its range (as *S. excolata*) from the Late Campanian through Late Maastrichtian).

9080'-9110' Early Palaeocene, Danian Planktonics Zone, *Eoglobigerina eobulloides simplicissima* Subzone, PK1a:- Contains *Eoglobigerina eobulloides simplicissima*. *Spiroplectammina spectabilis* still recorded at this level (rare), plus *Marssonella oxycona*.

Reworked Cretaceous species include *Stensioina pommerana*.

From 8580' another possible stratigraphical breakdown is:-

8580'-8699' Spongodiscid radiolaria Zone (no nominate taxon) NSP2/NSB1b.

8700'-8980' *Clavulina parisiensis/Clavulinoides anglicus* Zone, P3, NSB1b. (only if FDO of *Globastica daubjergensis* is regarded as reworked at 8700').

8980'-9079' Danian planktonics Zone, P2, NSB1a.

9080'-9110' Danian planktonics Zone, P1/2, NSB1a.

WELL 49/9-1. Southern North Sea. (See Enclosure No.6).

Samples were available from 1288' to 2580', from Eocene to Upper Cretaceous. 88 species of benthonic foraminifera were picked from this well, together with 3 species of planktonic foraminifera.

1288'-1389' Late Eocene/?Earliest Oligocene, NSB6b, *Brizalina cookei* Zone, CB6:- Contains *Brizalina cookei*, a marker species for the Middle to Late Eocene/Earliest Oligocene (King (1989)) plus *Turrilina alsatica*. *B. cookei* occurs within the *Karreriella (Karrerulina) conversa* Zone (see King (*op. cit.*)), but the nominate taxon for the latter Zone was not recorded at this level. *T. alsatica* is generally regarded as a marker species for the Oligocene (Doppert, 1975), Doppert and Neele (1983)). However, according to King (1983) this species ranges down into the Late Eocene (King, 1989 revised his range for this form and suggested that it is purely an Oligocene species). The Eocene age is confirmed by the presence of a typical Eocene benthic calcareous assemblage (found in King's (1983) sublittoral biofacies). Example species are; *Nodosaria minor*, *N.* aff. *spinescens*, *N. emaciata*, *Anomalinoides acuta*, *A. semicribratus*, *Melonis affine*, *Cibicides eocaenus*, *C. westi*, *Uvigerina* sp.1, and *Spiroplectinella deperdita*. *Svratkina perlata* was noted at 1306' and 1358'; this species is generally regarded as a Lower Oligocene form, but it is also known from latest Eocene sediments (Shell U.K. Expro.). Likewise these samples also contain examples of *Spirosigmoilinella compressa* which again is regarded as an Oligocene marker species, although this species has also been recorded from the latest Eocene (Gradstein *et al.*, 1988). Nannofossil data confirms the above dates, the samples being from the Late Eocene, Zones NP19/20 (NS11, from 1288'-1470', *teste* LTG.ms). The foraminiferal evidence for the age of sample 1389' is poor.

1390'-1535' Late to Middle? Eocene NSB6a:- Assemblage very much the same as that above. However, without *B. cookei* and *T. alsatica* (latter species last downhole occurrence (LDO) at 1356'). There is a new influx of different species at 1535'. Many of these forms are typical of the Middle to Early Eocene. Examples are *Dentalina elegantissima* (noted in Early Eocene, London Clay sediments), *Stilostomella adolphina*, and *Praeglobobulimina ovata*. The samples in this interval examined for nannofossils contained a similar assemblage to the preceeding interval (1288'-1389') but included the FDO's of *Sphenolithus celsus*, *Discoaster saipanensis* and *Discoaster barbadiensis*. In the absence of *Sphenolithus pseudoradians* and *Chiasmolithus oamaruensis* the NP19/20 age of the overlying interval probably still applies (*teste* LTG.ms).

1536'-1737' Middle Eocene, NSB5-6?:- At 1583' Uvigerina batjesi occurs. This was noted in Ypresian, Early Eocene, London Clay sediments. It was recorded from Middle (Lower) Eocene to Lower Eocene sediments by Doppert and Neele (1983) from deposits in the Netherlands and adjacent areas, from their FH and FI Zones. Uvigerina jacksonensis was also noted from 1583', the last occurrence downhole being in the Middle Eocene NSB5 Zone. This interval (1535'-1736') contained a well preserved and diverse nannofossil assemblage, and was dated as belonging to NP16, NS12 (teste LTG.ms). It is possible that there is an unconformity between this interval and the overlying one. Percultazonaria wetherellii was recorded from 1697'. Karreriella (?Karreriella) siphonella chilostoma was also present in the latter sample. The LDO of Heterolopa dutemplei praecinctus was at 1697' indicating that this was within Zone NSB5, lower Middle Eocene of King (1983).

1737'-2167' Middle Eocene, NSB5, CB5:- Again a typical Eocene assemblage is present. Species suggest a Middle Eocene age; the assemblage was as above but without U. batjesi. Examples of species include Lenticulina cultrata s.s., Cibicides eocaenus, Nodosaria emaciata, and P. wetherellii. The LCO of Uvigerina jacksonenisis was at 1930', together with it's LDO at 2026' suggests that this is Zone NSB5. The LDO of Brizalina cookei was also at 2026'. The FDO of the calcareous nannofossils Rhabdolithus gladius and the LDO of Nannotetrina species help to define this interval as belonging to Martini's (1971) NP15 Zone, NS13 early Middle Eocene (teste LTG.ms).

2168'-2380' Middle Eocene, NP14:- These samples contained the same foraminiferal assemblage as seen in the above interval (1737'-2167'). Nannofossil evidence indicates an NP14 age (NS14), early Middle Eocene till

2298'. The latter sample and 2380' barren of nannofossils. 2340' has an assemblage of indeterminate age (teste LTG.ms).

2380'-2463' Early Eocene, NSB4, Reticulophragmium amplectens Zone, AB6:- This interval contains abundant numbers of R. amplectens from 2380' to 2463'. Nannofossils absent from this interval. This is equivalent in part (see King (1989), Zone NSP6) to the Actinomid Radiolarian Zone (adapted from R.W. Jones (unpub.)). There is also an increased number of R. gr. excelsa in this interval. Thalmannammina gr. walteri was noted in 2400' and 2463', and Reticulophragmium sp.1 was noted from the latter sample. The latter species often occurs within the R. amplectens zone.

2464'-2528' Early Eocene NP12:- No samples were obtained from this interval for foraminiferal analysis. However, the nannofossils indicate an NP12 age (NS15), based on the co-ocurrence of Toweius occultatus, Discoaster kuepperi, Tribrachiatus orthostylus, and Discoaster lodoensis (teste LTG.ms).

2528'-2580' Early Eocene, NSB2-3:- A number of new species appear at this level, namely Karreriella (Karrerulina) conversa, together with Karreriella (Karrerulina) horrida, and Lenticulina multiformis.

2580' Early Eocene-Late Palaeocene, NSP4, Coscinodiscus sp.1 Zone, PK3:- Coscinodiscus sp.1 was recorded from 2580'.

2580'-2670' early Late Palaeocene NSB1b, CB2:- At 2647' Stensioina beccariiformis was noted which is common in this study in (wells 21/11-1) the Clavulinoides anglicius/Clavulina parisiensis and Spongoidiscid Radiolaria Zones, and marks the CB2 *S. beccariiformis* Zone. *Cibicidoides dayi* also occurred at this level. This species is known to range from the Late Cretaceous (Campanian) through to the Late Palaeocene (P5), see van Morkhoven *et al.* (1986). From 2658'-2698' the calcareous nannofossils indicate an age of NP4 (NS18), Early Palaeocene (*teste* LTG.ms)

2670' early Late Palaeocene NSB1b, PK2:-This NSB1 age is confirmed by the presence of *Cibicides* '?*proprius*', *Cibicides ekblomi*, *Cibicides succedens*, *Nodosaria torsicostata*, *Osangularia expansa*, and *Osangularia cordieriana* at 2670'. Also at 2670' "*Globanomalina*" *pseudobulloides* and *Globigerina [Subbotina] triloculinoides* were noted, which suggest that this could be within the planktonic zone PK2. The nannofossil assemblage indicates Zone NP4 (*teste* LTG.ms).

2698' Early Palaeocene *Tappanina selmensis* Zone, CB1:- At 2698' *T. selmensis* was recorded which marks the presence of the Early Palaeocene (Danian) CB1 Zone in this study. King (1983, 1989) records this species in his NSB1a Zone, Early Palaeocene, Danian. Van Morkhoven *et al.* (1986) noted that *T. selmensis* ranges from the Late Cretaceous (Maastrichtian) through Early Eocene (P6b). T. selmensis was predominantly an outer neritic species (it is only found in this study in the Southern North Sea), although it has also been noted in bathyal facies, see van Morkhoven *et al.* (*op. cit.*).

2730' Late Cretaceous:- Cretaceous species at this level include *Valvalabamina lenticula*, *Stensioina pommerana*, *Gavelinella complanata*, *Gyroidinoides nitida*, and *Verneuilina muensteri*. *S. pommerana* is rarely found in the Lowest Campanian, it more commonly occurs in the Middle Campanian to

Maastrichtian (according to Hart et al. (1981)). Valvalabamina lenticula tops on the Lower Maastrichtian. Verneuilina muensteri ranges from the Coniacian to the Lower Maastrichtian (Hart et al. (op. cit.)). Also noted here was Marssonella oxycona which ranges into the Early Late Palaeocene, and Trochammina ruthvenmurrayi which ranges down into the very top of the Maastrichtian.

WELL 49/19-1. Southern North Sea. (See Enclosure No.7).
13 samples were examined from this well, mostly of Eocene age. One sample was barren. 51 calcareous benthic species were noted, plus 5 agglutinated benthic taxa, together with 7 planktonic species.

1020' Barren.

1050' Undated:- Contains only Elphidium spp..

1080' ?Eocene:- Contains examples of Lenticulina cultrata s.s., which is generally only found in the Eocene (in Doppert and Neele's (1983) FH Zone Early?-Late Eocene, rarely occurs in the very base of their Early Oligocene FG Zone).

1080'-1140' Late Eocene, NSB6a of King (1989), CB6:- Percultazonaria wetherellii occurs at 1110', together with Spiroplectinella carinata, and Lenticulina cultrata s.s.. P. wetherellii occurs in Doppert and Neele's (1983) FH Zone Early?-Late Eocene as "Vaginulinopsis decorata". Another species recorded was Cibicidoides alleni. According to Murray et al. (1981) C. alleni ranges from the Late Palaeocene to the Early Eocene. King (1989) records this species from his NSB6a Zone (1989) Late Eocene.

1140'-1230' (?)Early-Middle Eocene, NSB4/NSB5, CB4, PK7 (1200'-1230'):- The Middle Eocene age (CB4 Zone) of this interval is based on the FDO of *Eponides karsteni* at 1140'. *E. karsteni* is noted by Doppert and Neele (1983) in their FH1 *Nummulites*- *Eponides* Zone, Late-Middle Eocene (as "*Eponides schriebersi*"). Also present is *Cibicidoides eocaenus* plus *Anomalinoides acuta*, *Nodosaria minor*, *Dentalina communis*, and *Alabamina obtusa*. *Cibicidoides eocaenus* ranges from the Early to Late Eocene in the North Sea Tertiary sediments (King, 1989). Van Morkhoven *et al.* (1986) note the range of this species as being from the Early Eocene (P6b of Blow, 1979) through Late Oligocene (P22). *A. obtusa* ranges (according to Murray *et al.*, 1981) from the Late Palaeocene to the Early Eocene. It is recorded by Murray and Wright (1974) from the Cuisian (latest Early Eocene). *Anomalinoides acuta* was recorded by Doppert and Neele (1983) from beds older than late Middle Eocene, as was *Nodosaria minor*. *Pseudohastigerina wilcoxensis* were noted at 1200'-1230' (a marker species for Zone PK7), which ranges from King's (1983) zones NSP5 early Early Eocene to NSP7, earliest Middle Eocene.

Reworked *Cancris auriculus primitivus* was recorded at 1140'. *C. auriculus primitivus* was rare, noted from the Early Eocene in Zone NSB3 of King (1983). These samples also contain reworked *Stensioina beccariiformis* from the Palaeocene. Reworked Cretaceus *Biglobigerinella aspera* occured at 1170'.

1230'-?1440' earliest Early Eocene, NSB3, *Gaudryina hiltermanni* Zone AB4, PK6, CB3 (1230-1380'):- Contains a distinctive assemblage which includes

Clavulinoides anglicus, *Gaudryina hiltermanni* (both marker species for AB4), *Anomalinoides capitatus*, and *Bulimina* sp. of King (1983). *Aragonia aragonensis* was recorded at 1260'. This species ranges from the Late Palaeocene (P5) to the latest Middle Eocene (according to van Morkhoven *et al.*, 1986). *Bulimina* sp. of King (1983) is a marker species for Zone CB3 (1230'-1380' in this well). *Pulsiphonina prima* occurred at 1260' which ranges from the Late Palaeocene to the Early Eocene (see Murray and Wright, 1974), noted from the London Clay). *Cibicides westi* occurs at this level, the total range of this species in Britain is recorded by Murray *et al.* (1981) as being from the Middle to Late Eocene, although Murray and Wright (*op. cit.*) noted this species in the Cuisian, Early Eocene. Other benthic species were *Stilostomella* sp. and *Stilostomella* aff. *adolphina*, which were also noted from London Clay samples (Hampstead Heath). Planktonic forms included *Globigerina [Subbotina] linaperta*, and *Acarinina* aff. *pentacamerata* (the marker species for PK6). *A. pentacamerata* s.s. is recorded from P7 to P9, Early Eocene (Blow, 1979). According to Blow (1979) *G.* [*Subbotina*] *linaperta* ranges from P4 (Late Palaeocene) to P16 (Late Eocene).

1440' Late Palaeocene?, CB2:- Contains, for example, *Cibicidoides* aff. *dayi*, *Lenticulina* aff. *cultrata*, *Ammodiscus cretaceus*, *Ammolagena clavata*, and *Repmanina charoides*. *C. dayi* s.s. ranges from the Late Cretaceous (Campanian) to the late Palaeocene (P5) (van Morkhoven *et al.*, 1986); it is common-few in Zone CB2. The agglutinated benthics in the above list occur more commonly in the Palaeocene than in the Eocene (Gradstein *et al.*, 1988).

One specimen of *P. wetherellii* was also picked. This species only occurs in Eocene sediments (Doppert and Neele (1983), King (1983) as *Vaginulinopsis decorata*). It may be caved.

WELL 25/10-1. Norwegian Sector of the Northern part of the Central N. Sea. (See Enclosure No.8).

4 samples were looked at from a core section from 5501' to 5886'. 37 species of foraminifera were noted, with 1 species of diatom. Well 25/10-1 is one of the wells examined in the Norwegian Petroleum Directorate Paper no.28, The Balder Area (1981). A stratigraphical breakdown in that report records the Hordaland Group from 2979'-5459', and the Rogaland Group from 5459'-5761' (Balder Formation, 5459'-5629', Sele Formation, 5629'-5761').

5501' Early Eocene, NSB3-4, *Spiroplectammina navarroana* Zone, AB5:- This Zone is based on the occurence of the nominate taxon recorded (few), plus a few *Adercotryma agterbergi*, abundant *Rhabdammina discreta*, few *Ammomarginulina macrospira*, *Recurvoides walteri*, *Karreriella (Karrerulina) conversa* and *Haplophragmoides walteri*. Rare *Haplophragmoides kirki*, *Paratrochamminoides irregularis* and *Spiroplectammina spectabilis* form A. Common *Karreriella (Karrerulina) horrida*. This is a rich and diverse agglutinated assemblage. The assemblage is a very distinctive Early Eocene agglutinated one (Gradstein *et al.*, 1988). For example, *H. kirki* is typically E. Eocene as is *S. spectabilis* form A (Gradstein *et al.*, *op. cit.*).

5510' Early Eocene, NSB3-4, ?AB4:- Common *Ammomarginulina macrospira*, *Haplohragmoides kirki*, *H. walteri*, *Karreriella (Karrerulina) conversa*, *Cyclammina* cf. *garcilassoi* and *Praecystammina globigerinaeformis*. The latter species is a useful marker for the early Early Eocene (Gradstein *et al.*, 1988). *Cyclammina* cf. *garcilassoi* is not usually common until the Late Palaeocene according to Gradstein *et al.* (*op. cit.*). Abundant *Rhabdammina discreta* recorded at this level. *Spiroplectammina navarroana* noted.

5648' Early Eocene-Late Palaeocene, NSP4, Coscinodiscus sp.1 Zone, PK3:- This is within the Sele Formation according to NPD paper 28. Contains the FDO of the nominate taxon at 5648'.

5886' 'Middle'/Late Palaeocene, NSB1b-2, Spiroplectammina spectabilis form B Zone, AB2:- Heimdal Formation, Montrose Group. Contains very abundant Rhabdammina discreta. Common S. spectabilis form B (index species for Zone AB2), Glomospira gordialis, Ammodiscus cretaceus, Repmanina charoides and Kalamopsis grzybowskii. Rare Spiroplectammina navarroana noted. S. navarroana re-occurs in the S. spectabilis form B interval. A few Ammodiscus planus were present in 5886', which is according to Gradstein et al. (1988) a Middle-Late Palaeocene to Early Palaeocene species. Abundant Rzehakina minima were recorded. Only abundant in the Mid.-Late and Early Palaeocene. Rarely occurs in the Latest Paleocene (Gradstein et al., op. cit.). A few Reticulophragmoides jarvisi were also noted, plus Ammolagena clavata. According to Gradstein and Kaminski (1988) R. jarvisi LDO is within their Reticulophragmium paupera-Trochammina ruthvenmurrayi Late Palaeocene Zone (NSB1 of King (1983), P3/4 of Blow (1979)). Hyperammina subnodosiformis were common in this sample. According to the NPD report (1981, see above) the base of the Montrose Group is at 6860' (Maureen Formation from 6430'-6860').

5.2. **Land Sections.**

The London Clay Formation, Parliament Hill Site. (See Enclosure No.9). PH001-PH004 Early Eocene, Globigerina [Subbotina] linaperta Zone PK4, and Zones AB4, CB3(PH001-2), NSP5, NSB3 of King (1983):- Contains common examples of the nominate taxon. Other forms that indicate this age are rare

Turrilina brevispira (PH001, PH002), rare to common Pulsiphonina prima (PH001, PH002), frequent to rare Nodosaria latejugata (PH001-PH003), Gaudryina hiltermanni (PH003), common to abundant Uvigerina batjesi (PH001-PH004), few to common Spiroplectinella adamsi (PH001-PH004), few to common Clavulinoides anglicus (PH001-PH004), few to abundant Percultazonaria wetherellii (PH001-PH004), and common to abundant Osangularia plummerae (PH001-PH004). C. anglicus was noted from Zone NSB3, E. Eocene, in the North Sea by King (1983). Osangularia sp. was used by King (1981) as a marker for the base of his Division C, P6b. O. plummerae, according to Brotzen (1940) occurs in large numbers in the London Clay. Cibicidoides alleni was also recorded in these samples in PH001, PH003 and PH004 as was Brizalina anglica in PH001-PH004. Other Eocene forms were Dorothia principiensis and Dorothia eocenica. D. principiensis was noted by Verdenius and van Hinte (1983) from Late to Middle Eocene sediments. Few to common Cenosphaera sp. was noted in PH001 and PH003.

British Library Site.(See Enclosure No.10).

BL001-BL005 Early Eocene/Late Palaeocene Coscinodiscus sp.1 Zone PK3, NSP4, NSB2, Division B (base of) to Division A of London Clay King (1981):- Contains Coscindiscus sp.2 of Bartenstein et al. (1962), plus reworked Cretaceous Eouvigerina aculeata and Biglobigerinella aspera. Rare Bathysiphon sp. was also noted. Samples in this Zone were mostly barren of foraminifera.

Euston Centre Site.

Early Eocene. Division B (upper part?), Zone ?AB4, NSB3 of King (1983):- One sample was examined from the excavations for the Euston Centre collected by R. Bowen. This sample contained a rich and diverse London Clay fauna, without *Osangularia plummerae*. Species noted included *Nodosaria latejugata*, *Percultazonaria wetherellii*, *Dentalina multilineata*, *Cibicides westi*, *Anomalinoides dorri*, *Spiroplectinella adamsi*, rare *Gaudryina hiltermanni* and a few planktonic species similar to *Globigerina chascanona*.

Pegwell Bay, Kent: Cliff End section, Pegwell Marls Member. Lithostratigraphic Unit 10 of Siesser et al. (1987), Late Palaeocene, Nannoplankton Zones ?NP6/7:- One sample was examined from the Palaeocene, Pegwell Bay. Noted from this sample were common *Vaginulinopsis praelonga*, abundant *Bulimina trigonalis*, and rarer *Alabamina* spp.

6. Integrated Stratigraphy and correlations with Standard Tertiary Biostratigraphic Schemes.

Correlation of the zonation used by the present writer with the standard planktonic Tertiary zonations is made difficult by the lack of planktonic index foraminifera in the Tertiary of the North Sea Basin. Most of the standard zonations were established in tropical or subtropical regions, in open marine environments. The middle to high latitude North Sea Basin only had a tenuous connection to open oceanic waters during the Tertiary.

Similar problems arose when the standard nannoplankton schemes were applied to the North Sea Tertiary (LTG.teste).

Figure 9 shows an integrated biostratigraphic scheme for the Palaeogene of the North Sea. The AB, CB and PK Zones established by the present writer are combined to give a scheme of higher stratigraphic resolution. The species Zones are correlated with the depositional sequences (S.S.) of Stewart (1987), the P and N Zones of Berggren et al. (1985), and the NSB and NSP Zones of King (1989).

L. Gallagher, in his PhD thesis, established NS Zones 23-1 (see fig.10), Early Palaeocene-Pliocene. He also proposed a combined zonation Zones 27-1 (CZ in this study, see fig.11) and correlated his Zones with the standard lithostratigraphic schemes for the North Sea Tertiary, and the Belgian and London-Hampshire Basins (see fig.8).

The Danian Planktonics Zone (PK1), correlated with P Zones 1-2, NP Zones 1-4, NS Zones 23-17, CZ Zones 27-21 (LTG.teste), and Kings (1983, 1989) NSP1 Zone. The highest occurrence of Eoglobigerina trivialis and Globastica daubjergensis marks the top of the Danian (Early Palaeocene) Zone PK1B (?top of NS17), Maureen formation (water depths of greater than

200-500m). The P1- P2 boundary is marked by the LAD's of *Eoglobigerina eobulloides simplicissima*, and *Eoglobigerina* aff. *trivialis* (*sensu* Blow 1979). This correlates with the Ekofisk Formation, SS1 of Stewart (1987), (water depths of less than 200-500m). Zones CZ 27-21 correlate directly with Zones NS23-17, the boundaries of the former being defined on the same species as the latter.

The *Clavulina parisiensis*/*Clavulinoides anglicus* Zone AB1 corresponds to SS.2 of Stewart (1987), P3, NSB1b, NSP1c-2, and nannoplankton Zones NP4-NP?6, NS16, CZ 20 (LTG.*teste*). Zone CZ 20 was defined (see L. Gallagher's thesis, Fig.49) by the FDO of *Clavulina parisienisis* or *Clavulinoides anglica* at the top, with the base defined by the FDO of *Globastica daubjergensis* and the LDO of *Fasciculthus* species. This early Late Palaeocene Zone is often thin (see chapter 4 for comments). The base of this Zone correlates with NSP1c of King 1989, which he correlated to Zone P3 by using the presence of rare *Globorotalia angulata* (P2 to lower P3) and *G. uncinata* (P2 to lower P3) (see also Crittenden 1981). The latter two species were not noted in this study. NSP2 of King (1989) contained rare examples of *Globorotalia chapmani* (range from P3-P6), not noted by the present writer.

The Spongiodiscid radiolaria Zone (*Cenodiscus lenticularis*), PK2, Early Palaeocene, correlates with the top of Zone NS16, CZ19, nannoplankton Zone NP5 of Martini 1971 (LTG.*teste*), NP6 of Berggren *et al*. 1985, NSP2 and NSB1b of King (1989), and P Zone older than P3. The FDO of "*Globanomalina*" *compressa*, "*G.*" *pseudobulloides* and *Globigerina* *[Subbotina]* *triloculinoides* occurs within this Zone. This is the top of Stewart's (1987) sequence 2.

Overlying this Zone is the *Spiroplectammina spectabilis* form B Zone, AB2, NP Zones 6-7 of Berggren *et al*. (1985). This correlates with Zone CZ18 (LTG.*teste*), early Late Palaeocene. Agglutinated species are common in this Zone not in the overlying Zone as shown Gallagher's PhD thesis, in his Fig.49 (fig.11, this study).

The sparsely microfossiliferous Zone, Late Palaeocene, Zone AB3 in this study, correlates with Zone NSB2, and Zone NSP3. King (1989) suggested that his NSB1/NSB2 boundary at the base of this Zone was near the NP8/9 boundary. The CZ Zone 17 correlates with this Zone (LTG.*teste*).

The Balder Formation was marked in this study by the *Coscinodiscus* sp.1 Zone, PK3, Late Palaeocene-?Early Eocene. This correlates with NP Zones 9-10 of Berggren *et al*. (*op. cit*.), NP10-11 of Martini 1971, and Zone CZ16 (LTG.*teste*), the top of which is defined by the LDO of *Discoaster lodoensis*, and the FDO of *Coscinodiscus* sp.1. King (1989) suggested that the NP9/10 boundary corresponds to the Sele Formation/Balder Formation boundary. The NSB2/NSB3 boundary is at the top of the Balder Formation. This interval represents reducing conditions, and corresponds to depositional sequence SS9 of Stewart (1987).

The Early Eocene, Ypresian is marked by the PK4, *Globigerina [Subbotina]* *linaperta* acme Zone; this represents a high stand of Stewart (1987). Many of the specimens found in this Zone are stained pink or red. This Zone was rare in the North Sea Tertiary. The London Clay Formation examined in this study falls within this Zone (see Enclosure Nos.9-10). This Zone corresponds to nannoplankton Zones NP11-12 of Berggren *et al*. (1985), and NS15, CZ15, NP12 of Martini 1971 (LTG.*teste*) and Zone NSP5 of King (1983, 1989). The base of Zone NS15 (and CZ15) is marked by the LDO of *Discoaster lodoensis*, and the top by the FDO of *Tribrachiatus orthostylus*.

The overlying late Early Eocene Spiroplectammina navarroana AB5 Zone, correlates with Zone NP13-14, CZ14 (LTG.teste). The FDO of Acarinina aff. pentacamerata is within this Zone. It correlates with Berggren et al.'s (1985) P8a-P9 Zones.

The Cenosphaera sp. Zone, PK5 late Early Eocene-early Middle Eocene, contains large numbers of the nominate taxon. It correlates with NP14 of Berggren et al. (1985). L. Gallagher (ms) correlated this Zone with NP14-15 of Martini 1971, NS14 and base of NS13, CZ Zones 13-12. CZ13 is defined by the FDO of Nannotetrina species at the top, while the base of this Zone is defined by the FDO of Spiroplectammina navarroana , and LDO of Sphenolithus furcatolithoides. CZ12 is defined by the FDO of common-abundant Cenosphaera sp. at its top, with the base defined by the LDO of Nannotetrina species (LTG.teste).

The Spiroplectammina spectabilis form A Zone, AB8, Middle Eocene, correlates with Zones NSP7-8a and NSB5a-5c of King (1989). It also corresponds to Zones NP14-17 of Berggren et al. (1985). L. Gallagher, in his PhD thesis correlated this Zone with Martini's 1971 Zones, NP15-16, and his NS Zones 13-12, CZ Zones 11-10. CZ11 was defined by the FDO of Rhabdosphaera gladius at the top, while the base was defined by abundant Cenosphaera sp. CZ Zone 10 was defined by the FDO of S. spectabilis form A at the top, with the base defined by the FDO of the nannofossil Rhabdosphaera gladius.

The late Middle Eocene Zone in this study is the Ammomarginulina macrospira Zone. This Zone is based upon information gathered from Gradstein et al. (1988), Gradstein and Kaminski (1989) and King (1989). It was not noted in this study, but the literature supports its erection. It corresponds, according to King (1989), to Berggren et al.'s (1985) NP Zones

17-20. L. Gallagher, in his PhD thesis, correlated this Zone with his NS12 Zone, upper part, Zone CZ9-8. Zone CZ8 was defined by the FDO of A. macrospira at the top of the Zone, with the FDO of nannofossils Chiasmolithus solitus and Discoaster distinctus at the base.

The Karreriella (Karrerulina) conversa Zone AB9, Late Eocene, correlates with NSB6, and NSP8c-9 of King (1989). L. Gallagher's North Sea Tertiary Zonation correlates the upper part of this Zone with his NS11 Zone defined by the FDO of the nannofossil Reticulofenestra reticulata at the top, with the LDO of Ismolithus recurvus at its base. This correlates with CZ Zone 6. CZ7 marks the very base of Zone AB9 and its top is defined by the LDO of the nannofossil Ismolithus recurvus, while the base of the Zone is defined by the FDO of Ammomarginulina macrospira. The very base of Zone AB9 was barren of nannofossils.

The Early Oligocene was marked by the presence of Rotaliatina bulimoides, Zone CB7. L. Gallagher correlated this Zone with his Zone NS10. and base of NS9, and CZ Zones 5-3. NS10 was defined by the FDO of Reticulofenestra umbilicus at the top, with the base defined by the FDO of Reticulofenestra reticulata (and Karreriella (Karrerulina) conversa). CZ Zone 5 was defined by the FDO of Karreriella (Karrerulina) conversa at its top, with the base defined by the FDO of Reticulofenestra reticulata. CZ4 was defined by the FDO of R. umbilicus at its top, with the base defined by the FDO of Karreriella (Karrerulina) conversa. The top of Zone CB7 was defined in this study by the FDO of Rotaliatina bulimoides. Zone CZ3 was defined by the FDO of the latter species at its top, with the base defined by the FDO of Reticulofenestra umbilicus (LTG.teste).

The Late Oligocene-Early Miocene Spirosigmoilinella compressa Zone, AB11a-b, correlates with Zones NP24-NN2 of Berggren et al. (1985), and

Zones NSB8/9, NSP9/10 of King (1989). Zone AB11a, Late Oligocene, correlates with L. Gallagher's NS9 (upper part), NS8 Zones, and Zones CZ2-1. CZ2 is defined by the LDO of *Cyclicargolithus abisectus* at its top, while the base is defined by the FDO of *Rotaliatina bulimoides*. Zone CZ1 is defined by the FDO's of *Zygrhablithus bijugatus* and *Reticulofenestra scissura* at the top, with the base defined by the LDO of *Cyclicargolithus abisectus* (LTG.*teste*).

CHAPTER 7.

PALAEOENVIRONMENTAL COMMENTS.

7.1.General Comments.

Because of their wide geographical range and large numbers, as well as long geological history, foraminifera are a good source of palaeoenvironmental data. The occurrence of benthonic species is controlled to a great extent by factors such as depth, temperature, amount of light, turbidity and turbulence of the water, character of the bottom sediments, water salinity and chemical availability, and food supply, symbiotic organisms, presence or absence of parasites and predators. Planktonic foraminifera are influenced by the same chemical and biological factors, but the important physical influences are temperature, currents, turbulence, and turbidity.

The upper depth limits of benthonic foraminifera are useful in palaeoenvironmental and palaeobathymetric interpretations. Recent studies have shown that the distribution of many benthonic forms is contolled by, and or positively correlated with, the variables that characterise different water masses. Although this pattern may fluctuate in space and time, there is an upper depth limit which is characteristic of each species.

The palaeodepth of a site then has classically been determined on the basis of its benthonic foraminiferal faunas. This, however, must take into account the changed adaptation of certain benthic foraminifera to environmental conditions between the Tertiary and the Recent, and similarly, probably, between the Cretaceous and the Tertiary.

7.2 The London Clay.

A palaeoenvironmental analysis of the Parliament Hill, London Clay Formation samples was carried out using the α indices (see Wright and

Murray 1972), and a triangular plot (Murray 1973), for living foraminiferids. Figure 12 shows where on this triangle the Parliament Hill sites 1 to 4 plotted, together with samples from Lord's Roundabout. The data from all the sites plot in the ROTALIINA corner, suggesting a shelf sea. The α indices graph (fig.13) confirms this, giving diversity indices of 5 to 16, indicating that sediments from the Parliament Hill samples were probably deposited in a shelf environment, in water depths of around 50 metres to 100 metres. These samples fall into Wright's (1974) faunule 3 or 4.

7.3 The North Sea Biofacies (King, 1983, 1989).

King (1983) established 3 depth-related benthonic foraminferid biofacies in the North Sea Tertiary.

The first was an 'inner sublittoral biofacies', with water depths of 0-50 metres. Included in this biofacies were elphidiids, cibicidids, miliolids, polymorphinids and rotaliids. The second was an 'outer sublittoral-epibathyal biofacies'; King (1989) divided this biofacies into two depth-related subfacies. The first subfacies (2a) is characterised by significant amounts of large nodosariids, plus bolivinids, valvulineriids, large buliminids and in the Neogene, large cassidulinids. King (1989) correlated this subfacies with Berggren and Aubert's (1975) "Midway-type" assemblage, and suggested water depths of 50m to 200m. The second subfacies (2b) contains stilostomellids, small gyroidinids, pleurostomellids, plus Pullenia and Oridorsalis. Large nodosariids are rarer than in subfacies 2a; specimens are usually small. King (op. cit.) correlated this subfacies with Berggren and Aubert's (1975) "Velasco-type" assemblage, and suggested water depths of greater than 200m. King (op. cit.) pointed out that subfacies 2a and 2b could only be differentiated in sediments of Late Palaeocene to

Early Miocene age. The third biofacies is the "Rhabdammina-biofacies", (King, 1983) or the non-calcareous bathyal biofacies (King, 1989). This biofacies is dominated by, or wholly composed of, 'flysch-type' agglutinated benthic foraminifera. The dominant superfamilies, according to King (op. cit.), are Astrorhizacea and Ammodiscacea with "Cyclamminids". Commonly encountered genera are; Reticulophragmium, Bathysiphon, Glomospira and Ammodiscus. The calcareous foraminifera when present are small and often partially dissolved. This biofacies occurs in the deepest parts of the basin; according to King (1989) it "laterally and vertically replaces biofacies 2b" (p.422). Water depths of more than 200m were suggested by King (op. cit.). This deeper water biofacies occupies the central part of the Central North Sea Tertiary Basin, while the shallower water biofacies are found towards the edges of the basin.

As implied above, King (1989) regarded these biofacies as largely depth-controlled assemblages.

7.4 The Flysch-type Agglutinated Biofacies.

7.4.1 General Comments.

According to King (1989), agglutinated foraminifera fall into two groups inhabiting different habitats and form, as fossils, two distinct assemblages, based on the presence or absence of $CaCO_3$ as an important part of the cement in the test wall. Group 1 (CA, or calcareous agglutinants group of King, op. cit.) consists of the Valvulinidae, and most of the Dorothiidae, Eggerellidae and Textulariidae. The CA group occurs with calcareous taxa in 'normal' marine environments. Group 2 (the NCA or non-calcareous agglutinants group of King, op. cit.) is made up of most of the Ammodiscacea, Astrorhizacea, Ammosphaeroidinidae, Haplophragmoididae Trochamminidae and Cyclammininae. The NCA groups of King (op. cit.) occur in assemblages where calcareous forms are absent or rare. NCA assemblages of King (op. cit.) occur in intertidal and lagoonal-abyssal environments, although in the North Sea they are mostly deep-water, and fall into the 'Rhabdammina-biofacies' of King (1983). In the Cenozoic of the North Sea Basin, from the Late Palaeocene-Middle Miocene, there has been a widespread development of 'flysch-type' agglutinated foraminifera (='Rhabdammina-biofacies' of King, 1983, NCA assemblage of King, 1989)

Environmental controls on these assemblages are discussed by Gradstein and Berggren (1981). These controls include restricted water circulation, which according to King (1989) will lead to a reduction in oxygen concentrations and an increase in the carbon dioxide levels at the sediment water interface; this will then produce a slightly acidic, reducing environment which will restrict the amount of calcium carbonate that can be precipitated. Only NCAs will persist under such conditions (King, op. cit.). Less extreme conditions allow the existence of some more 'tolerant' calcareous taxa, but the low calcium carbonate content of the sediment may cause these taxa to undergo post-mortem carbonate dissolution. The tests of calcareous foraminifera are often preserved as pyritised moulds. In the Oligocene of the Central part of the Central North Sea, where the flysch-type fauna occurs (Zone CB7, AB10, in well 29/10-1 for example) partly pyritised rare Gyroidina spp. occur. Planktonic foraminifera are rare in sediments containing flysch-type assemblages, as they also suffer from seafloor dissolution.

King (1989) suggested that the above restricted water circulation was caused by "basin compartmentalisation" (p.423); that is, the development of silled basins, where below the level of the sill there was restricted circulation. Above the sill level 'normal' marine, well-oxygenated water circulated. King (op. cit.) suggested that the effect of a silled basin would be accentuated during phases of low eustatic sea level (regressions).

7.4.2 The Relationship Between Flysch-type Fauna's, the cycles of Vail et al. (1977), and the depositional sequences (SS) of Stewart (1987).

King (1989) compared the relative extent of his NCA assemblages in the North Sea Basin with the worldwide eustatic sea level cycles described by Vail et al. (1977, see fig.14). NCA (=flysch-type) assemblages first appeared in the North Sea Tertiary in the basal part of the Late Palaeocene, at the same time as Vail et al.'s (op. cit.) low sea level phase at the base of his TP2.1 cycle. The flysch-type assemblages extend widely geographically in the Late Palaeocene in Zones AB1-AB2 in this study (King's, 1989 NSA1 Zone). In the early Late Palaeocene, Stewart (1987) recognised a rapid regression in his depositional sequence 3 (Zone AB2 in this study covers Stewarts,(op. cit.) sequences 3-6, see figs.14, 15, and 16). In Zone PK3 in this study (Early Eocene-Late Palaeocene) rare calcareous benthics were recorded, which indicates a shallow shelf environment (NSA2 of King, op. cit.). This correlates with the Late Palaeocene sea level falls of TP2.3 and TE1.1 of Vail et al. (op. cit.). This Zone is represented by Stewart's (1987), depositional sequence 9, as a lowstand system, that is a regressive phase (see fig.16). In the Early Eocene the flysch-type faunal assemblage (Rhabdammina-biofacies of King, 1983) reappeared; it is geographically widespread in the North Sea Tertiary Basin in the late Early Eocene, and early Middle Eocene. This reappearance coincides with the TE2.1 cycle of Vail et al. (op. cit.), when there was a eustatic sea level fall in the late Early Eocene (King, 1989). This corresponds to the Spiroplectammina navarroana Zone AB5 in this study (plus AB6-7?). The top of Stewart's (1987) depositional sequence 10, which correlates in part with Zone AB5, is represented by a rapid regression (figs.14 to 16). The flysch-type assemblages are more restricted geographically in the late Middle Eocene, especially in the upper part of the Planulina costata Zone CB5 (NSB5 of King, op. cit.). The flysch-type assemblages contracted in geographic extent, possibly due to a general rise in sea level (Vail et al., op. cit.), in the Late Eocene and Oligocene; these assemblages are very extensive in the 'Middle' Oligocene, although this cannot be related to a eustatic sea level rise (King, op. cit.). The sea level fell in cycle TE2.1, causing the flysch-type assemblages to contract in geographic extent, although they persisted in the deeper parts of the North Sea Basin in the Central Graben, Central North Sea in the Early Miocene (well 29/10-1 in this study). Diverse flysch-type faunas disappeared in the early Middle Miocene. King (1989) correlates this with a Middle Miocene high sea level phase, base of cycle TM2.2 (Vail et al., op. cit.). King (op. cit.) also correlates the presence of a limited flysch-type fauna (NCA) in the Late Miocene, in the Central Graben region of the Central North Sea, with the succesive sea level falls of cycles TM2.3 and TM3.1.

7.4.3 The Relationship between Flysch-type Faunas, planktonics and the Cycles of Vail et al. (1977), and Stewart (1987).

The marked vertical changes in the abundance and geographical extent of planktonic foraminifera in the North Sea Tertiary Basin are controlled, according to King (1989), by eustatic sea level changes. When there was a high sea level (or 'Highstand' of Stewart, 1987) in the North Sea Basin it allowed an influx of planktonic foraminifera from the North Atlantic water mass. Low sea levels restricted the entry of planktonics. King (op. cit.) pointed out that there was an inverse relationship between the geographic extent of planktonic foraminifera and agglutinated benthonics (NCA assemblage, see fig.14). In the Early Palaeocene (Zone PK1A-B in this study), there is a gradual regression in Stewart's (op. cit.) depositional sequence 1 (Danian), and in his sequence 2 (still partly in the Danian) a highstand system developed (fig.16). The disappearance of planktonic foraminifera in the Late Palaeocene (NSP3 of King, op. cit.) correlates with Vail et al.'s (1977) cycle TP2.1 (a low sea-level). However, King's (op. cit.) NSP3 Zone correlates with Stewart's (1987) Coscinodiscus spp. Zone (depositional sequence 8), which according to the latter author occurs in a 'Highstand' system, that is a transgression. There is a transgression in the latter part of the Early Eocene in the early part of Stewart's (op. cit.) depositional sequence 10, where there is a reappearance of planktonics (for example Globigerina [Subbotina] linaperta). At the base of the Cenosphaera Zone PK5 (NSP6 of King, 1989) there is a fall in planktonic abundance which correponds to the base of cycle TE2.1. The reappearance in abundance of planktonics in the late Middle-Late Eocene correlates with the TE2.1 and TE3 sea level rises. In the Early Miocene (Diatom sp.3 Zone NSP9 of King, op. cit.) there is a reduction in the planktonic abundance which according to King (op. cit.) correlates with the base of Vail et al.'s (op. cit.) TM1.2 cycle. In the late Early Miocene and Middle Miocene (NSP12 to NSP14a of King, op. cit.) there is a substantial increase in the abundance of planktonics. This corresponds to the highest Neogene sea levels (TM2.1 and TM2.2). The abundance of planktonic foraminfera falls in the Late Miocene, but increases again in the 'Middle' Pliocene (=TP1 and TP2 high sea levels).

7.4.4 Conclusions.

King (1989) regarded his correlations with Vail et al. 's (1977) work as only tentative because of the influence of local and basinal tectonic events in controlling the distribution of the faunal assemblages. The present writer must point out that the application of the cycles in Vail et al. (op. cit.) in the North Sea basin can only ever be tentative, as the Basin will be subject to local changes in sea bed depth caused by rifting, faulting, and uplift (commonplace in the Tertiary in the North Sea Basin). Hence basin depths may well be independent of any global phenomenon.

7.5 Palaeobathymetry of Flysch-type Fauna's in the Northern North Sea.

G.D. Jones (1988) examined the palaeobathymetry of Lower Selandian (Palaeocene) 'flysch-type' agglutinated foraminifera, from the Viking Graben region of the Central North Sea". According to G.D. Jones (op. cit.), agglutinated assemblages of the Late Cretaceous to Palaeogene age which are dominated by diverse primitive taxa occur in flysch-type deposits. Based on various lines of evidence (including geophysical 'backtracking', taxonomic comparisons with modern faunas, and geological evidence), Gradstein, Berggren and Miller (1982), showed that flysch-type assemblages preferred living in deep water from below the shelf edge at about 200m down to abyssal depths of about 4kms. Depth alone, though, is not an overriding factor influencing their occurrence. Many flysch-type assemblages, such as those in the Palaeogene sections of the North Sea and Labrador Basins, seem to be ultimately associated with restricted basins that were filled with organic rich, fine-grained, siliciclastic sediment. It was probably these carbonate poor conditions which hindered the development of a calcareous fauna and promoted the development of flysch-type assemblages.

The palaeoslope transect approach was used by G.D. Jones (op. cit.) to determine the palaeobathymetric trends of Late Palaeocene flysch-type agglutinants in the Viking Graben of the North Sea. Samples from 6 wells were examined (in Blocks 8 and 9 in the U.K. sector, and 25 in the Norwegian sector) which exemplify the observed faunal trends. The above wells are aligned in a transect perpendicular to the axis of the Viking Graben. Independent stratigraphic and seismic analysis allowed palaeoslope-palaeodepth determination, which indicates that during the Late Palaeocene, water depths ranged from 200m at the palaeoshelf edge down to about 1500m at the axis of the Viking Graben (that is, the palaeodepth gradient is from the shelf-edge to basin floor). The six wells studied all penetrate Late Palaeocene sections (below Zone P3 of Blow 1979, and Berggren _et_ _al_. 1985) containing abundant flysch-type agglutinants. Wells 1 and 2 (Blocks 8 and 9) represent upper slope depths between 200m and 500m. Wells 3 and 4 (Block 9) represent 500m to 1000m water depths. Wells 5 and 6 (Block 25) are located nearest the deepest part of the basin at about 1500m.

Tubular Astrorhizid fragments dominated the samples, with species of _Trochammina, Haplophragmoides, Spiroplectammina_, and _Saccammina_ forming a conspicuous but less abundant component. Calcareous elements were either absent, or extremely rare. Two of the samples examined by G.D. Jones (_op. cit_.) contained the distinctive, and abundant, large Radiolarian _Cenodiscus lenticularis_ (marker species for Zone PK2 in this study).

In the upper slope, represented by Well 1, specimens are fine to medium grained, white in colour, and relatively large. In the middle slope, represented by Well 3, the specimens are relatively coarse grained, brownish-green in colour and very large. On the Basin floor, specimens are fine grained, dark green in colour (or, in another sample, white in colour), and relatively small. Many of the Late Palaeocene agglutinants in well 29/10-1 were dark green. Micropalaeontologists working with Oil

Exploration companies (Gradstein pers. comms.) regard this green colouration as typical of early Late Palaeocene sediments in the Central North Sea Basin. The tubular Astrorhizid fragments dominate, particularly in the middle slope assemblages.

G.D. Jones (op. cit.) has an approach to the taxonomy of tubular forms which recognises that tubular fragments rarely, if ever, possess the diagnostic taxonomic features necessary for specific or even generic identification. Synonyms in the literature abound for such difficult forms. G.D. Jones (op.cit.) avoided adding to the existing taxonomic confusion, by lumping the Astrorhizids into four informal taxonomic groups ("A,B,C, & D"). Each fossil group was then related to possible modern generic analogues. The taxonomic approach used for the non-tubular forms, relies heavily on work by Kaminski et al. (1988) who have spent cosiderable effort comparing type specimens of flysch-type species and identifying synonymous taxa.

Analysis of the abundance distributions of 68 species indicates that 12 of the more common species have distinct palaeobathymetric distributions.

Middle slope assemblages tend to contain, in general, an abundance of large coarse-grained species such as Psammosphaera fusca, Recurvoides erici, Tolypammina sp. A and "tubular group C". Tests of Group C are large, extremely coarse-grained with a few grains much larger than others that protrude from the test wall, and branching was not observed. Analogues for Group C are Rhabdammina, Hyperammina and perhaps Bathysiphon. Also abundant in the middle slope environment was Tolypammina sp. A which was found attached to large quartz grains.

Basin floor species are quite distinct from shallower assemblages and are characterised by *Pseudobolivina* sp., *Rzehakina minima*, *Recurvoides walteri*, and "tubular Group A". *R. minima* and *R. walteri* occur in Zones AB1 and AB2 early Late Palaeocene in the Central North Sea.

Tests of "Group D" are small, occur as segments, are fine-grained and delicate, and sometimes branched. A modern generic analogue is *Rhizammina*.

"Tubular Group A" is far less abundant in the basin floor than in shallower assemblages. These forms are large, straight cylindrical, and fine to medium-grained with common annular constrictions and are never found branched. Possible modern generic analogues are *Rhabdammina* and *Bathysiphon*.

Haplophragmoides walteri is absent from the basin floor assemblages; this species is common in many North Sea Palaeocene-Eocene agglutinated assemblages.

The Radiolarian *Cenodiscus lenticularis* (Zone PK2) is restricted to the basin floor assemblages. This supports a number of reports which show the maximum abundances of Radiolaria to occur in the deepest portion of marine basins. *C. lenticularis* was abundant in well 14/29-1.

There is very little agreement when the numerical depth ranges of the species in the Tertiary of the Viking Graben are compared with depth ranges of the same species in the Tertiary from other basins. Therefore, flysch-type taxa cannot be used to quantify deep-water palaeobathymetry on a world-wide basis. When environmental conditions of the sea bottom are conducive, flysch-type assemblages will thrive, whether that favourable sea floor extends to the basin floor at 1500m as in the Viking Graben or to much greater depths as in the open ocean.

Kaminski *et al*. (1988) compared the palaeobathymetric trends of flysch-type agglutinants from the Late Cretaceous and Palaeogene of many regions. These included, Southern California, Western Atlantic margin, Trinidad, Labrador Sea, Polish Carpathians and Atlantic Eocene 'synclines'. Several agglutinated genera and species were found to consistently occur in greater abundance in the deeper facies of all these areas. These taxa included *Rhizammina* and *Rzehakina*. In the Palaeocene of the Viking Graben, *Rzehakina* is restricted to the deepest palaeoenvironment.

Reports on modern flysch-type agglutinants, from the North West continental margin, indicate that small, delicate, fine-grained and often branching forms, such as *Rhizammina*, prefer the fine-grained low energy environments (G.D. Jones, 1988). Conversely, coarser grained robust genera, including *Recurvoides*, *Psammosphaera* and *Rhabdammina* (common in Zone AB2), tend to prefer areas of higher energy. Using this as a model for the Late Palaeocene Viking Graben the fine-grained species *Rzehakina minima*, *Pseudobolivina* sp. and tubular Group D, are well concentrated at the basin floor and suggests that they are near Wells 5 and 6 which were tranquil areas.

Conversely, the coarse-grained species, *Recurvoides erici*, *Psammosphaera fusca*, *Tolypammina* sp. A and tubular Group C are all concentrated in the middle slope. This suggests that higher energy conditions existed in the area of Wells 3 to 4 during Late Palaeocene times.

Kaminski *et al*. (1988) plotted diversities for Palaeocene flysch-type material in Trinidad, for both turbiditic and non-turbiditic sections. Sample diversities in their data within turbidites showed a great variability, with values both higher and lower than those for non-turbidite sections. For example, in the Viking Graben, in some samples, the middle slope assemblages showed surprisingly higher diversities than those for both shallower and deeper water assemblages. G.D. Jones (1988) explained this as being the result of turbiditic currents. This great range of values for the turbidites is probably related to the various hydraulic regimes within a turbidite sequence, whereby a flow might leave behind a low diversity drag assemblage, and a rapidly decelerating flow might deposit a high diversity mixed assemblage of agglutinants derived from different sources. Using this idea of a model, the extreme diversity values in G.D. Jones's (1988) middle slope samples may reflect differing hydraulic regimes within turbidity currents. This means too, that the distribution of species in the middle slope may be based to some degree on transport of the sediment from shallower depths.

According to G.D. Jones (1988) some of the distributional patterns of the Late Palaeocene Viking Graben species seem to be explainable in terms of Recent data, which shows correlation of size, coarseness of test, and diversity pattern with bottom energy conditions and turbidity current deposition.

7.6 Depth Ranges for individual Cenozoic Deep-Water Benthic Species.

Van Morkhoven et al. (1986) suggested approximate depth ranges for individual Cenozoic benthic deep-water foraminifera. For example van Morkhoven et al. (op. cit.), state that Stensioina beccariiformis (marker species for Zone CB2, basal Late Palaeocene in this study) is a common species in Palaeocene bathyal assemblages, while Planulina costata (marker species for Zone CB5) is an upper-middle bathyal species. Van Morkhoven et al. (op. cit.) recorded Stensioina beccariiformis (CB2 marker species), Spiroplectammina spectabilis (marker species for Zone AB2, Late Palaeocene), and Nuttallides truempyi (occurs in Zone CB2) in a "Velasco-type" faunal assemblage (Berggren and Aubert, 1975), in middle to upper bathyal depths (500-700m). *Cibicidoides hyaphalus* was noted in zone CB2; a species noted by van Morkhoven *et al.* (*op. cit.*) in the lower bathyal depths (1000m-1500m), "Velasco-type" faunal assemblage, in the Palaeocene. *Cibididoides alleni*, *Osangularia plummerae* (both species are commonly found in the Early Eocene, Ypresian, London Clay Formation) were recorded in the middle neritic bathymetric zone, "Midway-type" fauna of Berggren and Aubert (*op. cit.*) in the Palaeocene. *Cyclammina* species were recorded in the upper-middle bathyal depths in the Eocene.

Van Morkhoven *et al.* (*op. cit.*) recorded *Cibicidoides eocaenus*, *Vaginulinopsis decorata* (=*Percultazonaria wetherellii*, common in the late Middle-Late Eocene, CB6 Zone), *Anomalinoides capitatus*, *Turrilina robertsi* (?=*T. brevispira* in this study, marker species for Zone CB3, Early Eocene), *Spiroplectammina spectabilis* (marker species for Zone AB8, middle Middle Eocene), *Gaudryina hiltermanni* (marker species for Zone AB4, Early Eocene) and *Planulina costata* (marker species for Zone CB5, Middle Eocene) in upper bathyal depths (200m-300m). This assemblage is typically found in the Southern North Sea (wells 49/9-1, 49/19-1), in the Eocene, Zones CB3-CB6.

In the Neogene van Morkhoven *et al.* (1986) recorded; *Sigmoilopsis schlumbergeri*, *Hoeglundina elegans*, *Siphonina reticulata* (index species for the early Late Miocene CB14 Zone), and *Eggerella bradyi* (=?*Karreriella (Meidamonella) bradyi*) from middle-upper bathyal depths. These species are common in Neogene sediments in the North Sea. *Bulimina elongata* (index species for Zone CB15, Late Miocene, in this study) was noted in upper-middle neritic assemblages in the Neogene (Vienna Basin faunal assemblage); while *Bulimina aculeata*, *Globocassidulina subglobosa*, and *Pullenia bulloides* (common species in the Miocene-Pliocene of the North Sea) were noted as lower neritic to upper bathyal species by van Morkhoven *et al.*

(*op. cit.*). *Cibicidoides dutemplei*, *C. praecinctus* (=*Heterolepa dutemplei praecinctus* in this study), *Sphaeroidina bulloides*, *Bulimina marginata* and *Oridorsalis umbonatus* were noted by van Morkhoven *et al.* (*op. cit.*) from middle-upper neritic depths, in the Neogene. These species are commonly encountered in the North Sea Tertiary.

In the Late Pliocene-Pleistocene, transport of microfossils from shallow shelf environments into deeper water by ice-rafting hampers any analysis of the assemblages. This, according to King (1989) may be why there is an association in the Neogene of the North Sea, of abundant *Ammonia*, *Elphidium* and *Haynesina* with *Bulimina* and *Uvigerina*. However, the first 4 genera (that is, excluding *Uvigerina*) occur together today in the Bristol Channel in water depths of approximately 50-60m (Banner *pers. comms.*).

7.7 **The Geological and Palaeobathymetric History of Tertiary North Sea Calcareous Benthics.**

In the latest Palaeocene-basal Early Eocene the calcareous benthics are restricted to inner shelf environments. According to King (*op. cit.*), in the Early Eocene there were a number of transgressions, and the outer shelf and bathyal habitats were repopulated by species from outside the basin. Many of these were descendants and survivors of Palaeocene forms. New Eocene species included *Percultazonaria wetherellii* (=*Vaginulinopsis decorata* of King, 1983, 1989), a species common in Zones CB3-CB6, and *Turrilina brevispira* (marker species for Zone CB3, Early Eocene, in this study). In the Early Oligocene, base of the *Rotaliatina bulimoides* Zone CB7, *Dorothia seigliei* Zone AB10 (=NSB7 of King, *op. cit.*), there is a major faunal 'turnover' as a result of regression and regional uplift in the Late Eocene-basal Oligocene, and a subsequent transgression in the

"Rupelian" (Early Oligocene). King (*op. cit.*) points out that in the "Rupelian" many new genera enter the Basin for the first time. Examples are; *Cassidulina* (for example *C. carapitana*), *Rotaliatina* (*R. bulimoides*), *Sphaeroidina* (*S. bulimoides*) and *Valvulineria* (rare in this study). There was a major extinction of calcareous benthics in the Early Miocene, with renewed diversification in the late Early Miocene-Middle Miocene. In the Early Pliocene cassidulinids (for example *Cassidulina laevigata* and *C. crassa*), and elphidiids (for example *Elphidium excavatum*) are common. In the mid-Late Pliocene, Zones NSB14b-NSB15, Arctic taxa were noted; examples are *Elphidium groenlandicum* and *Buccella frigida*. According to King (*op. cit.*) this is coincident with the first appearance of ice-rafted detritus. Elphidiids and cassidulinids are common in the Late Pliocene-Pleistocene.

CHAPTER 8.

8.1. Correlation Problems.

The erection of a scheme based on benthonic foraminfera for an area as large and varied in its facies as the North Sea Tertiary Basin possesses problems.

Extinctions were not isochronous as habitat-environments varied regionally. The tops (First Downhole Occurrences or FDOs) of certain species will vary across the basin. For example, Spiroplectammina spectabilis according to Gradstein et al. (1988) tops later in the Palaeocene in the Northern part of the Central North Sea than in the more central and southerly parts. There are also great facies variations between the central parts of the Central North sea and the edges of the Tertiary Basin, due to constraints such as water depth, rate of sedimentation, etc.

King (1983) based his studies on specimens greater than 125 microns in size. In this study, in an attempt to utilise available data more fully, all microfossils (foraminifera, radiolaria, diatoms and Bolboforma) above 74 microns in size were examined.

King (op. cit.) based his studies on ditch-cuttings. Such samples may give rise to poor biostratigraphical resolution due to caving of specimens from higher levels, if the well is not lined (cased) at regular intervals. As most of the oil companies are more interested in Palaeocene or older sediments, wells were not lined until below the Neogene. Hence, considerable caving has taken place in samples of the latter age. Reworking of older sediments is also commonplace in the North Sea Tertiary. In well 29/10-1 in the Central North Sea Tertiary Basin, Eocene species are often reworked into the Oligocene, and Oligocene species are often reworked into the Miocene. Such reworking and caving has affected the total range of

	S.S.	P.	N.S.B.	N.S.P.	N.P.	SPECIES ZONES.	ADDITIONAL FORMS, COMMENTS.	TOP OCCURRENCES OF MAJOR SPECIES.
E. MIOC. LATE OLIGOC		N4 P21b	9/8.	9/10.	NN2 NP24	SPIROSIGMOILINELLA COMPRESSA ZONE AB11a-b.	G. OFFICINALIS, G. AMPLIAPERTURA, RESTRICTED MARINE.	← N.T. ← G. MAMILLATA
EARLY OLIGO.		P21b P18.	7.	9.	24 21	ROTALIATINA BULIMOIDES ZONE, CB7.	NEAR NORMAL MARINE. HIGH STAND. OUTER SHELF, UPPER SLOPE.	← N.T. ← M. COMMUNIS.
LATE EOCENE		17 15.	6.	9 8c	21 20	KARRERULINA (KARRERULINA) CONVERSA ZONE, AB9.	REDUCING, UNSTABLE SUBSTRATE.	← K. CONVERSA, B. COOKEI, G. LINAPERTA GR.
MIDDLE EOCENE		>14.	6 5c.	8c 8b	20 17	AMMOMARGINULINA MACROSPIRA ZONE.	PLANKTONICS, NO YOUNGER THAN P18. P ZONE - ON DINOFLAG. (R.W. JONES, UNPUB.).	← N.T. K. GRZYBOWSKI.
		14 10	5c 5a	8a 7	17 14	SPIROPLECTAMMINA SPECTABILIS FORM A ZONE, AB8.	RESTRICTED MARINE. AGE DERIVED BY BRACKETING.	← N.T. -S. WILCOXENSIS
		10 9.	4.	6.	14.	ACTINOMID RADIOLARIA ZONE (CENOSPHAERA), PK5.	AS S. NAVARROANUS ZONE BLEOW, BUT MORE OPEN MARINE. 200-700M DEPTH.	← LARGE NUMBERS OF N.T., CENOSPHAERA. -ABUNDANT R. AMPLECTENS (AB6).
YPRESIAN, EARLY EOCENE.	10.	9 8a.	4.	6.	14 13	SPIROPLECTAMMINA NAVARROANUS ZONE, AB5.	RESTRICTED MARINE. -REGRESSION?	← A, PENTACAMERATA. -COMMON G. GR. LINAPERTA.
	10.	8 6b	4 3.	5a.	12 11	GLOBIGERINA GR. LINAPERTA ACME ZONE, PK4.	HIGH STAND (STEWART, 1987?). 200-300M, OPEN MARINE.	← ABUNDANT N.T., PLUS TURRILINA BREVISPIRA (CB3). PINK COLOURING.
THANETIAN	9.	6b 5.	2.	4.	10 9.	COSCINODISCUS SP.1 ZONE, PK3.	-REDUCING CONDITIONS. BALDER AND SELE FORMATIONS.	← N.T. PLUS TRICERATUM.
	8 7.	4.	2.	3.	9? 8	SPARSE INTERVAL. ZONE AB3.	DOUBTFUL AGE? TRANSGRESSIVE.	← HIGHEST OCCURENCE OF AGGLUTINANTS BELOW COSCINODISCUS SP.1.
	6 3.	4.	1c 1b.	3 2.	7 6.	SPIROPLECTAMMINA SPECTABILIS FORM B ZONE, AB2.	2250M? THANETIAN, BASED ON MICROPLANKTON (R.W. JONES,UNPUB.).	← ACME, N.T. S. NAVARROANUS RE-OCCURS.
	2.	>3.	1b.	2.	6.	SPONGODISCID RADIOLARIA ZONE, PK2 (CENODISCUS LENTICULARIS).	2c OF STEWART (1987). HIGH STAND.	← CENODISCUS SP. ← G. COMPRESSA, G. TRILOCULINOIDES, G. PSEUDOBULLOIDES.
	2.	3.	1b.	2 1c.	6? 4.	CLAVULINA PARISIENSIS /CLAVULINOIDES ANGLICUS ZONE, AB1.	BASAL LATE PALAEOCENE. >200-500M WATER DEPTH.	← N.T. S. BECCARIFORMIS (CB2 MARKER SPECIES).
DANIAN.	2.	2.	1a.	1.	4	DANIAN PLANKTONICS. ZONE PK1a-b.	SS.2 MAUREEN FMN. >200-500M DEPTH.	← E. TRIVIALIS, G. DAUBJERGENSIS, G. CF. COMPRESSA.
	1.	1.			1.		SS.1 EKOFISK FMN. <200-500M DEPTH.	← G. SIMPLICISSIMA, E. AFF. TRIVIALIS.

FIG.9.

THE NSP AND NSB ZONES ABOVE ARE BASED ON KING (1989); THE P ZONES ON BERGGREN ET AL.(1985) AS ARE THE NP ZONES:THE SS SEQUENCES ARE BASED ON STEWART (1987), WHILE THE AB, PK AND CB ZONES ARE DESCRIBED IN THIS STUDY (CHAPTER 6).

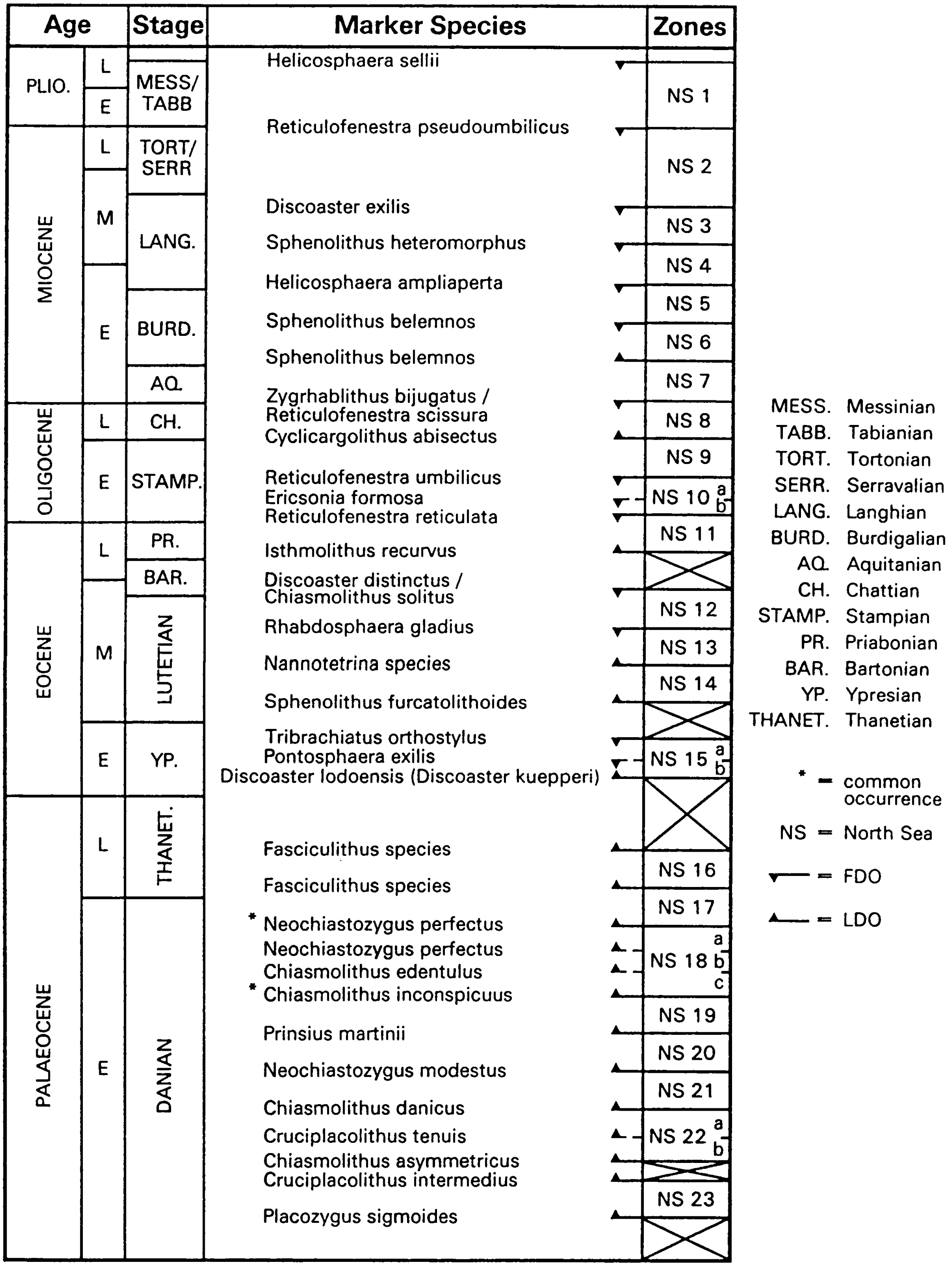
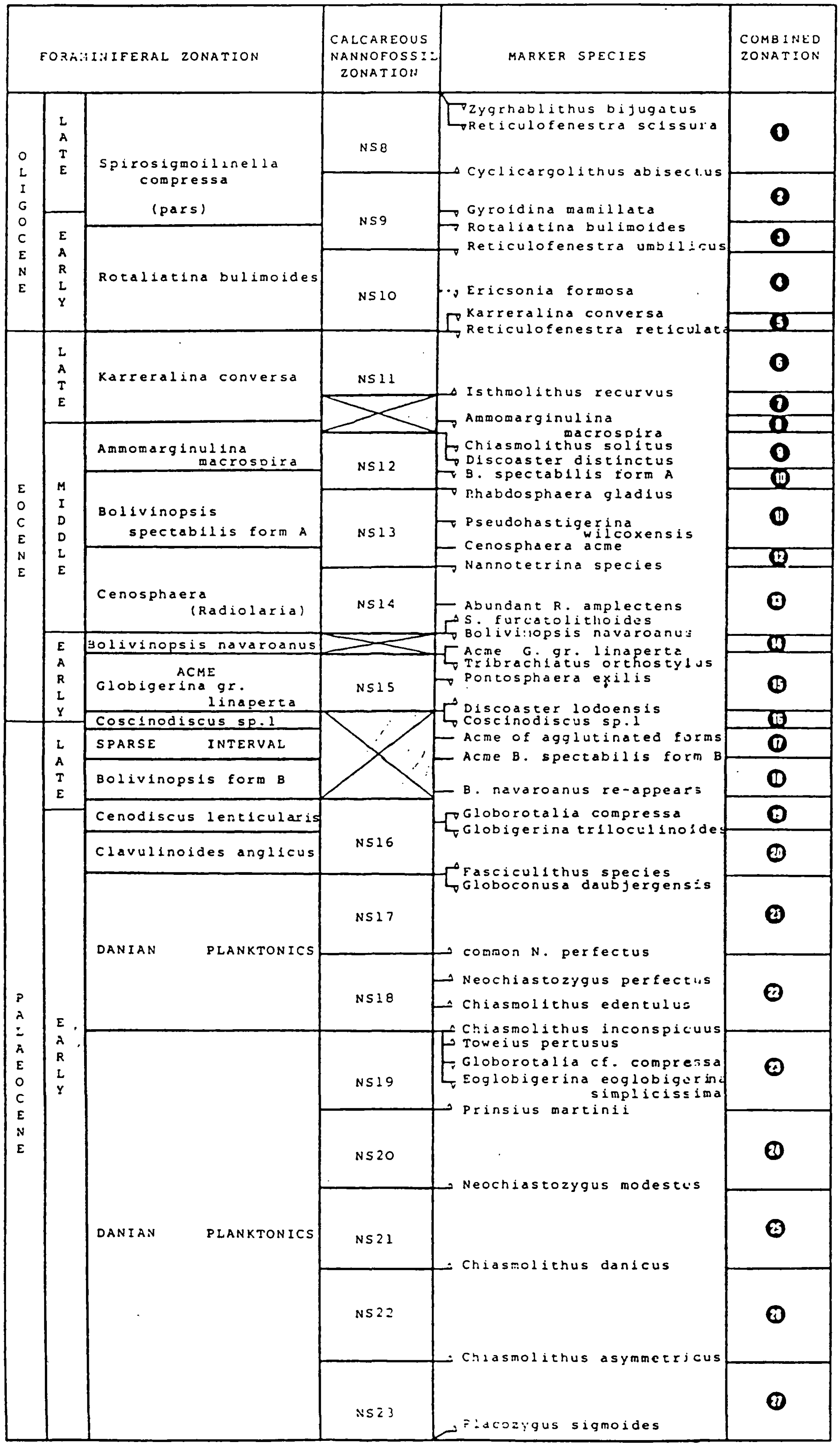


FIG.10.

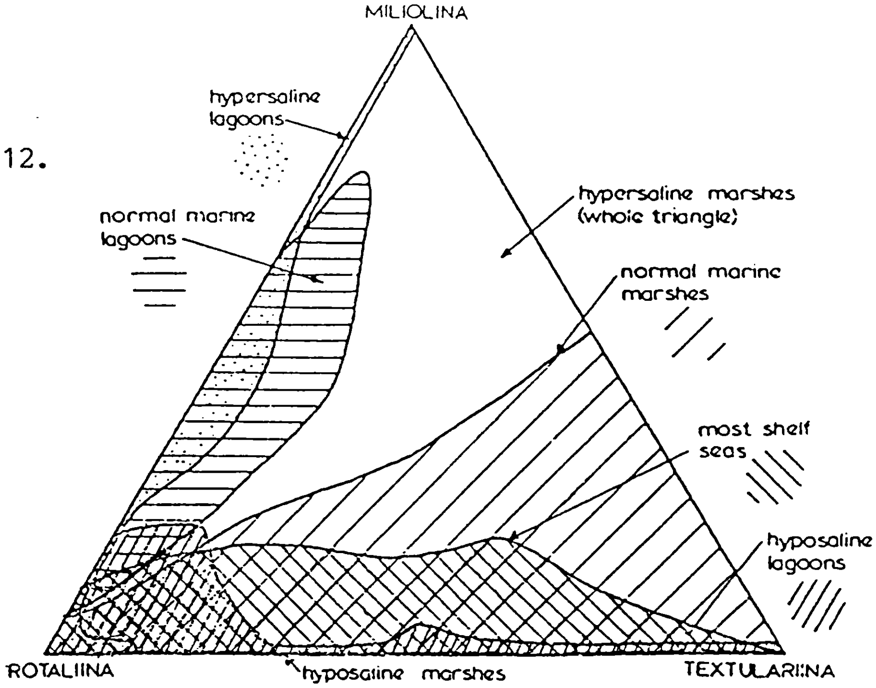
The Calcareous Nannofossil NS Zones of L. Gallagher, and Marker Species, correlated with Ages and Stages (from his Ph.D thesis).

FIG.11. COMBINED CALCAREOUS NANNOFOSSIL AND FORAMINIFERAL ZONATION

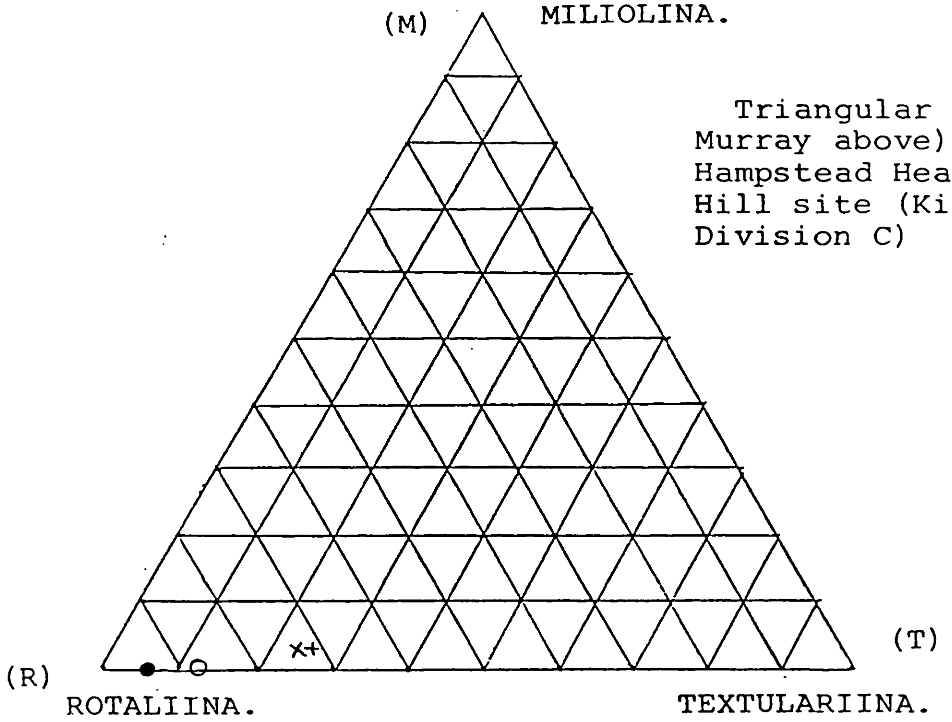


After Gallagher (teste).

FIG.12.



Summary triangular plot for living foraminiferids (from Murray 1973).



Triangular plot (after Murray above) for the Hampstead Heath Parliament Hill site (King's 1981 Division C)

KEY.

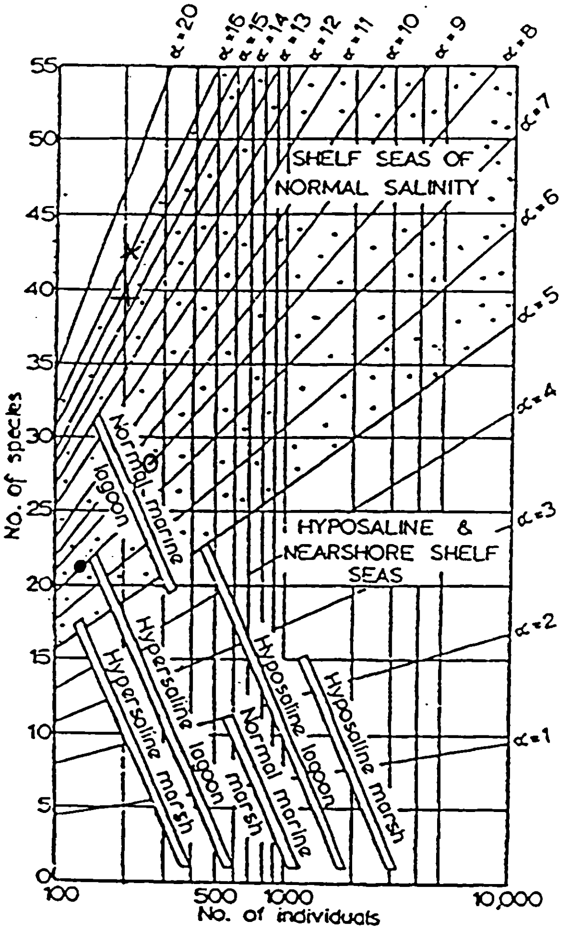
X=LC 4, (Hampstead Heath), R=74%,T=24%,M=2%.
Planktonics=5.2%,Benthonics=94.8%.

+=LC 3, R=73%,T=25%,M=2%. Planktonics=8.8%,Benthonics=91.2%.

●=LC 2, R=94%,T=7%,M=0%. Planktonics=5%,Benthonics=95%.

o=Lc 1, R=88%,T=11.5%,M=0.5%, Planktonics=6%,Benthonics=94%.

FIG.13.
Graphical techniques used by Murray and Wright to investigate the palaeoenvironments represented by the Isle of Wight Tertiaries.



Summary of the α indices for living foraminiferids showing the total range for each environment (from Wright and Murray 1972).

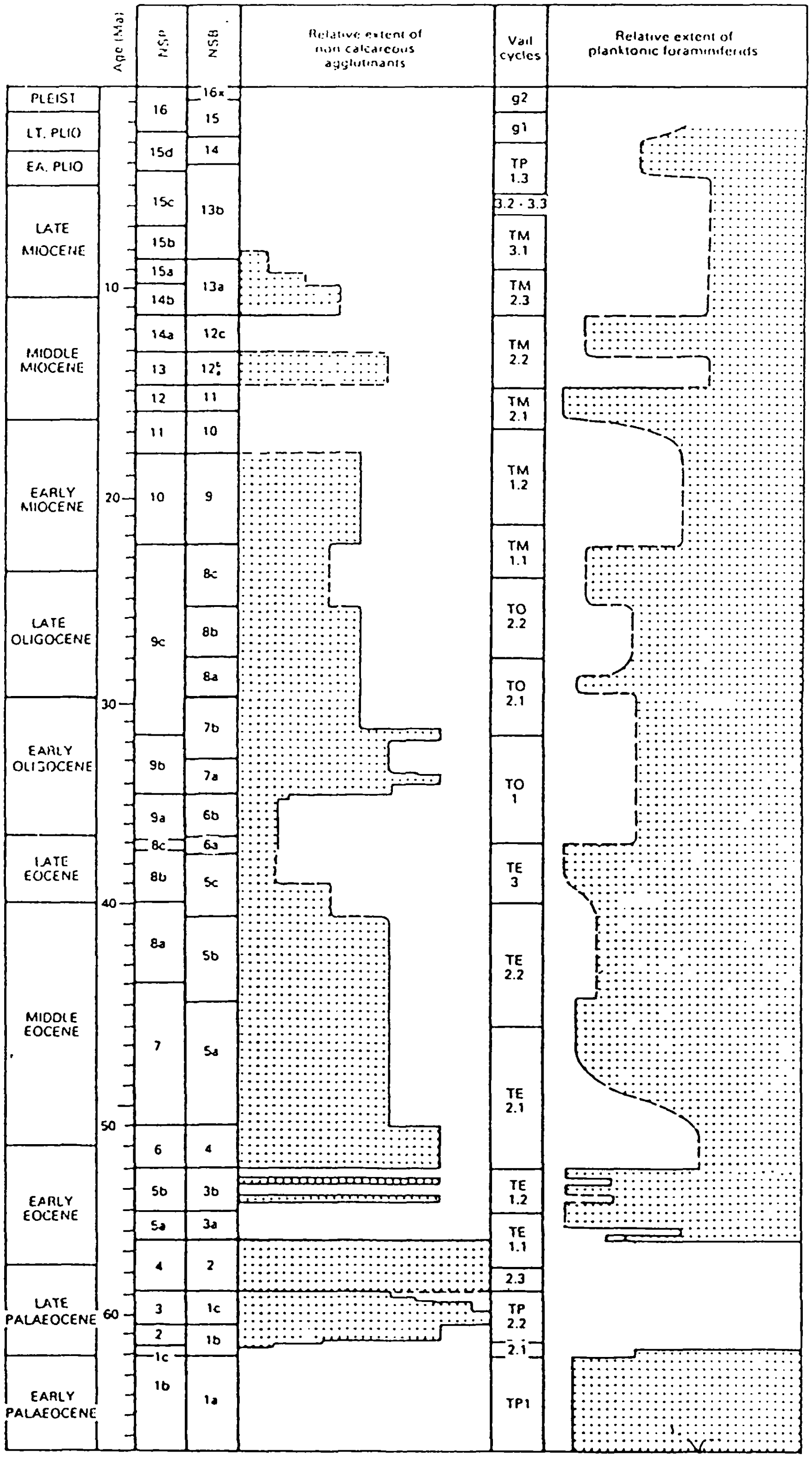
KEY.

✕ = LC 4, number of species is 42
" " individuals=212.
Alpha diversity=16.
+ = LC 3 number of species is 39.
" " individuals=204.
Alpha diversity=15.
● = LC 2 number of species is 22.
" " individuals=137.
Alpha diversity=7.
○ = LC 1 number of species is 27.
" " individuals=236.
Alpha diversity=8.

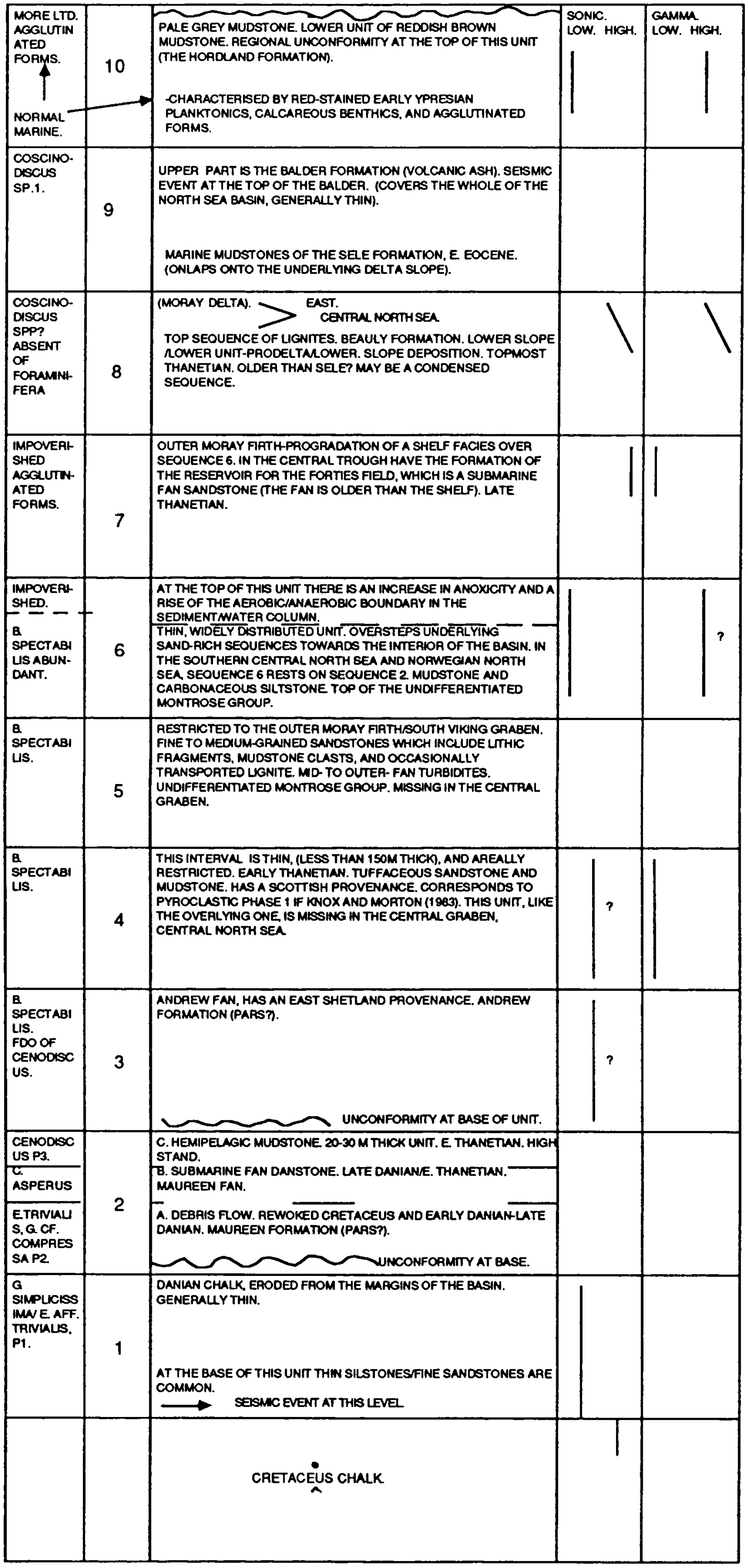
N.B. LC= Hampstead Heath samples.

FIG.14.

Cenozoic of the North Sea



The Correlation between King's (1989) NSP and NSB Zones and Vail et al.'s (1977) Cycles; and the Relationship between the Relative Extents of Non-Calcareous Agglutinants and Planktonic Foraminiferids.



			SONIC. LOW. HIGH.	GAMMA. LOW. HIGH.
MORE LTD. AGGLUTINATED FORMS. NORMAL MARINE.	10	PALE GREY MUDSTONE. LOWER UNIT OF REDDISH BROWN MUDSTONE. REGIONAL UNCONFORMITY AT THE TOP OF THIS UNIT (THE HORDLAND FORMATION). -CHARACTERISED BY RED-STAINED EARLY YPRESIAN PLANKTONICS, CALCAREOUS BENTHICS, AND AGGLUTINATED FORMS.		
COSCINODISCUS SP.1.	9	UPPER PART IS THE BALDER FORMATION (VOLCANIC ASH). SEISMIC EVENT AT THE TOP OF THE BALDER. (COVERS THE WHOLE OF THE NORTH SEA BASIN, GENERALLY THIN). MARINE MUDSTONES OF THE SELE FORMATION, E. EOCENE. (ONLAPS ONTO THE UNDERLYING DELTA SLOPE).		
COSCINODISCUS SPP? ABSENT OF FORAMINIFERA	8	(MORAY DELTA). > EAST. CENTRAL NORTH SEA. TOP SEQUENCE OF LIGNITES. BEAULY FORMATION. LOWER SLOPE /LOWER UNIT-PRODELTA/LOWER. SLOPE DEPOSITION. TOPMOST THANETIAN. OLDER THAN SELE? MAY BE A CONDENSED SEQUENCE.		
IMPOVERISHED AGGLUTINATED FORMS.	7	OUTER MORAY FIRTH-PROGRADATION OF A SHELF FACIES OVER SEQUENCE 6. IN THE CENTRAL TROUGH HAVE THE FORMATION OF THE RESERVOIR FOR THE FORTIES FIELD, WHICH IS A SUBMARINE FAN SANDSTONE (THE FAN IS OLDER THAN THE SHELF). LATE THANETIAN.		
IMPOVERISHED. B. SPECTABILIS ABUNDANT.	6	AT THE TOP OF THIS UNIT THERE IS AN INCREASE IN ANOXICITY AND A RISE OF THE AEROBIC/ANAEROBIC BOUNDARY IN THE SEDIMENT/WATER COLUMN. THIN, WIDELY DISTRIBUTED UNIT. OVERSTEPS UNDERLYING SAND-RICH SEQUENCES TOWARDS THE INTERIOR OF THE BASIN. IN THE SOUTHERN CENTRAL NORTH SEA AND NORWEGIAN NORTH SEA, SEQUENCE 6 RESTS ON SEQUENCE 2. MUDSTONE AND CARBONACEOUS SILTSTONE. TOP OF THE UNDIFFERENTIATED MONTROSE GROUP.		?
B. SPECTABILIS.	5	RESTRICTED TO THE OUTER MORAY FIRTH/SOUTH VIKING GRABEN. FINE TO MEDIUM-GRAINED SANDSTONES WHICH INCLUDE LITHIC FRAGMENTS, MUDSTONE CLASTS, AND OCCASIONALLY TRANSPORTED LIGNITE. MID- TO OUTER- FAN TURBIDITES. UNDIFFERENTIATED MONTROSE GROUP. MISSING IN THE CENTRAL GRABEN.		
B. SPECTABILIS.	4	THIS INTERVAL IS THIN, (LESS THAN 150M THICK), AND AREALLY RESTRICTED. EARLY THANETIAN. TUFFACEOUS SANDSTONE AND MUDSTONE. HAS A SCOTTISH PROVENANCE. CORRESPONDS TO PYROCLASTIC PHASE 1 IF KNOX AND MORTON (1983). THIS UNIT, LIKE THE OVERLYING ONE, IS MISSING IN THE CENTRAL GRABEN, CENTRAL NORTH SEA.	?	
B. SPECTABILIS. FDO OF CENODISCUS.	3	ANDREW FAN, HAS AN EAST SHETLAND PROVENANCE. ANDREW FORMATION (PARS?). UNCONFORMITY AT BASE OF UNIT.	?	
CENODISCUS P3. C. ASPERUS E.TRIVIALIS, G. CF. COMPRESSA P2.	2	C. HEMIPELAGIC MUDSTONE. 20-30 M THICK UNIT. E. THANETIAN. HIGH STAND. B. SUBMARINE FAN DANSTONE. LATE DANIAN/E. THANETIAN. MAUREEN FAN. A. DEBRIS FLOW. REWOKED CRETACEUS AND EARLY DANIAN-LATE DANIAN. MAUREEN FORMATION (PARS?). UNCONFORMITY AT BASE.		
G. SIMPLICISSIMA/ E. AFF. TRIVIALIS, P1.	1	DANIAN CHALK, ERODED FROM THE MARGINS OF THE BASIN. GENERALLY THIN. AT THE BASE OF THIS UNIT THIN SILSTONES/FINE SANDSTONES ARE COMMON. → SEISMIC EVENT AT THIS LEVEL.		
		CRETACEUS CHALK.		

FIG.15. The Biostratigraphy and Lithostratigraphy of the Palaeogene after Stewart (1987).

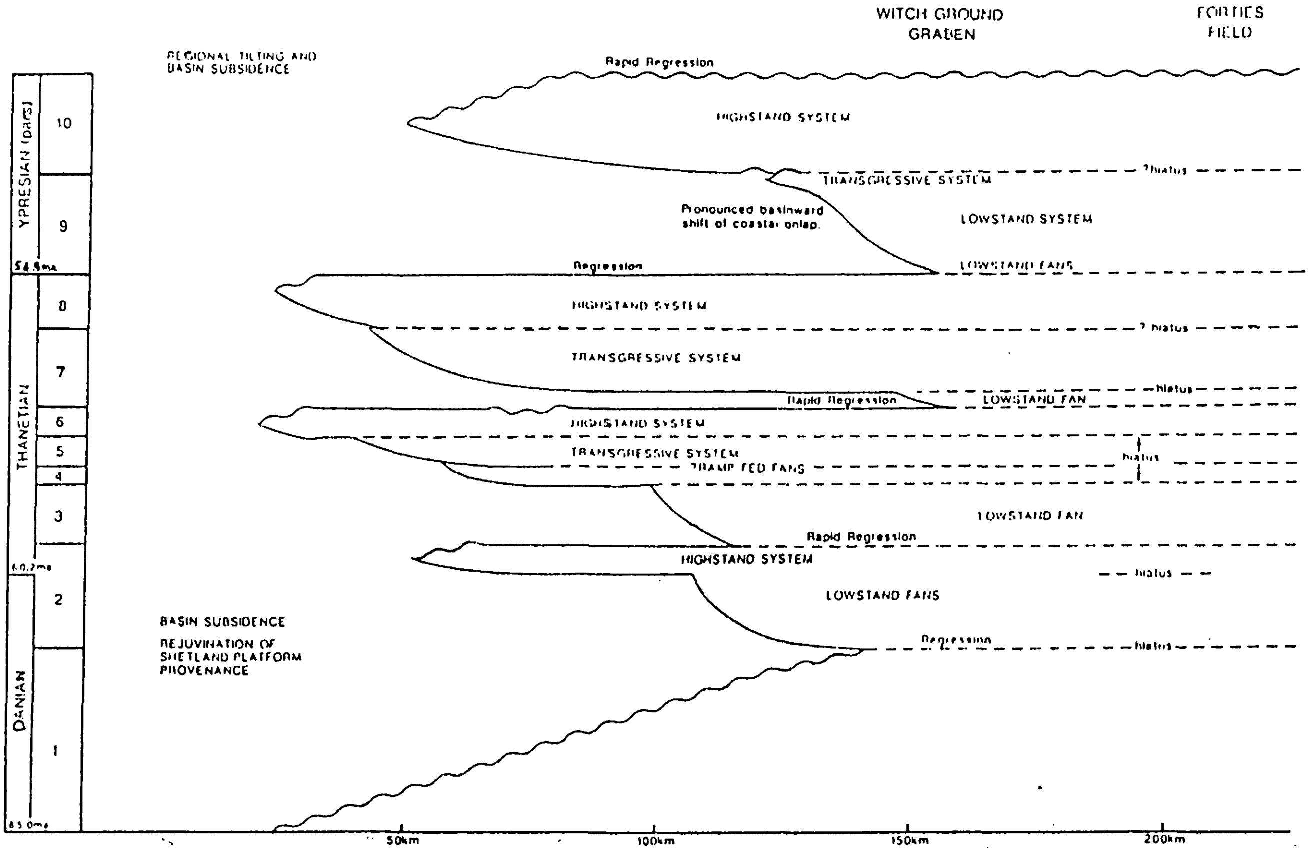


FIG.16. Coastal onlap curve for the Early Palaeogene of the central North Sea after Stewart (1987). The diagram shows the relative onlap positions of each of the ten described depositional sequences and the depositional systems operating within each. The terms 'highstand' and 'lowstand' refer only to the relative position of sea level.

species represented in the range-charts for Zones AB, CB, and PK (see Rangecharts with Enclosures).

The nannofossilstudy carried out by L. Gallagher in tandem with this study showed occasional discrepancies between the dates given by the foraminiferal data, and those indicated by the nannofossils. In well 21/11-1 the nannofossils indicated an Early Oligocene age for some samples which were identified as Late Eocene by the foraminifera. This foraminiferal date was based in part on examples of Perculatzonaria wetherellii (common in Zones CB3-CB6, Early-Late Eocene). Either this species and its associated fauna tops (have there FDOs) in the Early Oligocene (which does not appear to be the case in this study, and in the literature, see for example King 1989), or there has been considerable caving of nannofossil material. King (op. cit.) revised his 1983 NSB6 Zonation (Late Eocene), by extending it into the Early Oligocene. However, the forms used in this study to mark Zone CB6 did not extend into the Early Oligocene.

The nannofossil study used sidewall cores wherever possible, but when these were unavailable ditch-cuttings were utilised. When the latter were used, the results obtained were as subject to caving as were the foraminiferal studies. The preservation of nannofossils depended on the presence of a calcareous sediment. If the sediment was arenaceous or argillaceous, with no calcite, it was always barren of nannofossils, such barren sections were common in the wells examined in this study, especially in the Palaeocene and Eocene.

8.2. Suggested Further Study.

Further work is needed on the suprageneric classification of foraminifera. The present writer believes that more study is required concerning the validity of the superfamilies, etc. erected by Loeblich and Tappan (1988) for calcareous bethonic foraminifera (see Chapter 3.1, and 3.2).

Further study is also required on the Palaeocene and Late Oligocene-Early Miocene planktonic foraminifera from the North Sea Tertiary Basin. The Palaeocene forms examined in this study were often difficult to identify due to poor preservation. They were also apparently "variants" of well-known Palaeocene forms (such as *Eoglobigerina trivialis*, *Globanomalina compressa*, and *G. pseudobulloides*). The biostratigraphic usefulness of these "variants" needs to be confirmed by further stratigraphic and taxonomic work. The Late Oligocene-Early Miocene planktonic foraminifera also included "variants" of well known forms, such as *Globigerina angulisuturalis* and *G. ciperoensis*. The ranges of these species appear to be extended slightly in this study, and the present author suggests that further work to confirm this is required.

The Late Eocene-Early Oligocene boundary is sometimes difficult to distinguish in the North Sea Tertiary, and the nannofossil data and foraminiferal data do not not always agree. Further work on delimitation of this boundary may help to distinguish it more readily.

8.3. **Conclusions.**

This study, in tandem with the nannofossil study by L. Gallagher, has developed a useable biozonation of the North Sea Tertiary (mostly Palaeogene), utilising both nannofossils and foraminifera (see figs. 9 and 11).

Agglutinated benthic foraminifera (often present when nannofossils are absent) have been revised taxonomically, and have proved to be of considerable use biostratigraphically in the '<u>Rhabdammina</u>-biofacies', that is, in flysch-type faunal assemblages. They have also proved to be of some use palaeoenvironmentally (see Chapter 7.3, 7.4).

Palaeobathymetric data has been gathered in this study, and certain species are useful bathymetric markers, although their use has to be limited by the fact that considerable transport of material has probably taken place, from the basin edges towards the centres.

P.20 = P.25 or P.26.   P.17 = P.19 or P.20.

P.19 = P.23 or P.24.   P.16 = P.17 or P.18.

APPENDIX A.

Species Index for Agglutinated Foraminifera.

Adercotryma agterbergi Gradstein and Kaminski, p.150, pl.14, fig.7a-c.

Ammobaculites cf. *jarvisi* Cushman & Renz, p.146, pl.14, fig.4a-c.

Ammodiscus cretaceus (Reuss), p.126, pl.11, fig.6a-b.

Ammodiscus latus Grzybowski, p.127.

Ammodiscus planus Loeblich, p.127, pl.11, fig.7.

Ammolagena clavata (Jones & Parker), p.128, pl.11, fig.8a-b.

Ammomarginulina macrospira Bykova, p.147, pl.14, fig.5.

Bathysiphon sp., p.118.

Bolivinopsis rosula (Ehrenberg), p.164, pl.18, fig.2.

Clavulina parisiensis d'Orbigny, p.191.

Clavulinoides anglicus (Cushman), p.190, pl.20, fig.10, pl.21, fig.1a-b.

Cribrostomoides subglobosus, p.140, pl.13, fig.4a-b.

Cyclammina cf. *garcilassoi* Frizzell, p.162, pl.17, fig.3, pl.18, fig.1.

Cystammina pauciloculata (Brady), p.151, pl.14, fig.8a-b.

Dendrophyra excelsa Grzybowski, p.120.

Dendrophyra cf. *latissima* Grzybowski, p.121, pl.11, fig.2a-c.

Dendrophyra robusta Grzybowski, p.121.

Dorothia beloides Hillebrandt, p.180.

Dorothia eocenica Cushman, p.179, pl.19, fig.8.

Dorothia principiensis, p.179, pl.19, fig.7.

Dorothia seigliei Gradstein and Kaminski, p.180.

Dorothia aff. *seigliei* Gradstein and Kaminski, Appendix C.

Eratidus foliaceus (Brady), p.149, pl.14, fig.6a-b.

Gaudryina hiltermanni Meisl, p.177, pl.19, fig.6a-c.

Glomospira gordialis (Jones & Parker), p.129, pl.12, fig.1.

Glomospira irregularis (Grzybowski), p.130, pl.12, fig.2.

Glomospirella cf. *diffundens* (Cushman & Renz), p.130, pl.12, fig.3a-b.

Haplophragmoides sp., p.143, pl.14, fig.1.

Haplophragmoides kirki Wickenden, p.141, pl.13, fig.5a-d.

Haplophragmoides walteri Grzybowski, p.142, pl.13 fig.6.

Hormosina duplex (Grzybowski), p.138.

Hormosina ovulum Grzybowski, p.139, pl.13, fig.3.

Hormosina pilulifera (Brady), p.139, pl.13, fig.2.

Hyperammina subnodosiformis Grzybowski, p.125.

Kalamopsis grzybowski (Dylązánka), p.135, pl.12, fig.7a-b, pl.13, fig.1.

Karreriella (Karreriella) siphonella (Reuss), p.182, pl.20, fig.3a-b

Karreriella (?Karreriella) siphonella chilostoma (Reuss), p.183.

Karreriella (Karrerulina) conversa (Grzybowski), p.186, pl.20, fig.7a-b.

Karreriella (?Karrerulina) danica Cushman, p.185, pl.20, fig.5a-b.

Karreriella (Karrerulina) horrida Mjyatliuk, p.186, pl.20, fig.6.

Karreriella (Karrerulina) ?lenis (Grzybowski), p.187, pl.20, fig.8.

Karreriella (Meidamonella) bradyi (Cushman), p.185.

Karreriella (Meidamonella) mexicana (Nuttall), p.184, pl.20, fig.4a-b.

Labrospira scitula (Brady), p.143, pl.14, fig.2a-b.

Lituotuba lituiformis Brady, p.144, pl.14, fig.2a-b.

Mantanzia varians (Glaessner), p.198.

Marssonella sp., p.181, pl.20, fig.2.

Marssonella oxycona (Reuss), p.181, pl.19, fig.9, pl.20, fig.1.

Martinottiella communis (d'Orbigny), p.188, pl.20, fig.9.

Nodellum velascoense (Cushman), p.137.

Paratrochamminoides subcoronatus Grzybowski, p.145.

Placentammina complanata Franke, p.124, pl.11, fig.5.

Placentammina placenta (Grzybowski), p.123, pl.11, fig.4.

Praecystammina globigerinaeformis (Krasheninikov), p.152, pl.15, fig.1a-b.

Psammosphaera fusca Schulze, p.122, pl.11, fig.3.

Recurvoides sp.1, Appendix C.

Reophax sp., p.136.

Reophax subfusiformis Earland emend. Hoglund, p.136.

Repmannina charoides (Jones & Parker), p.131, pl.12, fig.4a-b.

Reticulophragmium sp.1, p.156, pl.15, fig.4.

Reticulophragmium amplectens (Grzybowski), p.155, pl.15, fig.3a-d, pl.17, fig.2.

Reticulophragmium paupera, p.159, pl.16, fig.3a-b.

Reticulophragmium placenta (Reuss), p.157, pl.15, fig.5a-e, pl.16, 1a-b, pl.17, fig.1.

Reticulophragmium rotundidorsata (Hantken), p.158, pl.16 fig.2a-c.

Reticulophragmoides jarvisi (Thalmann), p.160.

Reticulophragmoides sp.5 of Gradstein and Kaminski, p.160.

Rhabdammina discreta Brady, p.118, pl.10, fig.10a-b.

Rhizammina indivisa Brady, p.119, pl.10, fig.11a-b, pl.11, fig.1a-b.

Rzehakina epigona (Rzehak), p.133, pl.12, fig.5.

Rzehakina minima (Cushman & Renz), p.133.

Saccammina sphaerica Brady, p.124.

Sabellovoluta humboldti (Reuss), p.161, pl.16, fig.4a-c.

Sigmoilopsis schlumbergeri (Silvestri), Appendix C.

Siphotextularia sp., p.189, pl.19, fig.3a-b.

Spiroplectammina biformis (Parker & Jones), p.166.

Spiroplectammina navarroana Cushman, p.165, pl.18, fig.3a-b.

Spiroplectammina spectabilis (Grzybowski), p.167, pl.18, fig.4a-d.

Species Index for Calcareous Benthic Foraminifera.

Anomalinoides danica (Brotzen), p.28.

Anomalinoides dorri (Cole), p.26, pl.1. fig.12a-b, pl.2, fig.1.

Anomalinoides semicribratus (Beckmann), p.29, pl.2, fig.3.

Anomalinoides ypresiensis (ten Dam), p.31.

Aragonia aragonensis (Nuttall), p.19, pl.1, fig.6a-b.

Asterigerina bartoniana (ten Dam), p.46.

Asterigerina guerichi (Franke), p.47, pl.4, fig.3a-b.

Asterigerina staeschi ten Dam & Reinhold, p.46, pl.4, fig.2a-b.

Bolivina punctata d'Orbigny, p.88.

Brizalina anglica (Cushman), p.86, pl.8, fig.2.

Brizalina antiqua (d'Orbigny), p.87.

Brizalina cookei (Cushman), p.87, pl.8, fig.3.

Buccella frigida (Cushman), p.44, pl.3, fig.9a-b.

Bulimina sp. of King (1983), p.75.

Bulimina aculeata d'Orbigny, p.72.

Bulimina alsatica Cushman and Parker, p.75.

Bulimina denticulata Cushman & Parker, p.76.

Bulimina elongata d'Orbigny, p.74, pl.6, fig.7.

Bulimina elongata subulata Cushman and Parker, p.73.

Bulimina gibba Fornasini, p.74.

Bulimina marginata d'Orbigny, p.73.

Bulimina trigonalis ten Dam, p.74, pl.6, fig.8a-c.

Cancris auriculus primitivus Cushman & Todd, p.44.

Cassidulina carapitana Hedberg, p.20, pl.1, fig.7.

Cassidulina crassa d'Orbigny, p.20.

Cassidulina laevigata d'Orbigny, p.20.

Cassidulina pliocarinata Voorthuysen, p.20.

Dentalina sp., p.109, pl.10, fig.6.

Dentalina *elegantissima* (Hantken) var.A, p.106.

Dentalina *elegantissima* (Hantken) var. B, p.107, pl.10, fig.2.

Dentalina *eocenica* Cushman, p.108.

Dentalina *inornata* d'Orbigny, p.108, pl.10, fig.3.

Dentalina *megalopolitana* Reuss, p.107.

Dentalina *multilineata* Bornemann, p.106, pl.10, fig.1.

Elphidium *excavatum* (Terquem), p.56, pl.5, fig.3.

Elphidium *inflatum* (Reuss), p.57, pl.5, fig.4.

Eouvigerina *aculeata* (Ehrenberg), p.93.

Eouvigerina *americana* Cushman, p.94.

Eponides *karsteni* (Reuss), p.59, pl.5, fig.5a-d.

Eponides *lunata* Brotzen, p.58, see also Appendix C.

Eponides *plummerae* Cushman, p.59.

Fissurina *laevigata* Reuss, p.117.

Gavelinella *complanata* (Reuss), p.36.

Globocassidulina *subglobosa* (Brady), p.21.

Guttulina *frankei* Cushman & Ozawa, p.115.

Gyroidina *angustiumbilicata* ten Dam, p.50, pl.4, fig.5.

Gyroidina *octocamerata* Cushman & Hanna, p.49, pl.4, fig.4.

Gyroidina *soldanii* *girardana* (Reuss), p.51, pl.4, fig.7.

Gyroidina *soldanii* *mamillata* (Andreae), p.50, pl.4, fig.6.

Gyroidinoides sp., p.18, pl.1, fig.5.

Gyroidinoides *nitida* (Reuss), p.19.

Haynesina sp., p.18, pl.1, fig.9.

Heterolepa *dutemplei* *peelensis* (ten Dam & Reinhold), p.37, pl.3, fig.4a-b.

Heterolepa *dutemplei* *praecincta* (Karrer), p.37.

Heterolepa mexicanus (Nuttall), p.37, pl.3, fig.3a-c.

Hoeglundina elegans (d'Orbigny), p.43.

Korobkovella grosserugosa (Gümbel), p.70.

Lagena elongata (Ehrenberg), p.104.

Lagena hispida Reuss, p.105.

Lenticulina sp.1, p.100, pl.9, fig.7.

Lenticulina sp.2, p.101.

Lenticulina calcar (Linnaeus), p.104, pl.9, fig.10.

Lenticulina cultrata (de Montfort), p.102, pl.9, fig.8.

Lenticulina gutticostata Gümbel, p.103.

Lenticulina multiformis (Franke), p.103, pl.9, fig.9a-c.

Lenticulina cf. *pseudovortex* (Cole), p.102, pl.9, fig.5.

Lenticulina subangulata (Reuss), p.101, pl.9, fig.6.

Loxostomum lammersi Cushman & ten Dam, p.19.

Loxostomum teretum Cushman, p.19.

Marginulina aff. *attenuata* Neugeboren, p.96, pl.8, fig.11.

Melonis affinis (Reuss), p.39, pl.3, fig.5.

Monspeliensina pseudotepida (Van Voorthuysen), Appendix C.

Nododaria sp.1, p.113.

Nodosaria sp.2, p.113, pl.10, fig.7.

Nodosaria consobrina (d'Orbigny), p.114, pl.10, fig.8.

Nodosaria emaciata (Reuss), p.112.

Nodosaria intermittens Roemer, p.112.

Nodosaria konincki (Reuss), p.114.

Nodosaria latejugata Gümbel, p.111, pl.10, fig.4a-b.

Nodosaria longiscata d'Orbigny, p.110.

Nodosaria minor Hantken, p.112.

Nodosaria aff. *raphanus* (Linnaeus), p.111, pl.10, fig.5.

Nodosaria *torsicostata* ten Dam, p.114.

Nonion *compressum* (di Napoli), p.23.

Nonion *granosum* (d'Orbigny), p.23.

Nonion *orbiculare* (Brady), p.23.

Nuttallides *truempyi* (Nuttall), p.48.

Oolina *hexagona* (Williamson), p.116.

Oridorsalis *umbonatus* (Reuss), p.52, pl.4, fig.8a-b.

Osangularia *expansa* (Toulmin), p.18.

Osangularia *corderiana* gr. (d'Orbigny), p.18.

Osangularia *navarroana* (Cushman), p.18.

Osangularia *plummerae* Brotzen, p.17, pl.1, fig.4.

Percultazonaria sp.1, Appendix C.

Percultazonaria *wetherellii* (Jones), p.96, pl.8, fig.12, pl.9, fig.1a-b.

Percultazonaria *wetherellii* var. (Jones), p.98, pl.9, fig.2.

Percultazonaria aff. *wetherellii* (Jones), Appendix C.

Planulina *costata* (Hantken), p.60, pl.5, fig.6a-b.

Plectofrondicularia *seminuda* (Reuss), p.115, pl.10, fig.9a-b.

Praeglobobulimina *ovata* (d'Orbigny), p.71, pl.6, fig.6.

Pseudonodosaria sp.1, p.94, pl.8, fig.7.

Pseudonodosaria sp.2, p.94, pl.8, fig.8.

Pseudonodosaria sp.3, p.95, pl.8, fig.9.

Pseudononion *boueanus* (d'Orbigny), p.24, pl.1, fig.10.

Pullenia *bulloides* (d'Orbigny), p.22.

Pullenia *quaternaria* Reuss, p.22.

Pullenia *quinqueloba* (Reuss), p.21, pl.1, fig.8.

Pulsiphonina *prima* (Plummer), p.39, pl.3, fig.6a-b.

Quadrimorphina allomorphinoides (Reuss), p.25.

Quinqueloculina imperialis Hanna and Hanna, p.16, pl.1, fig.1a.

Quinqueloba imperialis porterensis Rau, p.16, pl.1, fig.1b.

Quinqueloba ludwigi Reuss, p.16, pl.1, fig.2.

Quinqueloculina seminula (Linnaeus), p.16.

Rotalia canui Cushman, p.55.

Rotaliatina bulimoides (Reuss), p.52, pl.4, fig.9.

Saracenaria sp., p.95, pl.8, fig.10.

Sigmomorphina regularis (Roemer), p.116.

Siphonina reticulata (Czjzeck), p.45, pl.4, fig.1a-b.

Siphonodosaria pauperata (d'Orbigny), p.93.

Sphaeroidina bulloides d'Orbigny, p.85, pl.8, fig.1.

Sphaeroidina variabilis Reuss, p.86.

Stainforthia schriebersiana (Czjzek), p.76.

Stensioina beccariiformis (White), p.40, pl.3, fig.7a-b.

Stensioina pommerana Brotzen, p.41.

Stilostomella sp., p.91.

Stilostomella adolphina (d'Orbigny), p.91, pl.8, fig.5a-d.

Stilistomella hirsuta (d'Orbigny), p.92.

Stilostomella palaeocenica (Cushman & Todd), p.90, pl.8, fig.4.

Stilostomella spinescens (Reuss), p.92, pl.8, fig.6.

Svratkina perlata (Andreae), p.55.

Tappanina selmensis (Cushman), p.89.

Trifarina bradyi Cushman, p.83, pl.7, fig.6a-b..

Turrilina alsatica (Andreae), p.85, pl.7, fig.8a-b.

Turrilina brevispira (ten Dam), p.84, pl.7, fig.7a-b.

Uvigerina sp.1, p.80, pl.7, fig.4.

Species Index for Planktonic Foraminifera, Radiolaria, Diatoms and Microplankton.

Radiolaria.

Diatoms.

Microplankton.

Planktonic Foraminifera.

Globigerina woodi Jenkins, p.204.

'*G'. pseudovenezuelana* Blow and Banner group, Appendix C.

"*Globigerinella*" *obesa* (Bolli), Appendix C.

Globigerinoides quadrilobatus trilobus (Reuss), p.206, pl.22, fig.5.

Globoconusa conusa Khalilov, p.230, pl.23, fig.8.

Globorotalia praescitula Blow, p.227, pl.23, fig.7a-b.

Globorotalia scitula (Brady), p.227.

Globorotaloides suteri Bolli, p.207, pl.22, fig.6.

'*Guembelina*' spp., Appendix C.

Neogloboquadrina continuosa (Blow), p.225, pl.23, fig.5.

Neogloboquadrina aff. *increbescens* (Bandy), p.225.

Neogloboquadrina mayeri (Cushman), p.226, pl.23, fig.6.

Pseudohastigerina wilcoxensis (Cushman & Ponton), p.214, pl.22, fig.10.

Pseudotextularia spp., Appendix C.

Sphaeroidinellopsis subdehiscens (Blow), p.209, pl.22, fig.7.

Tenuitella munda (Jenkins), p.210, pl.22, fig.8.

APPENDIX B.

Comments on the Range-Chart Computer Program Used in this study.

The Shell Expro. U.K. range-chart computer program was used in this study (see Enclosures for CB Zones Rangechart, PK Zones Rangechart, and AB Zones Rangechart). The thickness of each line drawn in each zone represents the percentage of a particular species in that zone, while the length of each line shows whether the species in question is recorded throughout that zone . For example, Cassidulina laevigata in Zone CB14, occurs as 20-30% of the species in that zone, while it occurs throughout that zone (100% of samples). Globorotalia scitula occurs in Zone CB13, as 30-40% of the species in that zone, while G. scitula occurs in 75% of samples.

The AB range-chart contains useful agglutinated benthonic species, and also useful calcareous benthics and planktonics. Similarly, the CB range chart not only contains calcareous benthics, but also useful agglutinated benthonics and planktonics. The PK range-chart contains primarily planktonic species, but also useful calcareous benthics and agglutinated forms.

There are disadvantages with this particular program. Zone CB1 is empty of data because it is only recorded in one sample in one well in this study (well 49/9-1, Southern North Sea). As it occurs as such a low percentage of samples it is ignored by the computer program. Zones CB9-CB11 are also absent of data for similar reasons. They are only recorded as spot samples in one or two wells, so are ignored. Any species that occur as 1% (or less) of species listed are also ignored by the program. Although this means that the more common index forms are included in the range-chart, any rare species that are useful stratigraphically are left out of the chart, for example Globoconusa conusa, a biostratigraphically valuable

Early Palaeocene planktonic species, is of rare occurrence only (well 29/10-1, Central North Sea), so the program ignores it completely in the PK Zone range-chart. Similarly, Zone PK4 is barren of data (see PK Rangechart) possibly because there were only 4 samples noted within this zone (from the London Clay formation). The range-chart showing AB Zones contains one Zone (AB5) that is barren of data. This zone was only noted in a few samples in one well (Norwegian sector, 25/10-1), so it also was ignored by the computer program Work by Gradstein et al. (1988) and King (1989) has shown that the latter zone is a useful one in the North Sea Tertiary Basin. There is a real danger that too much regard for quantiative biostratigraphic principles will cause serious loss of correlative and stratigraphic data for Shell Expro. U.K. The diamonds may be rare, but they are more valuable than the more numerous grains of quartz gravel!

The range-chart for each set of Zones (AB, CB, PK) also includes other useful species of radiolaria (for example Cenodiscus lenticularis) and diatoms (for example Coscinodiscus sp.1).

Further Comments on the Rangechart Computer Program.

For each zonation scheme (CB, PK, AB) various zones were determined. The name and range of each zone in each well, tops and where appropriate bottoms (established by either the top of the underlying zone, geophysical or lithological data), were entered into the Shell Expro. U.K. computer.

The computer program then determined from the computer's database the species occurring, their frequency and spread within these zones. When printing the rangechart the species linked to that zonation scheme were printed out first followed by the remaining species. It should be noted that the program could not differentiate between calcareous benthic and agglutinated benthic fossils, consequently when using zonations CB and AB, calcareous and agglutinated benthics were printed together.

APPENDIX C.

Taxonomic and Biostratigraphical Notes on Selected Genera and Species.

The species *Eponides lunata* Brotzen (1948, see p.65 this thesis) was used as the type species for Hansen's (1970, p.101) genus *Paralabamina* (see also Loeblich and Tappan 1988, p.641, pl.721, figs.1-7) Loeblich and Tappan's (ibid.) figs.1-3 on their plate 721 are hypotypes of Hansen's species which he claimed were the same as Brotzen's (see Loeblich and Tappan pl.721, figs.5-7, holotypes). However, Hansen's hypotypes appear to be different from Brotzen's species. Loeblich and Tappan (op. cit.) only tentatively accepted Hansen's explanation that his hypotypes were identified by Dr. F. Brotzen as *E. lunata*. Hansen's figures show a form which is less compressed towards the less acute periphery, and has coarser pores on the spiral side with fewer whorls and therefore fewer chambers visible than *E. lunata* s.s. The umbilical side in Brotzen's (1948) holotype (see Loeblich and Tappan op. cit., figs.5-7, pl.721) is also much more convex, as is the spiral side. *E. lunata* of Brotzen is a more lenticular form than Hansen's 'example' of this species. *Paralabamina* differs from *Eponides* in having an optically granular wall. *Eponides* may also have supplementary areal openings although due to problems of preservation in North Sea material these were not observed. *E. lunata* from the North Sea Tertiary also possessed an imperforate keel, and imperforate sutures, as in Brotzens holotype, features not present in Hansens hypotype. Hence, the genus *Paralabamina* was not accepted for the purposes of this thesis.

Percultazonaria sp.1, noted on page 267 in the well descriptions, is not noted in the taxonomic section of this thesis as this species is simply a smoother 'variant' of *Percultazonaria wetherellii* (Jones), which rarely ranges up into the Oligocene. *P. wetherellii* s.s. is an Eocene species. *P.* aff. *wetherellii* (p.276) was sometimes noted in the Early Oligocene in this thesis. It was not a consistent marker species, and often poorly preserved. It is another 'variant' of *P. wetherellii* and was included into the species concept. *Monspielensina pseudotepida* (Van Voorthuysen) noted on p.274 is a very well known species in the Pliocene and is prone to caving downhole. It was not covered in the taxonomic sections because it was of very limited stratigraphic use for the purposes of this thesis. *Cibicides '?proprius'* Brotzen (p.302) is probably a variety of *Cibicidoides alleni* (Plummer). *Valvalabamina lenticula* (Reuss) on p.302 is not covered in the taxonomic section of this thesis as it was not encountered in Tertiary sediments.

Recurvoides sp.1 (p.269) is a rare species, and is not of any use biostratigraphically. *Sigmoilopsis schlumbergeri* (Silvestri, 1904) noted on page 274 is a well known species that is only useful biostratigraphically in the Pliocene/Pleistocene, which is outside the scope of this thesis. It often occurs as a caved species in the Neogene. *Dorothia* aff. *segliei* Gradstein and Kaminski (p.278) is a coarser walled, and possibly reworked example, of *D. segliei* s.s. It was not a consistent marker form. *Spirosigmoilinella* sp.1 (p.293) is a 'variety' of *S. compressa* Matsunaga, and only occurs in one or two wells in this thesis. Other more useful species occur with it, such as *Spiroplectinella wilcoxensis* (Cushman and Ponton).

Other species mentioned in the well descriptions and not covered in the taxonomic section in this thesis include '*Guembelina*' spp. (p.281) and *Pseudotextularia* spp. (p.273). Both were poorly preserved, and were not discussed in chapter 3 because there were other, more useful forms present in the wells in this study at the same stratigraphic horizons, such as

Stensioina beccariiformis (White) and "G." aff. compressa (Plummer).

Globigerina ouachitaensis Howe and Wallace (1932, p.74, pl.10, figs.7a-c) (see p.293) is another well known species. Bolli and Saunders (1985, fig.13.15a-b, holotype) illustrate examples that are typical of North Sea forms, with a wide centrally placed quadrate umbilicus and an aperture with a thin rim or lip. There are 4 subglobular chambers in the final whorl, in a higher spire than G. ciperoensis Bolli. G. ouachitaensis s.l. and G. praebulloides s.l. are often very difficult to distinguish in the North Sea, as 'intermediate' forms are often present. The final chamber in praebulloides is larger than in ouachitaensis, giving a more elongated equatorial outline than ouachitaensis, which has a more quadrate one (see Bolli and Saunders op. cit., p.182 for comments). The umbilicus on praebulloides is not quadrate in outline as in typical ouachitaensis. The latter species was not discussed in chapter 3 because it was a long-ranging form of limited use stratigraphically, and 'variants' of the species were common often making positive identification difficult. These factors make it unsuitable as a marker species in this thesis. G. praebulloides leroyi Blow and Banner rarely occurs in the North Sea Tertiary, and is therefore of very limited use in this thesis (see p.292). G. [Subbotina] angiporoides Hornibrook (p.292) was rarely noted in this thesis. It is a long-ranging species according to Blow (1979, p.1250, pl.12, figs.3-5, pl.244, fig.7) and was of limited biostratigraphical use in the North Sea Tertiary. The generic name Subbotina Brotzen and Pozaryska is placed into square brackets to show that it is an alternative genus, as in Globigerina [Subbotina] linaperta Finlay gr. Members of the 'G'. pseudovenezuelana Blow and Banner 'group' (includes varieties of 'G'. venezuelana Hedberg) were also noted in this study (well 21/30-1, 2310'DC). This 'group' consisted of forms with

3.5 to 4, low trochospirally coiled, rather appressed chambers in the last whorl. The apertures are low arched and may have a triangular tooth-like lip (as in *G. pseudovenezuelana*, see Bolli and Saunders 1985, p.180). This group was rarely noted in the North Sea Tertiary. It is more common in Oligocene faunas (see Bolli and Saunders, op. cit.). In the North Sea the existence of variants of this group make it difficult to identify reliably, so making it a difficult group to work with stratigraphically. Rare "*Globigerinella*" *obesa* (Bolli) was also noted in the North Sea Tertiary. It was of very limited biostratigraphical value so was not discussed in chapter 3 (see Bolli and Saunders 1985, fig.26.44, and Kennett and Srinivasan 1983, p.235, pl.59, figs.2-5). *Chiloguembelina* sp. was also rarely noted in this study, and was of little biostratigraphic value.

Methodology.

Two wells were picked in this study by the present writer, one of approximately 8,000' of Pliocene to Palaeocene sediments (Well 29/10-1, Central North Sea, Central Graben, sample interval 10' to 50'); the other, (25/10-1, Norwegian sector of the Northern North Sea, Viking Graben) of 4 samples from a core section from the Late Palaeocene to Early Eocene. 6 other wells, from the Southern and Central North Sea were pre-picked by Shell Expro. U.K. at 10' to 50' intervals. The wells picked by Shell Expro. U.K. used "fist-sized" samples (approximately 400 gms). One picking tray of coarse sediment (above 425μm), 3 of medium (between 150μm and 425μm), and one of fine (below 150μm) were picked by Shell, with a maximum of 200 specimens per sample (although this number was often not reached). All samples were processed using a seive size of 63μm or 74μm. Well 29/10-1, processed and picked by the present writer, was picked using the Shell Expro. U.K. method. A maximum of 200 to 250 specimens were picked from each sample (depending on abundance) from the London Clay, and "Thanetian" sections, and from Well 25/10-1.

The type collection was established mostly from well 29/10-1, 25/10-1, and the London Clay land sections; although biostratigraphically useful species not occurring in the latter two wells were also included.

All wells were logged onto standard Shell Expro. U.K. logging sheets, where the depth and type of sample (for example, ditch-cutting, side-wall sample or core), the species and their abundance, were recorded. The zonation scheme (AB, PK and CB zones) was established by first examining the data entered onto the aforementioned logging sheets in order to ascertain the total ranges of the species, and hence derive the biozonation used. This data was entered onto the Shell Expro. U.K. computer system.

The zones on the distribution charts (see Enc. 1-10) were drawn up using biostratigraphical, lithostratigraphical and geophysical data.

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PLATE DESCRIPTIONS.

Plate 1.

Fig.1a. Quinqueloculina imperialis Hanna and Hanna. X75. Well 29/10-1, 7030'DC, Early Oligocene, Zone CB7, AB10 (reworked).

b. Quinqueloculina imperialis porterensis Rau. X75. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone CB3.

Fig.2. Quinqueloculina ludwigi Reuss. X100. London Clay Formation, Parliament Hill, sample PH004. Early Eocene, Ypresian, Zone AB4.

Fig.3. Cornuspira involvens (Reuss). X50. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

Fig.4. Osangularia plummerae Brotzen. X100. London Clay Formation, Parliament Hill, sample PH004. Early Eocene, Ypresian, Zone AB4.

Fig.5. Gyroidinoides sp. X250. London Clay Formation, British Library Site, sample BL001. Early Eocene, Ypresain, Zone PK3.

Fig.6a. Aragonia aragonensis (Nuttall). X100. Well 49/19-1, 1260'SWS, earliest Early Eocene, Zones CB3, AB4.

b. Aragonia aragonensis (Nuttall). X725. Wall structure, and apertural face. Well 49/19-1, 1260'SWS, earliest Early Eocene, Zones CB3, AB4.

Fig.7. Cassidulina carapitana (Hedberg). X75. Well 14/29-1, 1880'DC, Early Oligocene, Zone CB7a marker species.

Fig.8. Pullenia quinqueloba (Reuss). X100. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

Fig.9. Haynesina sp. X75. Well 21/11-1. 2130'DC, Early Pliocene.

Fig.10. Pseudononion boueanus (d'Orbigny). X75. Well 21/11-1, 2370'DC., Early Miocene, Zones CB13, PK11.

Fig.11. Chilostomelloides oviformis (Sherborn & Chapman). X50. London Clay

Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

Fig.12a. *Anomalinoides dorri* (Cole). X100. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

b. *Anomalinoides dorri* (Cole). X100. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

Plate 2.

Fig.1. *Anomalinoides dorri* (Cole). X100. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

Fig.2a. *Anomalinoides capitatus* (Gümbel). X100. Well 49/19-1, 1260'DC, earliest Early Eocene, Zones CB3, AB4, PK6.

b. *Anomalinoides capitatus* (Gümbel). X250. Same specimen as Fig.2a, this plate. Well 49/19-1, 1260'DC, earliest Early Eocene, Zones CB3, AB4, PK6.

c. *Anomalinoides capitatus* (Gümbel). X175. Same specimen as Fig.2a. Well 49/19-1, 1260'DC, earliest Early Eocene, Zones CB3, AB4, PK6.

d. *Anomalinoides capitatus* (Gümbel). X75. Same specimen as Fig.2a. Well 49/19-1, 1260'DC, earliest Early Eocene, Zones CB3, AB4, PK6.

Fig.3. *Anomalinoides semicribratus* (Beckmann). X180. Well 49/19-1, 1260'DC, earliest Early Eocene, Zones CB3, AB4.

Fig.4a. *Anomalinoides acuta* Plummer. X100. Well 49/9-1, 1288'SWS, Late Eocene, Zone CB6.

b. *Anomalinoides acuta* Plummer. X100. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

Fig.5a. *Anomalinoides acuta anomalinoides* (ten Dam). X100. Well 49/19-1, 1170'DC, ?Early-Middle Eocene, Zones CB4, PK7.

b. *Anomalinoides acuta anomalinoides* (ten Dam). X100. Well 49/19-1, 1170'DC, ?Early-Middle Eocene, Zones CB4, PK7.

c. *Anomalinoides acuta anomalinoides* (ten Dam). X100. Well 49/19-1, 1170'DC, ?Early-Middle Eocene, Zones CB4, PK7.

Fig.6a. *Cibicidoides alleni* (Plummer) subsp.A. X100. Thickened, raised spiral suture. Well 49/19-1, 1230'DC, earliest Early Eocene, Zones, CB3, PK6, AB4.

b. *Cibicidoides alleni* (Plummer) subsp.A. X75. London Clay Formation, Parliament Hill site, sample PHOO3. Early Eocene, Ypresian, Zone AB4.

c. *Cibicidoides alleni* (Plummer) subsp.A. X75. London Clay Formation, Parliament Hill site, sample PHOO3. Early Eocene, Ypresian, Zone AB4.

Plate 3.

Fig.1a. *Cibicidoides alleni* (Plummer) subsp.B. X50. London Clay Formation, Parliament Hill site, sample PHOO4. Early Eocene, Ypresian, Zone AB4.

b. *Cibicidoides alleni* (Plummer) subsp.B. X50. London Clay Formation, Parliament Hill site, sample PHOO4. Early Eocene, Ypresian, Zone AB4.

Fig.2a. *Cibicidoides eocaenus* (Gümbel). X75. Well 49/19-1, 1230'DC, earliest Early Eocene, Zones CB3, PK6, AB4.

b. *Cibicidoides eocaenus* (Gümbel). X75. Well 49/19-1, 1230'DC, earliest Early Eocene, Zones CB3, PK6, AB4.

Fig.3a. *Heterolepa mexicanus* (Nuttall). X100. Well 49/19-1, 1260'DC, earliest Early Eocene, Zones CB3, PK6, AB4.

b. *Heterolepa mexicanus* (Nuttal). X50. Well 49/19-1, 1140'DC, Late Eocene, Zone CB6.

c. *Heterolepa mexicanus* (Nuttall). X50. Well 49/19-1, 1260'DC, earliest Early Eocene, Zones CB3, PK6, AB4.

Fig.4a. Heterolepa dutemplei peelensis (ten Dam & Reinhold). X100. Well 21/11-1, 2670'DC, Middle Oligocene, Zone CB7.

b. Heterolepa dutemplei peelensis (ten Dam & Reinhold). X100. Well 21/11-1, 2670'DC, Middle Oligocene, Zone CB7.

Fig.5. Melonis affinis (Reuss). X100. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

Fig.6a. Pulsiphonina prima (Plummer). X100. London Clay Formation, Parliament Hill site, sample PH002. Early Eocene, Ypresian, Zone CB3.

b. Pulsiphonina prima (Plummer). X100. London Clay Formation, Parliament Hill site, sample PH002. Early Eocene, Ypresian, Zone CB3.

Fig.7a. Stensioina beccariiformis (White). X100. Well 21/30-1, 6690'SWS, Late Palaeocene, Thanetian, Zones CB2, AB2.

b. Stensioina beccariiformis (White). X75. Well 49/19-1, 1440'DC, ?Late Palaeocene, Thanetian, Zone CB2.

Fig.8. Ceratobulimina contraria (Reuss). X100. Well 49/9-1, 1288'SWS, Late Eocene/?Earliest Oligocene, Zone CB6.

Fig.9a. Buccella frigida (Cushman). X100. Well 21/11-1, 2130'DC, Early Pliocene.

b. Buccella frigida (Cushman). X100. Different specimens. Well 21/11-1, 2130'DC, Early Pliocene.

Plate 4.

Fig.1a. Siphonina reticulata (Czjzek). X350. Aperture on neck with lip. Well 29/10-1, 4840'DC, early Middle Miocene, Zone AB11b.

b. Siphonina reticulata (Czjzek). X100. Well 29/10-1, 4810'DC, early Middle Miocene, Zone AB11b.

c. Siphonina reticulata (Czjzek). X100. Well 29/10-1, 4810'DC, early

Middle Miocene, Zone AB11b.

Fig.2a. *Asterigerina staeschi* ten Dam & Reinhold. X100. Well 21/11-1, 2370'DC, Early Miocene, Zones CB13, PK11.

b. *Asterigerina staeschi* ten Dam & Reinhold. X100. Well 21/11-1, 2370'DC, Early Miocene, Zones CB13, PK11.

Fig.3a. *Asterigerina guerichi* (Franke). X50. Well 21/11-1, 2610'DC, early Late Oligocene, Zone CB8.

b. *Asterigerina guerichi* (Franke). X100. Well 21/11-1, 2610'DC, early Late Oligocene, Zone CB8.

Fig.4. *Gyroidina* aff. *octocamerata* Cushman & Hanna. X100. London Clay Formation, Parliament Hill site, sample PH003. Early Eocene, Ypresian, Zone AB4.

Fig.5. *Gyroidina angustiumbilicata* ten Dam. X100. London Clay Formation, Parliament Hill site, sample PH003. Early Eocene, Ypresian, Zone AB4.

Fig.6. *Gyroidina soldanii mamillata* (Andreae). X100. Well 21/11-1, 2790'DC, Middle Oligocene, Zone CB7, AB10.

Fig.7. *Gyroidina soldanii girardana* (Reuss). X75. Well 21/11-1, 2730'DC, Middle Oligocene, Zone CB7, AB10.

Fig.8a. *Oridorsalis umbonatus* (Reuss). X100. Well 29/10-1, 6100'DC, Early Miocene/Late Oligocene, Zone CB10-11.

b. *Oridorsalis umbonatus* (Reuss). X100. Well 29/10-1, 6000'DC, Early Miocene/Late Oligocene, Zone CB10-11.

Fig.9. *Rotaliatina bulimoides* (Reuss). X100. Well 21/11-1, 2670'DC, Middle Oligocene, Zones CB7 (marker species), AB10.

Fig.10a. *Alabamina wilcoxensis* Toulmin. X100. London Clay Formation, Parliament Hill site, sample PH003. Early Eocene, Ypresian, Zone AB4.

b. *Alabamina wilcoxensis* Toulmin. X100. London Clay Formation, Parliament Hill site, sample PHOO3. Early Eocene, Ypresian, Zone AB4.

Plate 5.

Fig.1. *Alabamina wilcoxensis* Toulmin. X100. London Clay Formation, Parliament Hill site. Sample PH003. Early Eocene, Ypresian, Zone AB4.

Fig.2. *Alabamina obtusa* (Burrows & Holland). X100. London Clay Formation, Parliament Hill site. Sample PH003. Early Eocene, Ypresian, Zone AB4.

Fig.3. *Elphidium excavatum* (Terquem). X100. Well 21/11-1, 2130'DC, Early Pliocene.

Fig.4. *Elphidium inflatum* (Reuss). X75. Well 21/11-1, 2310'DC, Early Miocene, Zone ?PK11.

Fig.5a. *Eponides karsteni* (Reuss). X100. Well 49/19-1, 1230'DC, earliest Early Eocene, Zones CB3, PK6.

b. *Eponides karsteni* (Reuss). X500. Aperture with distinct rim. Well 49/19-1, 1230'DC, earliest Early Eocene, Zones CB3, PK6.

c. *Eponides karsteni* (Reuss). X50. Well 49/19-1, 1230'DC, earliest Early Eocene, Zones CB3, PK6.

d. *Eponides karsteni* (Reuss). X75. Well 49/19-1, 1170'DC, Early-Middle Eocene, Zones CB4 (marker species), PK7.

Fig.6a. *Planulina costata* (Hantken). X50. 14/29-1, 2270-00'DC, Middle Eocene, Zone CB5 (marker species).

b. *Planulina costata* (Hantken). X50. 14/29-1, 2450-80'DC, ?Middle Eocene, Zone ?CB5.

Fig.7. *Cibicidina cunobelini* Haynes. X100. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.8a. *Cibicides lobatulus* (Walker & Jacob) s.l. X75. London Clay

Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

b. *Cibicides lobatulus* (Walker & Jacob) s.l. X75. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.9a. *Cibicides westi* (Howe). X75. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

b. *Cibicides westi* (Howe). X100. London Clay Formation, Euston Centre site. Early Eocene, Ypresian, Zone AB4.

Plate 6.

Fig.1a. *Cibicides anglica* (Bowen). X100. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

b. *Cibicides anglica* (Bowen). X100. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.2.a. *Cibicides tenellus* (Reuss). X75. Well 21/11-1, 2370'DC, Early Miocene, Zones CB13, PK11.

b. *Cibicides tenellus* (Reuss). X75. Well 21/11-1, 2310'DC, Early Miocene, Zone ?PK11.

c. *Cibicides tenellus* (Reuss). X75. Well 21/11-1, 2310'DC, Early Miocene, Zone ?PK11.

Fig.3a. *Cibicides pseudoungerianus* (Cushman). X75. Well 21/11-1, 2130'DC, Early Pliocene.

b. *Cibicides pseudoungerianus* (Cushman). X75. Well 21/11-1, 2130'DC, Early Pliocene.

Fig.4a. *Cibicides ungerianus* (d'Orbigny). X75. Well 21/11-1, 3090'DC, Late Eocene, Zone PK8.

b. Cibicides ungerianus (d'Orbigny). X75. Well 21/11-1, 3090'DC, Late Eocene, Zone PK8 (different specimen than Fig.4a, this plate).

Fig.5. Cibicides pygmeus (Hantken). X75. London Clay Formation, Parliament Hill site. Sample PH003. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.6. Praeglobobulimina ovata (d'Orbigny). X100. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.7. Bulimina elongata d'Orbigny. X100. Well 29/10-1, 5520-30'DC, Early-early Middle Miocene, Zone CB12.

Fig.8a. Bulimina trigonalis ten Dam. X100. Pegwell Bay. Bed 10, Late Palaeocene, Thanetian, Zone NP6/7.

b. Bulimina trigonalis ten Dam. X180. Pegwell Bay. Bed 10, Late Palaeocene, Thanetian, Zone NP6/7.

c. Bulimina trigonalis ten Dam. X75. Pegwell Bay. Bed 10, Late Palaeocene, Thanetian, Zone NP6/7.

Plate 7.

Fig.1. Cassidulinoides bradyi (Norman). X200. Well 29/10-1, 4810'DC, early Middle Miocene, Zone AB11b.

Fig.2a. Uvigerina batjesi Kaaschieter 'var.' A. X100. London Clay Formation, Parliament Hill site. Sample PH001. Early Eocene, Ypresian, Zones CB3, AB4, PK4.

b. Uvigerina batjesi Kaaschieter 'var.' B. X180. London Clay Formation, Parliament Hill site. Sample PH001. Early Eocene, Ypresian, Zones CB3, AB4, PK4.

Fig.3. Uvigerina pygmaea langeri Daniels and Spiegler. X100. Well 49/9-1, 1306'SWS, Late Eocene/?Earliest Oligocene, Zone CB6.

Fig.4. Uvigerina sp.1. X100. Well 49/9-1, 1306'SWS, Late Eocene/?Earliest

Oligocene, Zone CB6.

Fig.5a. *Uvigerina macrocarinata* Papp & Turnovsky. X40. Well 21/11-1, 2370'DC, Early Miocene, Zones, CB13, PK10-11.

b. *Uvigerina macrocarinata* Papp & Turnovsky. X75. Well 21/11-1, 2370'DC, Early Miocene, Zones, CB13, PK10-11.

Fig.6a. *Trifarina bradyi* Cushman. X180. Well 49/19-1, 1230'DC, earliest Early Eocene, Zones CB3, AB4, PK6.

b. *Trifarina bradyi* Cushman. X1000. Aperture with distinct rim. Well 49/19-1, 1230'DC, earliest Early Eocene, Zones CB3, AB4, PK6 (same specimen as Fig.6a, this plate).

Fig.7a. *Turrilina brevispira* ten Dam. X180. Well 29/10-1, 8610'DC, Late Palaeocene, Thanetian, Zone CB2 (specimen caved).

b. *Turrilina brevispira* ten Dam. X180. London Clay Formation, Parliament Hill site. Sample PH001. Early Eocene, Ypresian, Zones CB3, AB4, PK4.

Fig.8a. *Turrilina alsatica* Andreae. X180. Well 29/10-1, 6940'DC, Early Oligocene, Zones CB7, PK9.

b. *Turrilina alsatica* Andreae. X250. Well 49/9-1, 1306'SWS, Late Eocene/?Earliest Oligocene, Zone CB6.

Plate 8.

Fig.1. *Sphaeroidina bulloides* d'Orbigny. X100. Well 21/11-1, 2810'DC, Late Eocene, Zone ?CB6 (caved?).

Fig.2. *Brizalina anglica* Cushman. X100. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.3. *Brizalina cookei* (Cushman). X180. 49/9-1, 1288'SWS, Late Eocene/?Earliest Oligocene, Zone CB6 (marker species).

Fig.4. *Stilostomella paleocenica* (Cushman and Todd). X50. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.5a. *Stilostomella adolphina* (d'Orbigny). X400. 3-4 rows of spines on the base of a rounded chamber. 49/19-1, 1140'DC, ?Early-Middle Eocene, Zones CB4, PK7.

Fig.5b. *Stilostomella adolphina* (d'Orbigny). X100. 49/19-1, 1140'DC, ?Early-Middle Eocene, Zones CB4, PK7. Same specimen as Fig.5a, this plate.

c. *Stilostomella adolphina* (d'Orbigny). X250. Earlier chambers than Fig.5a, this plate, less spinose with spines shown in the suture between chambers. Also shows the way the spines point towards the basal spine. 49/19-1, 1140'DC, ?Early-Middle Eocene, Zones CB4, PK7.

d. *Stilostomella adolphina* (d'Orbigny). X250. Short basal spines with a row of spines along the base of the first formed chamber. 49/19-1, 1140'DC, ?Early-Middle Eocene, Zones CB4, PK7.

Fig.6. *Stilostomella spinescens* (Reuss). X75. Well 21/11-1, 2790'DC, Middle Oligocene, Zones CB7, AB10.

Fig.7. *Pseudonodosaria* sp.1. X75. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.8. *Pseudonodosaria* sp.2. X100. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.9. *Pseudonodosaria* sp.3. X35. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.10. *Saracenaria* sp. X50. London Clay Formation, Parliament Hill site. Sample PH003. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.11. *Marginulina* cf *attenuata* Neugeboren. X75. London Clay Formation, Parliament Hill site. Sample PH003. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.12. *Percultazonaria wetherellii* (Jones). X25. London Clay Formation, Parliament Hill site. Sample PH001. Early Eocene, Ypresian, Zones AB4, PK4.

Plate 9.

Fig.1a. *Percultazonaria wetherellii* (Jones). X75. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

b. *Percultazonaria wetherellii* (Jones). X75. Broken juvenile showing internal chamber arrangement in later part of test. London Clay Formation, Euston Centre site. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.2. *Percultazonaria wetherellii* (Jones) var. X100. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.3. *Vaginulinopsis* aff. *jonesi* (Reuss). X50. Well 29/10-1, 6200'DC, Late-'Middle' Oligocene, Zones AB11a, CB9.

Fig.4. *Vaginulinopsis praelonga* ten Dam. X35. Pegwell Bay, Bed 10, Late Palaeocene, Thanetian, Zone NP6/7.

Fig.5. *Lenticulina* cf. *pseudovortex* (Cole). X50. London Clay Formation, Parliament Hill site, sample PH002. Early Eocene, Ypresian, Zones CB3, AB4, PK4.

Fig.6. *Lenticulina subangulata* (Reuss). X50. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.7. *Lenticulina* sp.1. X50. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.8. *Lenticulina cultrata* (de Montfort). X50. 49/19-1, 1140'DC, ?Early-Middle Eocene, Zones CB4, PK7.

Fig.9a. *Lenticulina multiformis* (Franke). X35. 49/19-1, 1260'DC, earliest Early Eocene, Zones CB3, AB4, PK6.

b. *Lenticulina multiformis* (Franke). X35. 49/19-1, 1260'DC, earliest Early Eocene, Zones CB3, AB4, PK6 (same specimen as Fig.9a, this plate).

c. *Lenticulina multiformis* (Franke). X75. Shows broken aperture with curved septal face. 49/19-1, 1260'DC, earliest Early Eocene, Zones CB3, AB4, PK6 (same specimen as Fig.8a, this plate).

Fig.10. *Lenticulina calcar* (Linnaeus) X35. 14/29-1, 1970'DC, Late Eocene-Early Oligocene, Zone ?NSB6 of King 1983.

Plate 10.

Fig.1. *Dentalina multilineata* Bornemann. X50. London Clay Formation, Euston Centre site. Early Eocene, Ypresian, Zone AB4.

Fig.2. *Dentalina elegantissima* (Hantken), 'var.' B. X25. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.3. *Dentalina inornata* (d'Orbigny). X75. London Clay Formatiomn, Parliament Hill site, sample PH002. Early Eocene, Ypresian, Zone CB3, AB4, PK4.

Fig.4a. *Nodosaria latejugata* Gümbel. X35. London Clay Formation, Parliament Hill site. Sample PH002. Early Eocene, Ypresian, Zones CB3, AB4, PK4.

b. *Nodosaria latejugata* Gümbel. X25. London Clay Formation, Parliament Hill site. Sample PH002. Early Eocene, Ypresian, Zones CB3, AB4, PK4.

Fig.5. *Nodosaria* aff. *raphanus* Linnaeus. X50. London Clay Formation, Parliament Hill site. Sample PH003. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.6. *Nodosaria* sp.2. X50. London Clay Formation, Parliament Hill site. Sample PH003. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.7. *Nodosaria* sp.3. X25. London Clay Formation, Parliament Hill site. Sample PH003. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.8. *Nodosaria consobrina* (d'Orbigny). X35. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.9a. *Plectofrondicularia seminuda* (Reuss). X100. Well 29/10-1, 6100'DC, Early Miocene-Late Oligocene, Zones CB10-11, PK10. A marker species for Zone CB10.

b. *Plectofrondicularia seminuda* (Reuss). X100. Well 29/10-1, 6100'DC, Early Miocene-Late Oligocene, Zones CB10-11, PK10.

Fig.10a. *Rhabdammina discreta* Brady. X40. Well 29/10-1, 6940'DC, Early Oligocene, Zones AB10, CB7, PK9.

b. *Rhabdammina discreta* Brady. X100. Wall structure. Well 29/10-1, 6940'DC, Early Oligocene, Zones AB10, CB7, PK9.

Fig.11a. *Rhizammina indivisa* Brady. X100. Coarse walled form. Well 29/10-1, 8060'DC, Early-early Middle Eocene, Zones AB6, PK5.

b. *Rhizammina indivisa* Brady. X250. Smooth walled form. Well 29/10-1, 9080'DC, Early Palaeocene, Zone PK1a.

Plate 11.

Fig.1a. *Rhizammina indivisa* Brady. X100. Well 29/10-1, 7460'DC, Early Oligocene, Zones AB10, CB7, PK9.

b. *Rhizammina indivisa* Brady. X75. Well 29/10-1, 7460'DC, Early Oligocene, Zones AB10, CB7, PK9.

Fig.2a. *Dendrophyra* cf. *latissima* Grzybowski. X180. Well 29/10-1, 8120'DC, Early-early Middle Eocene, Zone AB6.

b. *Dendrophyra* cf. *latissima* Grzybowski. X100. Well 29/10-1, 6310'DC, Late-'Middle' Oligocene, Zones AB11a, CB9.

c. *Dendrophyra* cf. *latissima* Grzybowski. X180. Well 29/10-1, 6360'DC, Early Oligocene, Zones AB10, CB7, PK9.

Fig.3. *Psammosphaera* *fusca* Schulze. X100. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

Fig.4. *Placentammina* *placenta* (Grzybowski). X100. Well 25/10-1, 5886'core, 'Middle'-Late Palaeocene, Zone AB2.

Fig.5. *Placentammina* *complanata* Franke. X100. Well 29/10-1, 6360'DC, Early Oligocene, Zones AB10, CB7, PK9.

Fig.6a. *Ammodiscus* *cretaceus* (Reuss). X50. Well 21/30-1, 6690'SWS, Late Palaeocene, Thanetian, Zones AB2, CB2.

b. *Ammodiscus* *cretaceus* (Reuss). X75. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.7. *Ammodiscus* *planus* Loeblich. X200. Well 25/10-1, 5886' core, 'Middle'-Late Palaeocene, Zone AB2.

Fig.8a. *Ammolagena* *clavata* (Jones & Parker). X75, on *Spiroplectammina* *navarroana* Cushman. Well 25/10-1, 5501' core, Early Eocene, Zone AB5.

b. *Ammolagena* *clavata* (Jones & Parker). X50, on *Ammodiscus* *cretaceus* (Reuss). Well 29/10-1, 8590'DC, Late Palaeocene, Thanetian, Zone CB2.

Plate 12.

Fig.1. *Glomospira* *gordialis* (Jones & Parker). X100. Well 49/19-1, 1440'DC, ?Late Palaeocene, Zone CB2.

Fig.2. *Glomospira* *irregularis* (Grzybowski). X100. Well 49/19-1, 1440'DC, ?Late Palaeocene, Zone CB2.

Fig.3.a. *Glomospirella* cf. *diffundens* (Cushman & Renz). X100. Well 29/10-1, 6940'DC, Early Oligocene, Zones AB10, CB7, PK9.

b. *Glomospirella* cf. *diffundens* (Cushman & Renz). X750. Wall structure and initial streptospiral coil. Well 29/10-1, 6940'DC, Early Oligocene, Zones AB10, CB7, PK9.

Fig.4a. *Repmanina charoides* (Jones & Parker). X100. Well 29/10-1, 7000'DC, Early Oligocene, Zones AB10, CB7, PK9.

b. *Repmanina charoides* (Jones & Parker). X100. Well 29/10-1, 7000'DC, Early Oligocene, Zones AB10, CB7, PK9.

Fig.5. *Rzehakina epigona* (Rzehak). X180. Well 29/10-1, 7460'DC, Early Oligocene, Zones AB10, CB7, PK9 (reworked example).

Fig.6a. *Spirosigmoilinella compressa* Matsunaga. X75. Well 29/10-1, 7000'DC, Early Oligocene, Zones AB10, CB7, PK9.

b. *Spirosigmoilinella compressa* Matsunaga. X100. Well 29/10-1, 5520'DC, Early-early Middle Miocene, Zone CB12.

Fig.7a. *Kalamopsis grzybowski* (Dylązánka). X180. Well 25/10-1, 5510' core, Early Eocene, Zone ?AB4.

b. *Kalamopsis grzybowski* (Dylązánka). X75. Well 25/10-1, 5510' core, Early Eocene, Zone ?AB4.

Plate 13.

Fig.1. *Kalamopsis grzybowski* (Dylązánka). X500. Well 25/10-1, 5510' core, Early Eocene, Zone ?AB4.

Fig.2. *Hormosina pilulifera* (Brady). X100. Well 29/10-1, 7460'DC Early Oligocene, Zones AB10, CB7, PK9.

Fig.3. *Hormosina ovulum* (Grzybowski). X75. Well 29/10-1, 8010'DC, Early-early Middle Eocene, Zones AB6, PK5.

Fig.4a. *Cribrostomoides subglobosus* (Sars). X75. Well 14/29-1, 4670'DC, Late Palaeocene, Thanetian, Zone AB3.

b. *Cribrostomoides subglobosus* (Sars). X50. Well 14/29-1, 4670'DC, Late Palaeocene, Thanetian, Zone AB3.

Fig.5a. *Haplophragmoides kirki* Wickenden. X180. Well 21/30-1, 6210'SWS, Early-Middle Eocene, Zone AB6.

b. Haplophragmoides kirki Wickenden. X180. Well 21/30-1, 6210'SWS, Early-Middle Eocene, Zone AB6.

c. Haplophragmoides kirki Wickenden. X400. Apertural face and wall. Well 21/30-1, 6210'SWS, Early-Middle Eocene, Zone AB6 (same specimen as fig.5c, this plate).

d. Haplophragmoides kirki Wickenden. X180. Well 21/30-1, 6210'SWS, Early-Middle Eocene, Zone AB6.

Fig.6. Haplophragmoides walteri (Grzybowski). X100. Well 25/10-1, 5510' core, Early Eocene, Zone ?AB4. Uncompressed example.

Plate 14.

Fig.1. Haplophragmoides sp. X75. London Clay Formation, Parliament Hill site. Sample PH003. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.2a. Labrospira scitula (Brady). X50. Well 21/30-1, 6045'SWS, Early-Middle Eocene, Zone AB6.

b. Labrospira scitula (Brady). X180. Same specimen as fig.2a, this plate, showing apertural face and wall. Well 21/30-1, 6045'SWS, Early-Middle Eocene, Zone AB6.

Fig.3. Lituotuba lituiformis (Brady). X75. Well 25/10-1, 5510' core, Early Eocene, Zone ?AB4.

Fig.4a. Ammobaculites cf. jarvisi Cushman & Renz. X100. Juvenile form? London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

b. Ammobaculites cf. jarvisi Cushman & Renz. X35. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

c. *Ammobaculites* cf. *jarvisi* Cushman & Renz. X75. Juvenile form? Early chambers broken to show chamber arrangement. London Clay Formation, Parliament Hill site. Sample PH004. Early Eocene, Ypresian, Zones AB4, PK4.

Fig.5. *Ammomarginulina macrospira* Bykova. X180. Well 25/10-1, 5510' core, Early Eocene, Zone ?AB4.

Fig.6a. *Eratidus foliaceus* (Brady). X180. Well 29/10-1, 7460'DC, Early Oligocene, Zones AB10, CB7, PK9.

b. *Eratidus foliaceus* (Brady). X180. Well 29/10-1, 7460'DC, Early Oligocene, Zones AB10, CB7, PK9.

Fig.7a. *Adercotryma agterbergi* Gradstein & Kaminski. X100. Well 21/30-1, 6045'SWS, Early-Middle Eocene, Zone AB6.

b. *Adercotryma agterbergi* Gradstein & Kaminski. X100. Well 21/30-1, 6045'SWS, Early-Middle Eocene, Zone AB6.

c. *Adercotryma agterbergi* Gradstein & Kaminski. X100. Well 21/30-1, 6045'SWS, Early-Middle Eocene, Zone AB6.

Fig.8a. *Cystammina pauciloculata* (Brady). X100. Well 29/10-1, 8210'DC, Late Paleocene, Thanetian, Zones CB2, ?PK2.

b. *Cystammina pauciloculata* (Brady). X100. Well 29/10-1, 8210'DC, Late Paleocene, Thanetian, Zones CB2, ?PK2. Same specimen as fig.8a, this plate.

Plate 15.

Fig.1a. *Praecystammina globigerinaeformis* (Krasheninikov). X100. Well 21/30-1, 6210'SWS, Early-Middle Eocene, Zone AB6.

b. *Praecystammina globigerinaeformis* (Krasheninikov). X400. Same specimen as fig.1a, this plate. Raised, slit-like aperture. Well 21/30-1, 6210'SWS, Early-Middle Eocene, Zone AB6.

Fig.2. *Thalmannammina walteri* (Grzybowski). X50. Well 14/29-1, 4610'DC,

Late Palaeocene, Thanetian, Zone AB2.

Fig.3a. *Reticulophragmium amplectens* (Grzybowski). X500. Broken apertural face, showing the remains of a slit-like aperture. 49/9-1, 2463'SWS, Early Eocene, Zone AB6.

b. *Reticulophragmium amplectens* (Grzybowski). X75. 49/9-1, 2463'SWS,Early Eocene, Zone AB6.

c. *Reticulophragmium amplectens* (Grzybowski). X180. 49/9-1, 2463'SWS, Early Eocene, Zone AB6.

d. *Reticulophragmium amplectens* (Grzybowski). X75. 49/9-1, 2463'SWS, Early Eocene, Zone AB6.

Fig.4. *Reticulophragmium* sp.1 X50. 49/9-1, 2463'SWS, Early Eocene, Zone AB6.

Fig.5a. *Reticulophragmium placenta* (Reuss). X50. Well 21/11-1, 3860'DC, Early Eocene-Late Palaeocene, Zone PK3.

b. *Reticulophragmium placenta* (Reuss). X100. Well 29/10-1, 7210'DC, Early Oligocene, Zones AB10, CB7, PK9.

c. *Reticulophragmium placenta* (Reuss). X50. Well 29/10-1, 7000'DC, Early Oligocene, Zones AB10, CB7, PK9.

d. *Reticulophragmium placenta* (Reuss). X50. Well 29/10-1, 7000'DC, Early Oligocene, Zones AB10, CB7, PK9.

e. *Reticulophragmium placenta* (Reuss). X35. Well 29/10-1, 7780'DC, Earlyiearly Middle Eocene, Zones AB6, PK5.

Plate 16.

Fig.1a. *Reticulophragmium placenta* (Reuss). X180. Broken final chamber, showing alveolae. Same specimen as fig.5e, Pl.15. Well 29/10-1, 7780'DC, Early-early Middle Eocene, Zones AB6, PK5.

b. Reticulophragmium placenta (Reuss). X375. Aperture slit-like. Sharper peripheral margin below the apertural face than in R. rotundidorsata (Hantken) (fig.2c, this plate). Well 29/10-1, 7460'DC, Early Oligocene, Zones AB10, CB7, PK9.

Fig.2a. Reticulophragmium rotundidorsata (Hantken). X100. Well 21/30-1, 5470'SWS, earliest Late Oligocene to Early Oligocene, Zones AB10, CB7.

b. Reticulophragmium rotundidorsata (Hantken). X75. Well 21/30-1, 5470'SWS, earliest Late Oligocene to Early Oligocene, Zones AB10, CB7.

c. Reticulophragmium rotundidorsata (Hantken). X250. Aperture slit-like, with rounded peripheral margin below the apertural face. Same specimen as fig.2b, this plate. Well 21/30-1, 5470'SWS, earliest Late Oligocene to Early Oligocene, Zones AB10, CB7.

Fig.3a. Reticulophragmium paupera (Thalmann). X50. Wall of fine flat grains. Well 14/29-1, 4250'DC, Late Palaeocene, Zone AB2.

b. Reticulophragmium paupera (Thalmann). X50. Wall of fine flat grains. Well 14/29-1, 4670'DC, Late Palaeocene, Zone AB2.

Fig.4a. Sabellovoluta humboldti (Reuss). X35. Well 21/11-1, 2670'DC, 'Middle' Oligocene, Zones AB10, CB7.

b. Sabellovoluta humboldti (Reuss). X750. Close-up of broken final chamber showing alveolae. Same specimen as fig4a, this plate. Well 21/11-1, 2670'DC, 'Middle' Oligocene, Zones AB10, CB7.

c. Sabellovoluta humboldti (Reuss). X250. Alveolae. Same specimen as fig.4a, this plate. Well 21/11-1, 2670'DC, 'Middle' Oligocene, Zones AB10, CB7.

Plate 17. Thick Sections.

Fig.1. Reticulophragmium placenta (Reuss). X500. Well 29/10-1, 7000'DC,

Early Oligocene, Zones AB10, CB7, PK9.

Fig.2. Reticulophragmium amplectens (Grzybowski). X500. Well 49/9-1, 2463'SWS, Early Eocene, Zone AB6.

Fig.3. Cyclammina cf. garcillassoi (Frizzell). X600. Well 29/10-1, 8610'DC, Late Palaeocene, Thanetian, Zone CB2.

Plate 18.

Fig.1. Cyclammina cf. garcilassoi (Frizzell). X50. Well 29/10-1, 8610'DC, Late Palaeocene, Thanetian, Zone CB2.

Fig.2. Bolivinopsis rosula (Ehrenberg). X180. Portsdown 1 well, 47'-50', Late Cretaceous.

Fig.3a. Spiroplectammina navarroana Cushman. X75. Well 25/10-1, 5510' core, Early Eocene, Zone ?AB4.

b. Spiroplectammina navarroana Cushman. X100. Well 25/10-1, 5510' core, Early Eocene, Zone ?AB4.

Fig.4a. Spiroplectammina spectabilis (Grzybowski) form B. X75. Well 21/30-1, 6690'SWS, Late Palaeocene, Thanetian, Zones AB2 (marker species for that zone), CB2, ?PK2.

b. Spiroplectammina spectabilis (Grzybowski) form B. X50. Microspheric example. Well 21/30-1, 6690'SWS, Late Palaeocene, Thanetian, Zones AB2 (marker species for that zone), CB2, ?PK2.

c. Spiroplectammina spectabilis (Grzybowski) form A. X100. Well 21/30-1, 6107'SWS, Early-Middle Eocene, Zones AB6.

d. Spiroplectammina spectabilis (Grzybowski) form A. X100. Well 25/10-1, 5510' core, Early Eocene, Zone ?AB4.

Fig.5a. Spiroplectinella adamsi (Lalicker). X75. London Clay Formation, Parliament Hill site. Sample PH001. Early Eocene, Ypresian, Zones AB4, CB3, PK4.

b. *Spiroplectinella adamsi* (Lalicker). X75. Juvenile? 49/19-1. 1140'DC, ?Early-Middle Eocene, Zones CB4, PK7.

Fig.6. *Spiroplectinella carinata* (d'Orbigny). X50. Well 49/19-1, 1110'DC, Late Eocene, Zone CB6.

Fig.7a. *Spiroplectinella deperdita* (d'Orbigny). X75. Well 49/19-1. 1230'DC, earliest Early Eocene, Zones AB4, PK6, CB3.

b. *Spiroplectinella deperdita* (d'Orbigny). X75. Well 49/19-1. 1230'DC, earliest Early Eocene, Zones AB4, PK6, CB3.

c. *Spiroplectinella deperdita* (d'Orbigny). X50. Well 14/29-1. 2450'DC, ?Middle Eocene, Zone ?CB5.

Fig.8. *Spiroplectinella wilcoxensis* (Cushman & Ponton). X50. Well 21/11-1, 3080'DC, Late Eocene, Zone ?CB6.

Plate 19.

Fig.1. *Spiroplectinella wilcoxensis* (Cushman & Ponton). X50. Well 14/29-1, 2330'DC, Middle Eocene, Zones CB5, PK6.

Fig.2. *Spiroplectinella excolata* Cushman. X50. Well 14/29-1, 2270'DC, Late Eocene, Zone NSB6 of King (1983).

Fig.3a. *Siphotextularia* sp.1. X75. Well 49/9-1, 1535'SWS, Late-Middle? Eocene, Zone NSB6a of King (1983).

b. *Siphotextularia* sp.1. X50. Well 49/9-1, 1535'SWS, Late-Middle? Eocene, Zone NSB6a of King (1983).

Fig.4a. *Trochammina subvesicularis* Homola & Hanzliková. X10. Well 21/30-1, 6690'SWS, Late Palaeocene, Thanetian, Zones AB2, CB2, ?PK2.

b. *Trochammina subvesicularis* Homola & Hanzliková. X100. Well 14/29-1, 4790'DC, Late Palaeocene, Thanetian, Zone AB2.

c. *Trochammina subvesicularis* Homola & Hanzliková. X100. Well 21/30-1, 6690'SWS, Late Palaeocene, Thanetian, Zones AB2, CB2, ?PK2. Same specimen as fig.4a, this plate.

d. *Trochammina subvesicularis* Homola & Hanzliková. X375. Apertural face. Well 21/30-1, 6690'SWS, Late Palaeocene, Thanetian, Zones AB2, CB2, ?PK2.

Fig.5a. *Trochammina ruthven-murrayi* (Cushman & Renz). X75. Well 14/29-1, 4790'DC, Late Palaeocene, Thanetian, Zone AB2.

b. *Trochammina ruthven-murrayi* (Cushman & Renz). X50. Well 14/29-1, 4310'DC, Late Palaeocene, Thanetian, Zone AB2.

c. *Trochammina ruthven-murrayi* (Cushman & Renz). X50. Well 14/29-1, 4310'DC, Late Palaeocene, Thanetian, Zone AB2. Same specimen as fig.5b, this plate.

Fig.6a. *Gaudryina hiltermanni* (Meisl). X50. Juvenile. London Clay Formation, Parliament Hill site, sample PH003. Early Eocene, Ypresian, Zone AB4.

b. *Gaudryina hiltermanni* (Meisl). X50. Juvenile. View of initial chambers. London Clay Formation, Parliament Hill site, sample PH003. Early Eocene, Ypresian, Zone AB4.

c. *Gaudryina hiltermanni* (Meisl). X35. Adult. Well 49/19-1, 1230'DC, earliest Early Eocene, Zones AB4 (marker species for that zone), CB3, PK6.

Fig.7. *Dorothia principiensis* Cushman & Parker. X75. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

Fig.8. *Dorothia eocenica* Cushman. X75. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

Fig.9. *Marssonella oxycona* (Reuss). X100. Well 29/10-1, 9110'DC, Early Palaeocene, Danian, Zone PK1a.

Plate 20.

Fig.1. *Marssonella oxycona* (Reuss). X375. Basal slit aperture on flat face. Same specimen as fig.9, plate 18. Well 29/10-1, 9110'DC, Early Palaeocene, Danian, Zone PK1a.

Fig.2. *Marssonella* sp. X50. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

Fig.3a. *Karreriella (Karreriella) siphonella* (Reuss). X50. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

b. *Karreriella (Karreriella) siphonella* (Reuss). X50. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

Fig.4a. *Karreriella (?Meidamonella) mexicana* (Nuttall). X100. Well 21/11-1, 3080'DC, Late Eocene, Zone ?CB6.

b. *Karreriella (?Meidamonella) mexicana* (Nuttall). X1000. Shows hooked lip around aperture. Same specimen as fig.4a, this plate. Well 21/11-1, 3080'DC, Late Eocene, Zone ?CB6.

Fig.5a. *Karreriella (?Karrerulina) danica* Cushman. X75. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

b. *Karreriella (?Karrerulina) danica* Cushman. X75. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4. Same specimen as fig.5a, this plate.

Fig.6. *Karreriella (Karrerulina) horrida* Mjatliuk. X180. Well 25/10-1, 5510' core, Early Eocene, Zone ?AB4.

Fig.7a. *Karreriella (Karrerulina) conversa* (Grzybowski). X100. Well 21/30-1, 6210'SWS, Early-Middle Eocene, Zone AB6.

b. Karreriella (Karrerulina) conversa (Grzybowski). X100. Well 21/30-1, 6210'SWS, Early-Middle Eocene, Zone AB6.

Fig.8. Karreriella (Karrerulina) ?lenis (Grzybowski). X180. Well 14/29-1, 5770'SWS, Late Palaeocene, Zone AB2.

Fig.9. Martinotiella communis (d'Orbigny). X75. Well 29/10-1, 4990'DC, early Middle Miocene, Zone AB11b.

Fig.10. Clavulinoides anglicus (Cushman). X50. Well 49/19-1, 1260'DC, earliest Early Eocene, Zones AB4, CB3, PK6.

Plate 21.

Fig.1a. Clavulinoides anglicus (Cushman). X50. London Clay Formation, Parliament Hill site, sample PH003. Early Eocene, Ypresian, Zones AB4, PK4.

b. Clavulinoides anglicus (Cushman). X375. Canaliculate wall structure. Well 49/19-1, 1260'DC, earliest Early Eocene, Zones AB4, CB3, PK6.

Fig.2a. Textularia sp. X100. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

b. Textularia sp. X100. Same specimen as fig.2a, this plate. View of initial chambers. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

Fig.3. Textularia chapmani Lalicker. X100, Well 49/9-1 1288'SWS, Late Eocene/?earliest Oligocene, Zone CB6 (reworked).

Fig.4a. Globastica daubjergensis (Brönnimann). X180. Well 21/11-1, 5219'SWS, early Late Palaeocene, Thanetian, Zones PK2, CB2.

b. Globastica daubjergensis (Brönnimann). X180. Well 29/10-1, 9010'DC, Early Palaeocene, Danian planktonics Zone PK1b, and Zone CB2.

c Globastica daubjergensis (Brönnimann). X180. Wills Point, Midway, Alabamina, U.S.A., '*Globorotalia*' *trinidadensis* Zone.

d. *Globastica daubjergensis* (Brönnimann). X250. Wills Point, Midway, Alabamina, U.S.A., *'Globorotalia' trinidadensis* Bolli Zone.

e. *Globastica daubjergensis* (Brönnimann). X750. Wills Point, Midway, Alabamina, U.S.A., *'Globototalia' trinidadensis* Bolli Zone.

Fig.5. *Globigerina ampliapertura* Bolli. X180. Well 21/11-1, 2370'DC, Early Miocene, Zones CB13, PK11 (reworked).

Fig.6. *Globigerina ciperoensis* Bolli. X180. Well 29/10-1, 5810'DC, late Early Miocene, Zone PK12.

Fig.7. *Globigerina ciperoensis* Bolli. X100. Well 21/11-1, 2310'DC, Early Miocene, Zone ?PK11.

Fig.8. *Globigerina eocaena* Gümbel. X100. Well 21/11-1, 2810'DC, Late Eocene, Zone ?CB6.

Fig.9. *Globigerina* cf. *falconensis* Blow. X100. Well 29/10-1, 4990'DC, early Middle Miocene, Zone AB11b.

Plate 22.

Fig.1a. *Globigerina [Subbotina] triloculinoides* Plummer. X100. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zones PK4, AB4.

b. *Globigerina [Subbotina] triloculinoides* Plummer. X100. London Clay Formation, Parliament Hill site, sample PH004. Early Eocene, Ypresian, Zone AB4.

Fig.2. *Globigerina praebulloides occlusa* Blow & Banner. X180. Well 21/11-1, 2247'SWS, early Middle-early Late Miocene, Zone NSB13 of King (1983). (Reworked).

Fig.3. *Globigerina praebulloides praebulloides* Blow. X100. Well 29/10-1,

5000'DC, early Middle Miocene, Zone AB11b.

Fig.4. *Catapsydrax unicavus unicavus* Bolli, Loeblich & Tappan. X100. Well 21/11-1, 2310'DC, Early Miocene, Zone ?PK11.

Fig.5. *Globigerinoides quadrilobatus trilobus* (Reuss). X100. Well 29/10-1, 5530'DC, Early-early Middle Miocene, Zone CB12.

Fig.6. *Globorotaloides suteri* Bolli. X180. Well 21/11-1, 2000'DC, Early Pliocene.

Fig.7. *Sphaeroidinellopsis subdehiscens* (Blow). X100. Well 29/10-1, 5530'DC, early-early Middle Miocene, Zone CB12.

Fig.8. *Tenuitella munda* (Jenkins). X180. Well 21/11-1, 2000'DC, Early Pliocene.

Fig.9. *Globigerapsis index index* (Finlay). X100. Well 21/11-1, 3090'DC, Late Eocene, Zone PK8.

Fig.10 *Pseudohastigerina wilcoxensis* (Cushman & Ponton). X180. Well 49/19-1, 1200'DC, ?Early-Middle Eocene, Zones PK7, CB4.

Fig.11. "*Globanomalina*" *compressa* (Plummer). X250. Well 29/10-1, 9010'DC, Early Palaeocene, Danian planktonics Zone PK1b, and Zone CB2.

Fig.12a. "*Globanomalina*" *pseudobulloides* (Plummer). X250. Well 29/10-1, 9060'DC, Early Palaeocene, Danian planktonics Zone PK1b, also Zone CB2.

b. "*Globanomalina*" *pseudobulloides* (Plummer). X250. Well 21/30-1, 6690'SWS, Late Palaeocene, Thanetian, Zones ?PK2, AB2, CB2.

c. "*Globanomalina*" *pseudobulloides* (Plummer). X180. Well 21/30-1, 6690'SWS, Late Palaeocene, Thanetian, Zones ?PK2, AB2, CB2.

Fig.13. "*Globanomalina*" *varianta* (Subbotina). X100. Well 29/10-1, 9010'DC, Early Palaeocene, Danian, Zones PK1b, CB2.

Fig.14. *Globanomalina danica* (Bang). X250. Well 29/10-1, 9060'DC, Early Palaeocene, Danian, Zones PK1b, CB2.

Plate 23.

Fig.1. Eoglobigerina trivialis (Subbotina). X750. Well 29/10-1, 9030'DC, Early Palaeocene, Danian, Zones PK1b, CB2.

Fig.2. Eoglobigerina cf. trivialis (Subbotina). X250. Well 29/10-1, 9090'DC, Early Palaeocene, Danian. Zone PK1a.

Fig.3. Biglobigerinella cf. aspera (Ehreberg). X375. London Clay Formation, British Library site, sample BL001. Early Eocene, Ypresian, Zone PK3.

Fig.4. Acarinina aff. pentacamerata (Subbotina). X250. Well 49/19-1, 1230'DC, earliest Early Eocene, Zones PK6, AB4, CB3.

Fig.5. Neogloboquadrina continuosa Blow. X100. Well 29/10-1, 4990'DC, aerly Middle miocene, Zone AB11b.

Fig.6. Neogloboquadrina mayeri (Cushman). X100. Well 21/11-1, 2370'DC, Early Miocene, Zones PK11, CB13.

Fig.7.a. Globorotalia scitula (Brady) praescitula Blow. X180. Well 29/10-1, 5800'DC, Early-early Middle Miocene, Zone CB12.

b. Globorotalia scitula (Brady) praescitula Blow. X100. Well 29/10-1, 5940'DC, Early Miocene and, or Late Oligocene, zones PK10, CB10-11.

Fig.8. Globoconusa conusa Khalilov. X180. Well 29/10-1, Early Palaeocene, Danian, Zone PK1a, CB2.

Fig.9. Cenosphaera sp. X400. London Clay Formation, Parliament Hill site, sample PH001. Early Eocene, Ypresian, Zone AB4, PK4.

Fig.10a. Cenodiscus lenticularis (Grzybowski). X75. Well 14/29-1, 5810'DC, Late Palaeocene, Thanetian, Zones PK2, CB2.

b. Cenodiscus lenticularis (Grzybowski). X400. Shows reticulate wall. Well 14/29-1, 5810'DC, Late Palaeocene, Thanetian, Zones PK2, CB2.

Fig.11. Coscinodiscus sp.2. X100. London Clay Formation, British Library site, sample BL002. Early Eocene, Ypresian, Zone PK3.

Fig.12. Diatom sp.3 of King 1983. X200. Well 29/10-1, 7360'DC, Early Oligocene, Zone PK9, AB10.


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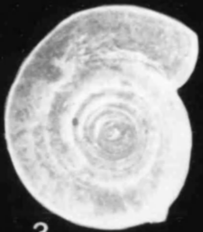
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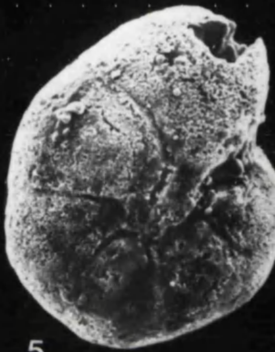
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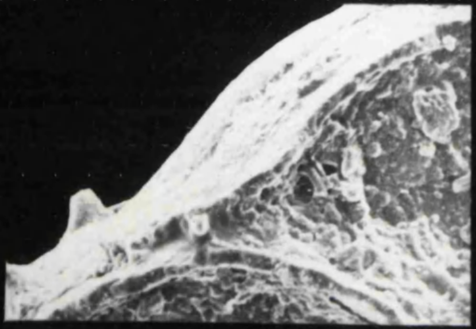
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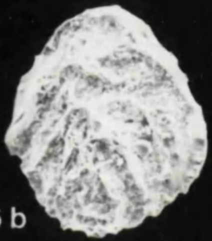
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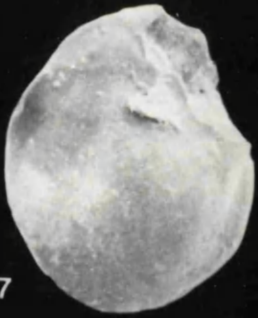
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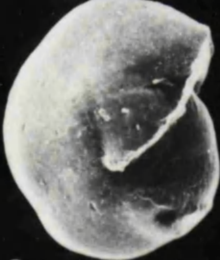
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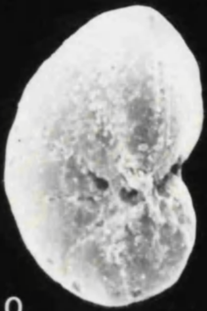
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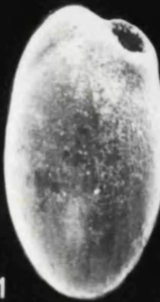
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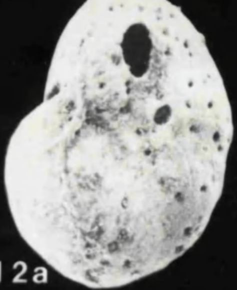
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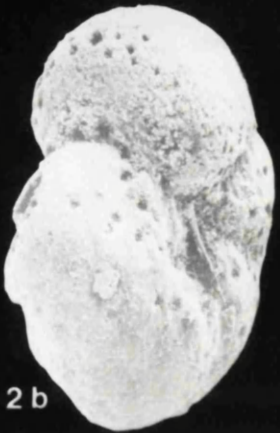
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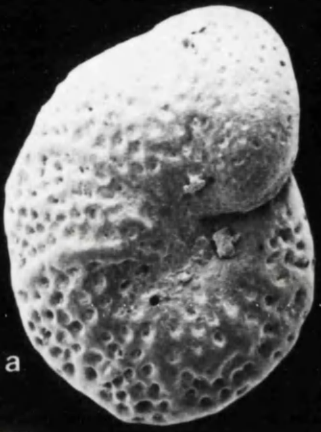
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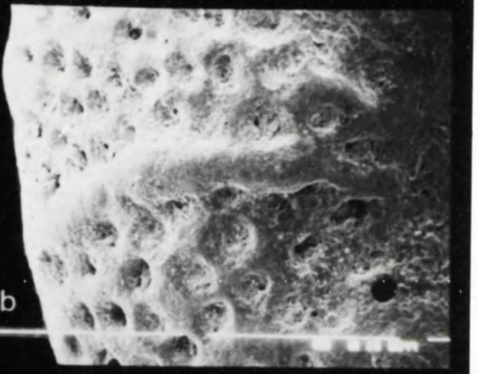
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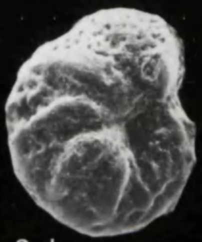
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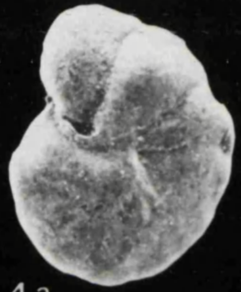
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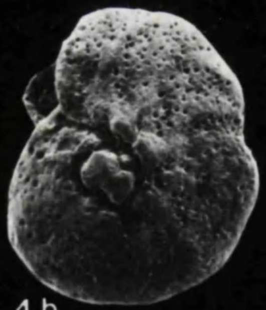
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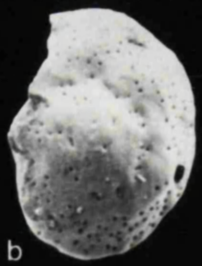
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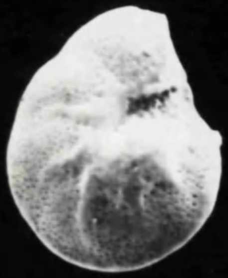
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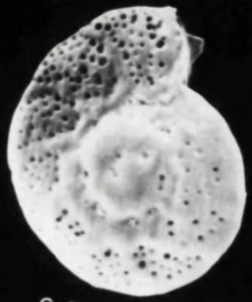
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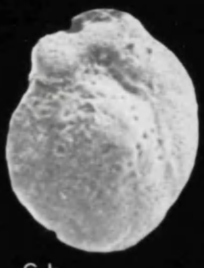
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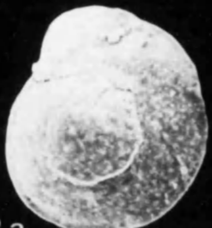
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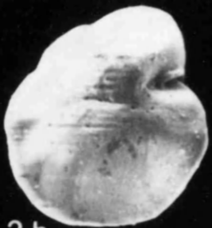
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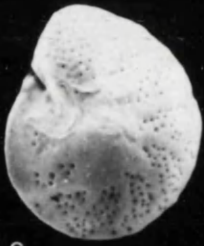
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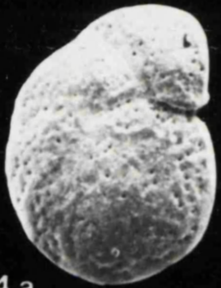
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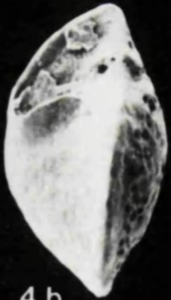
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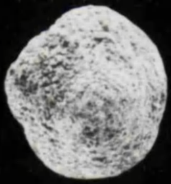
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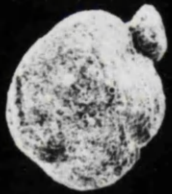
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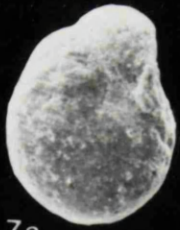
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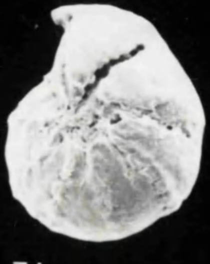
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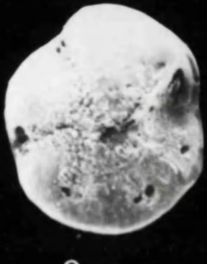
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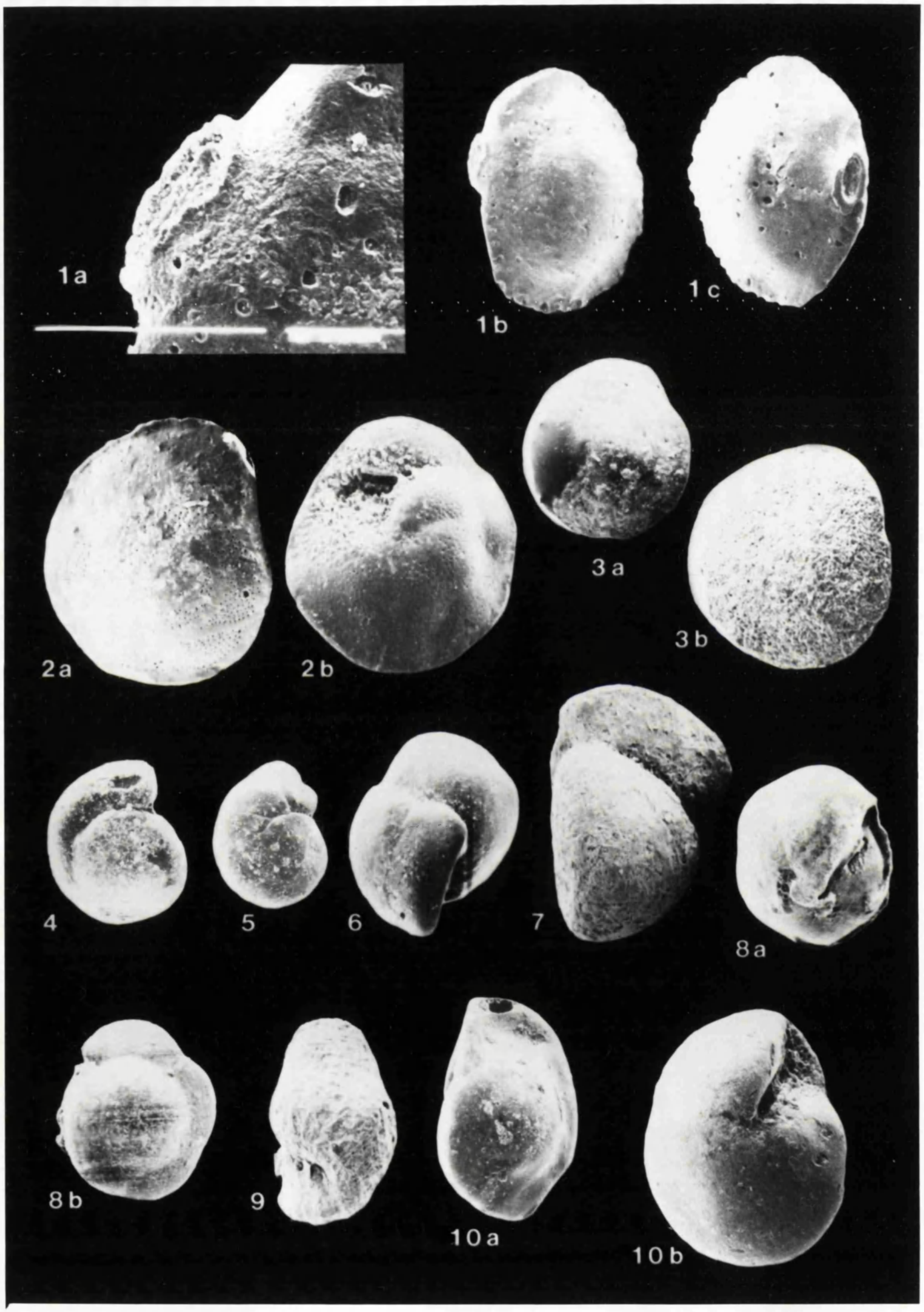
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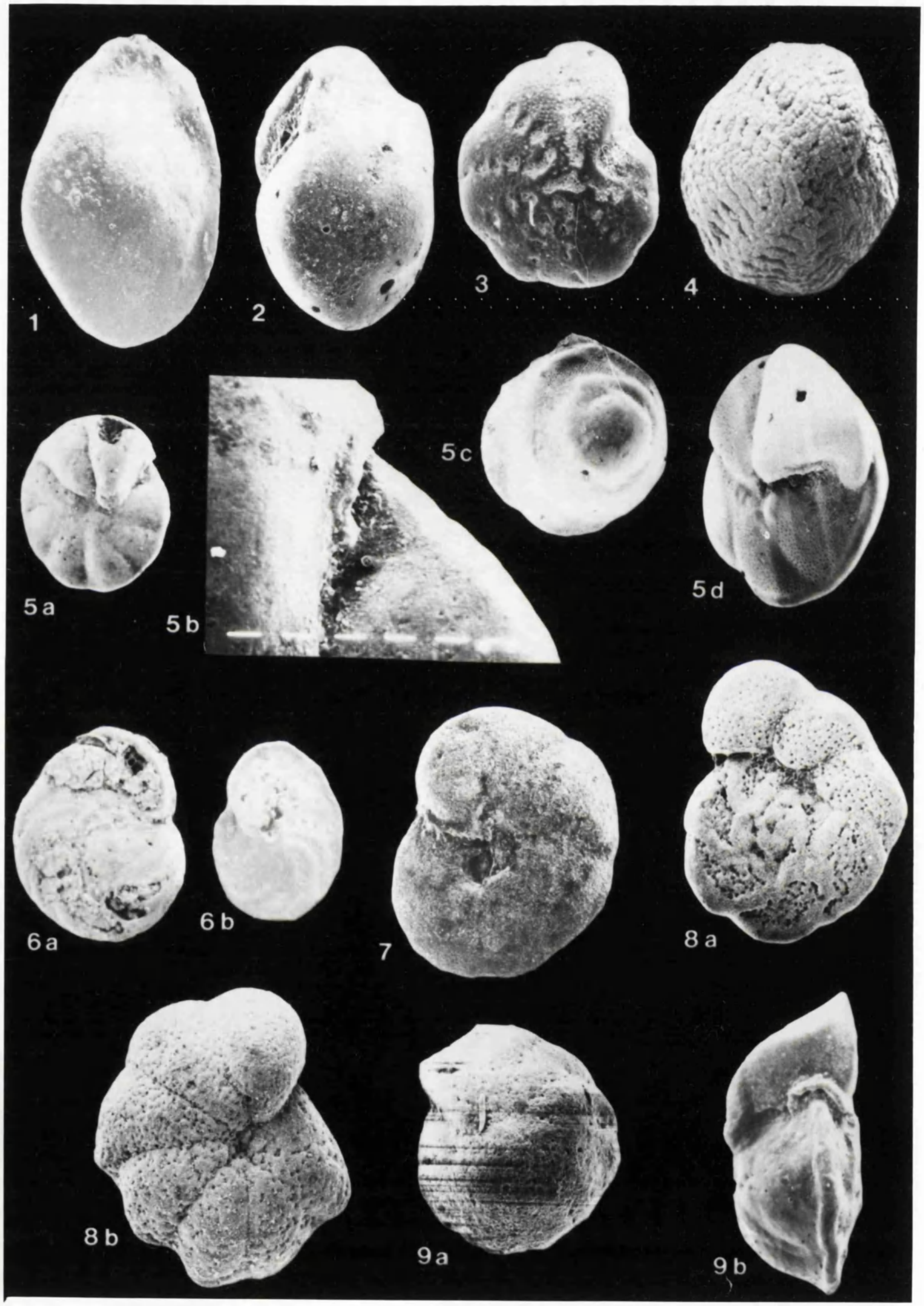
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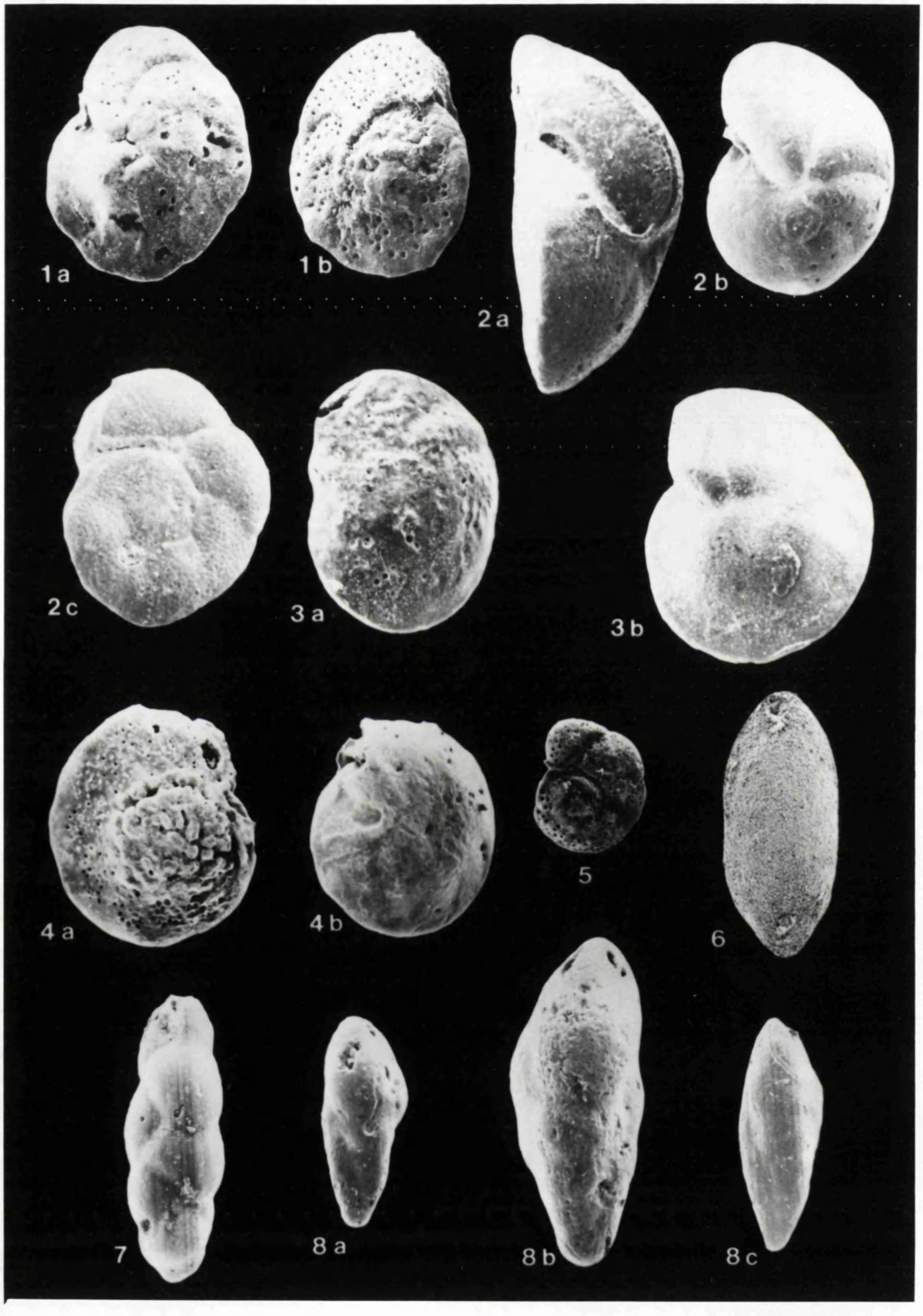
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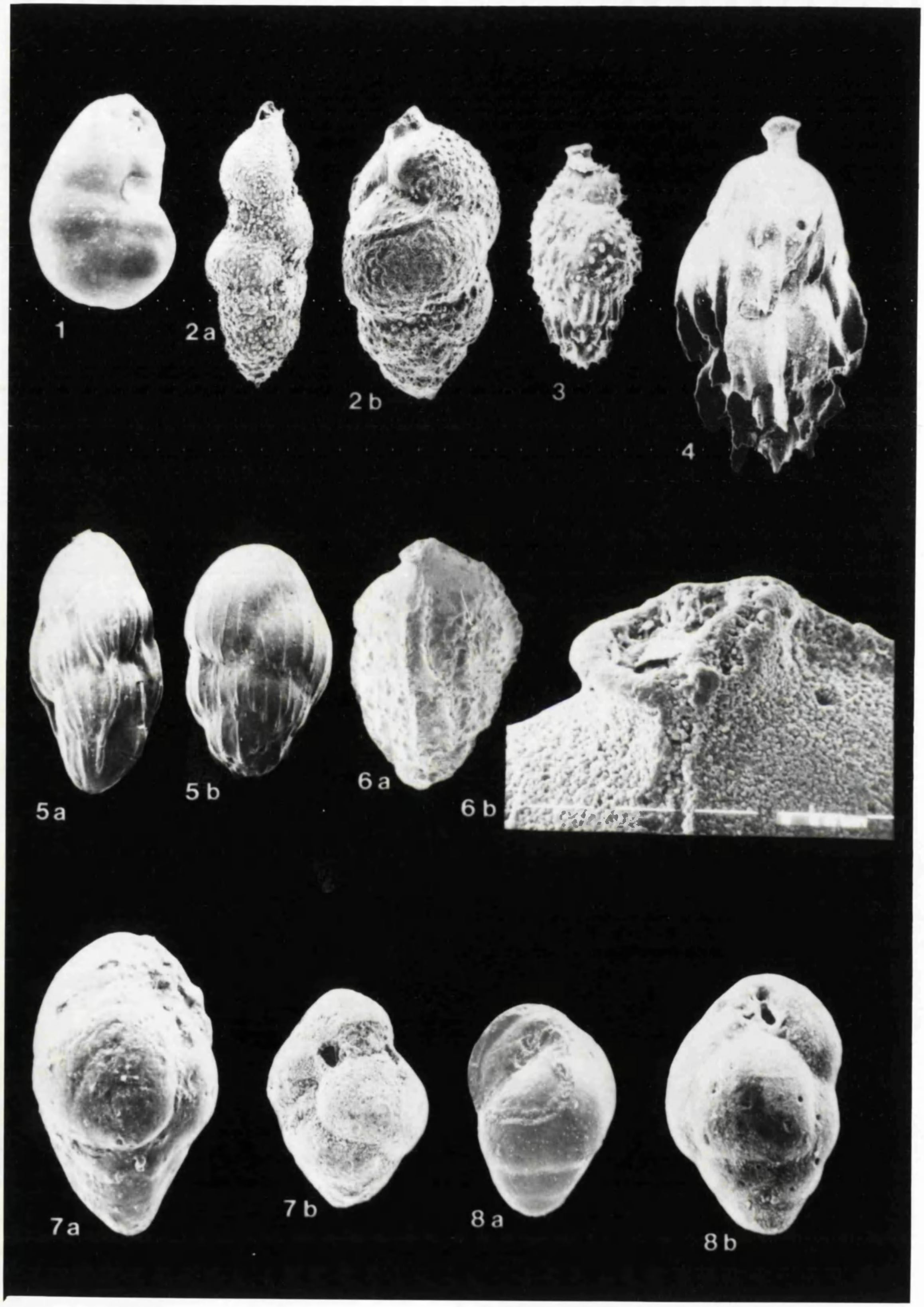
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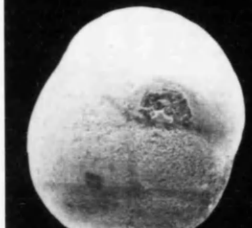
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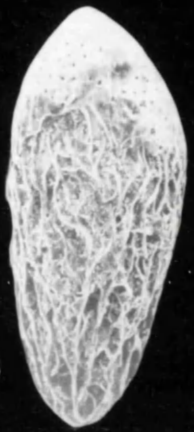
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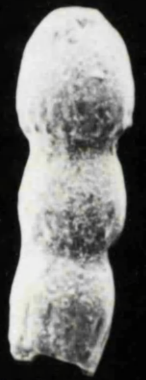
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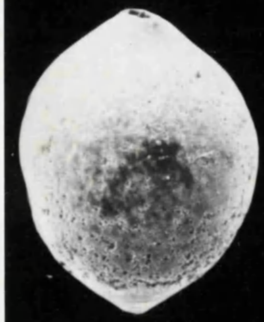
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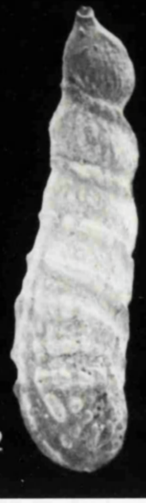
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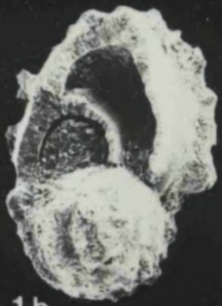

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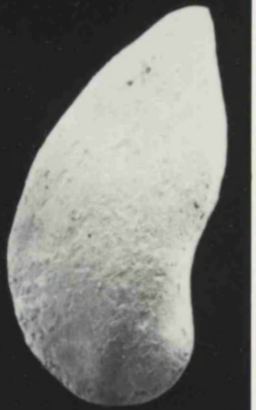

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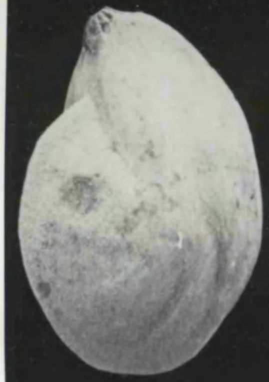

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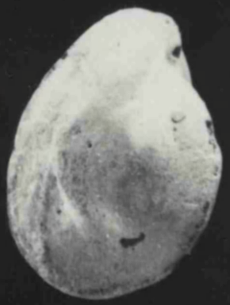

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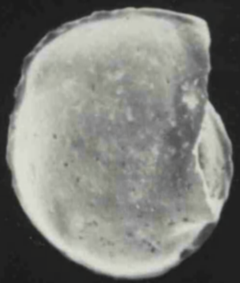

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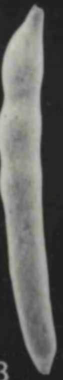

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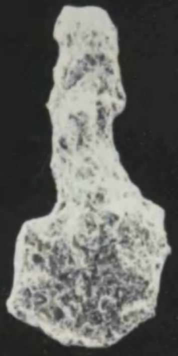

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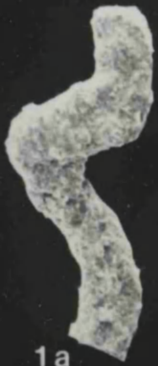
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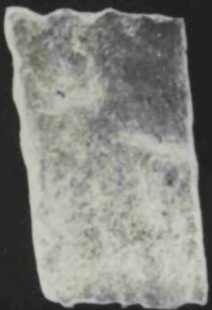
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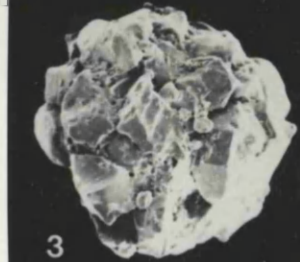
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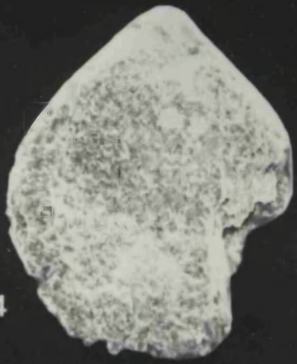
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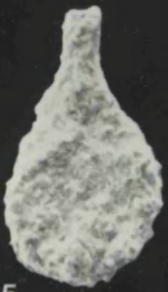
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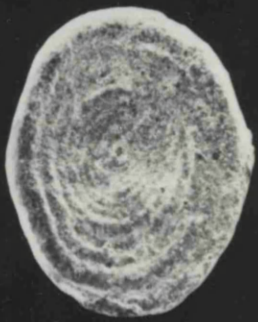
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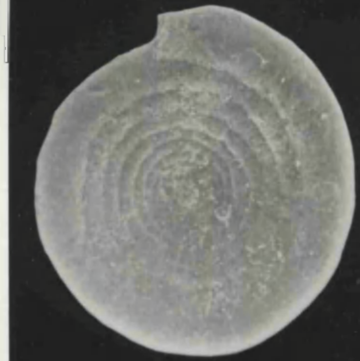
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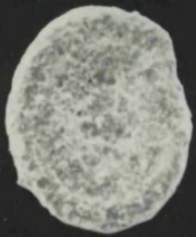
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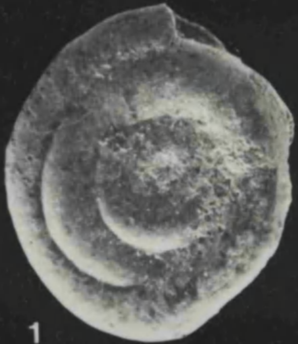
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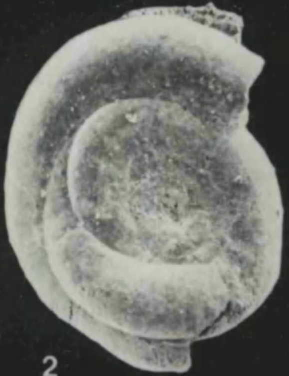
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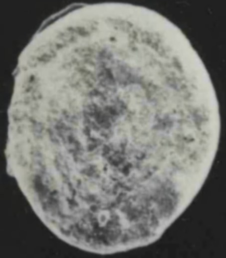
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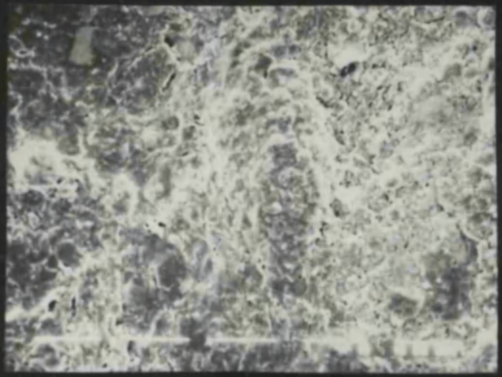
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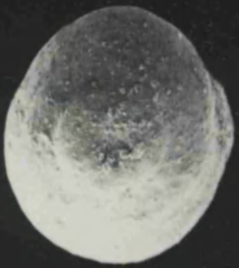
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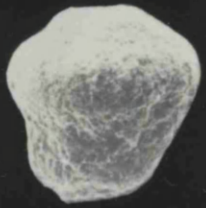
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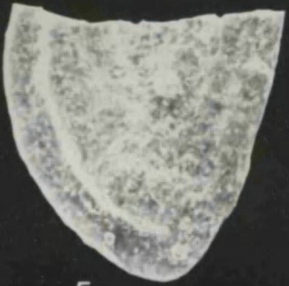
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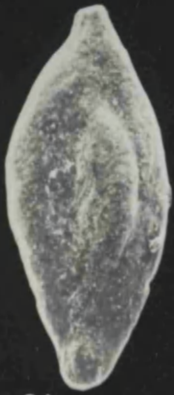
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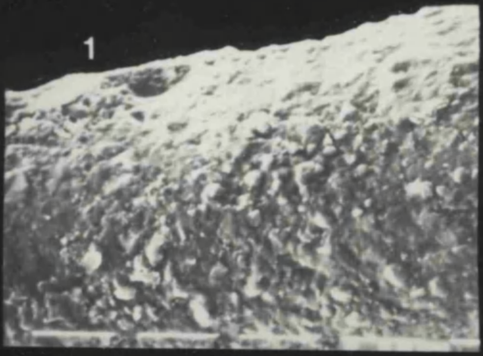

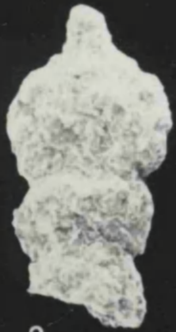

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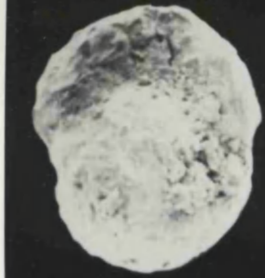

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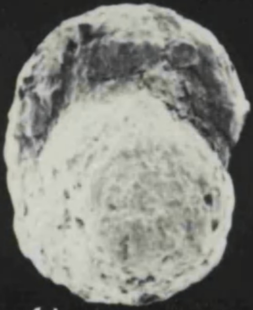

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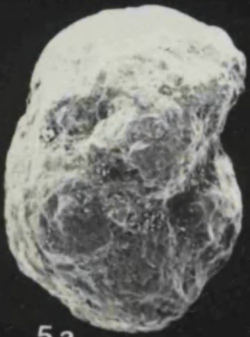

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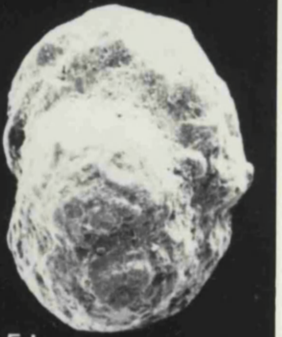

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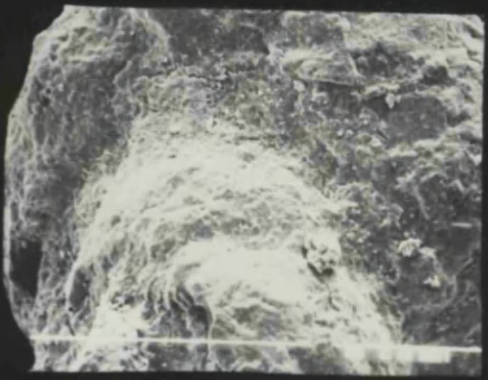

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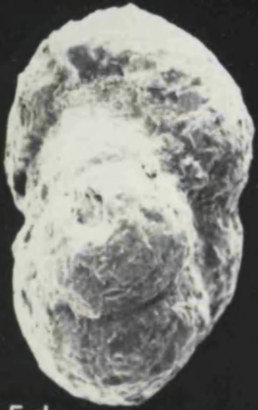

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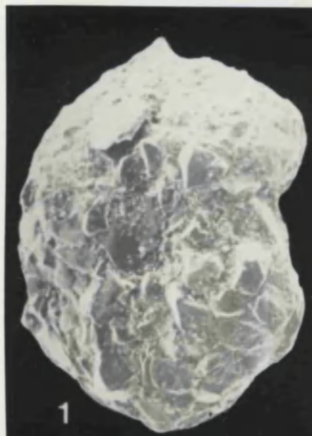
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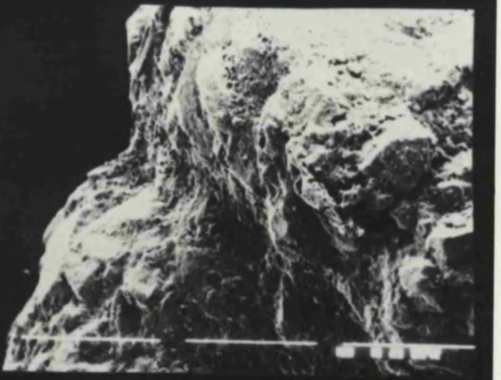
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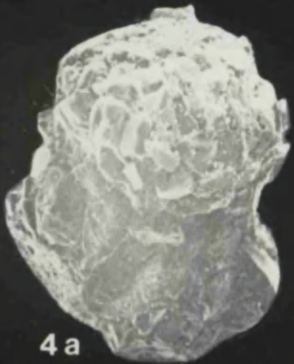
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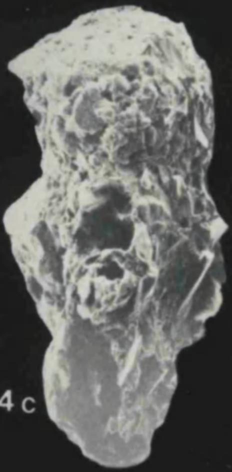
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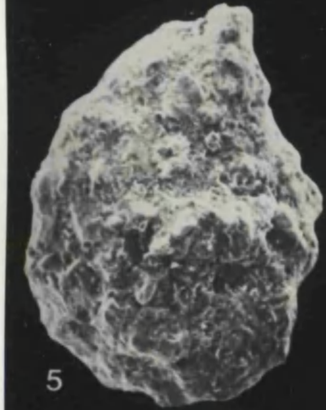
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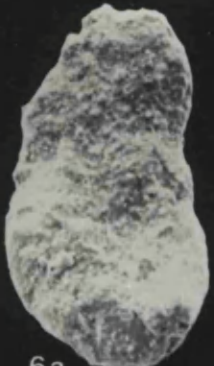
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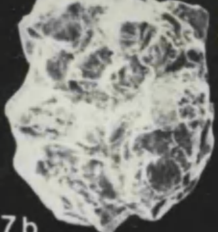
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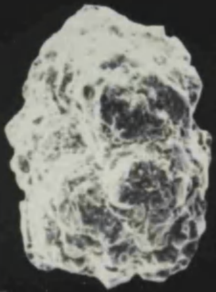
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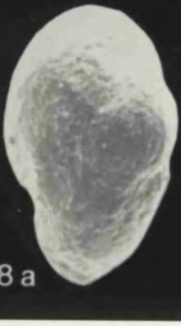
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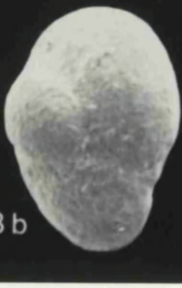
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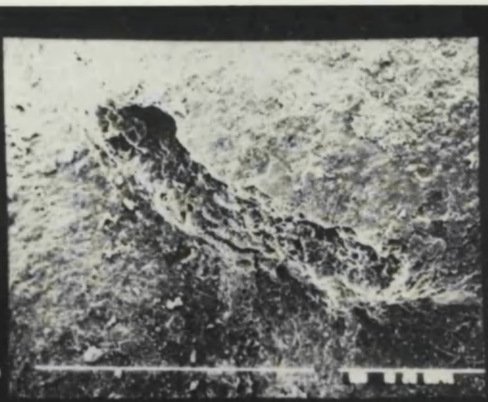
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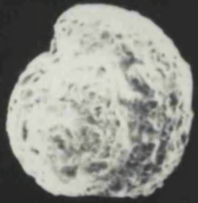
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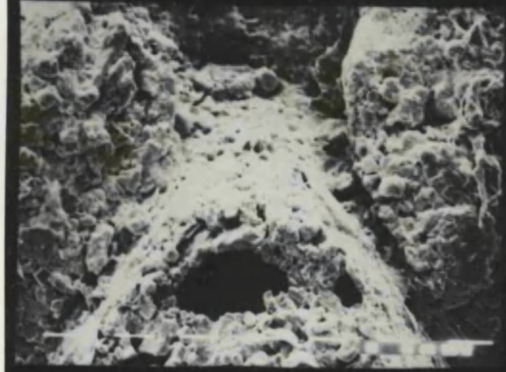
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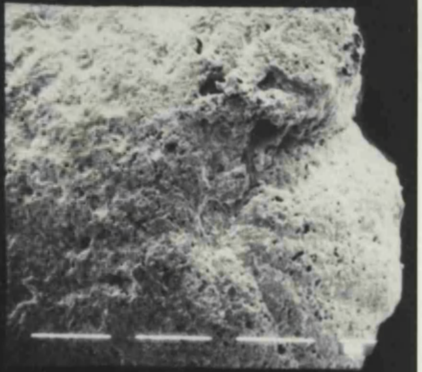
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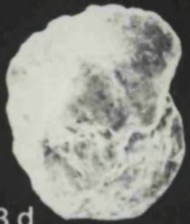
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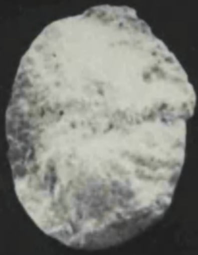
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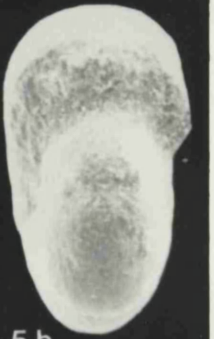
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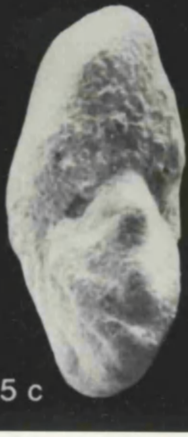
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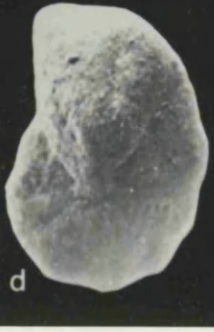
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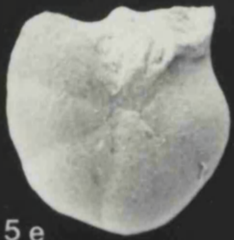
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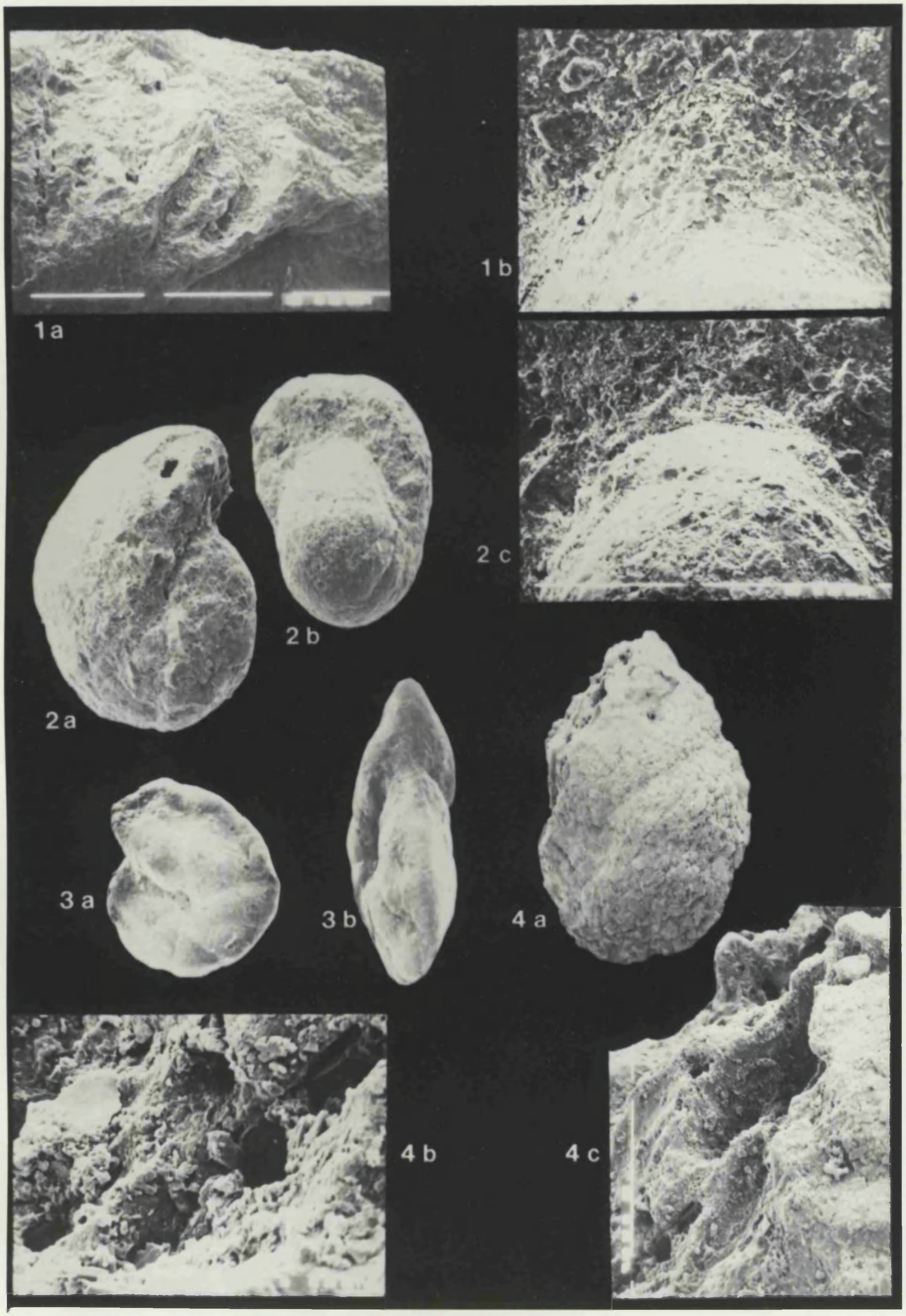
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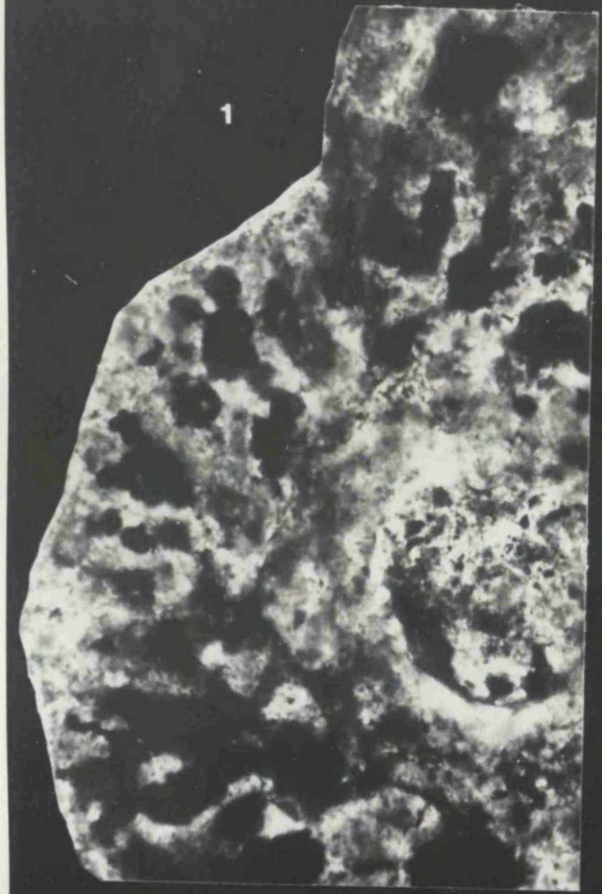

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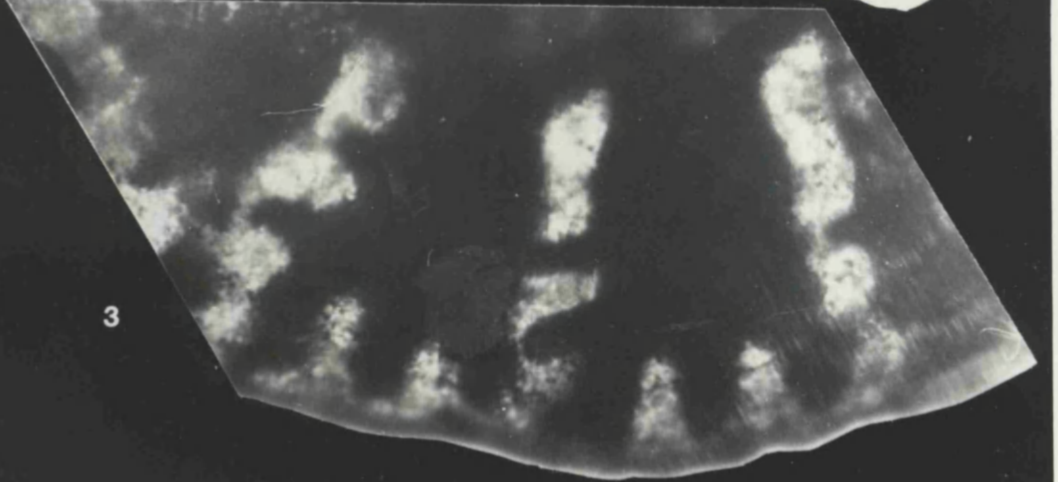

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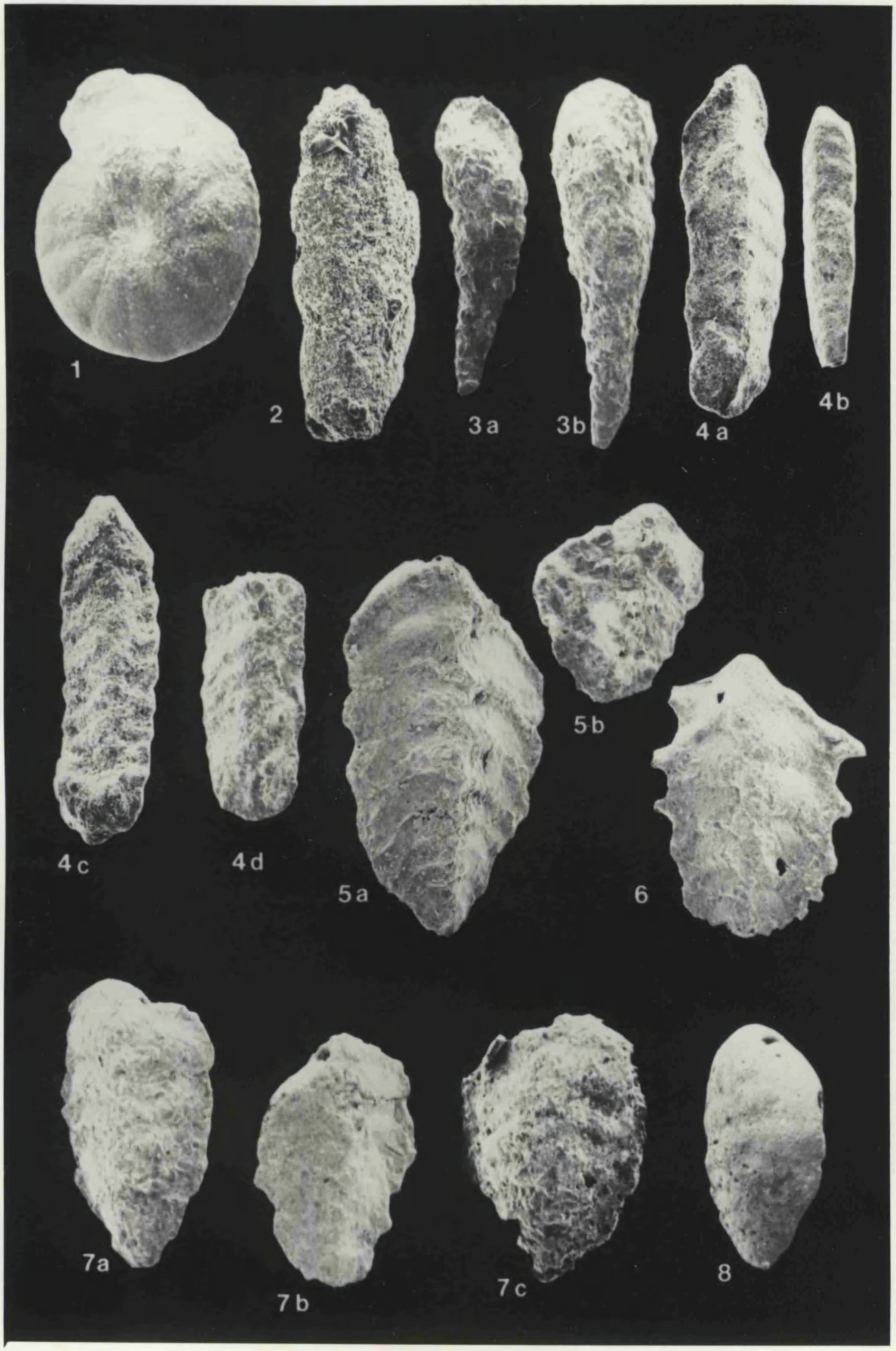
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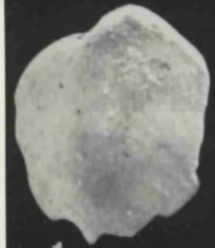
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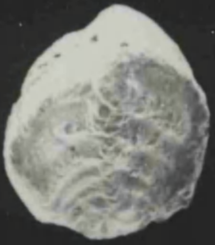
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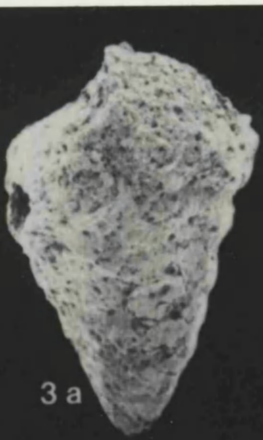
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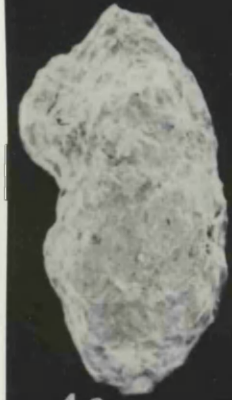
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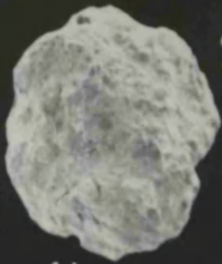
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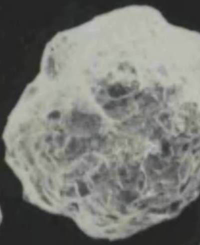
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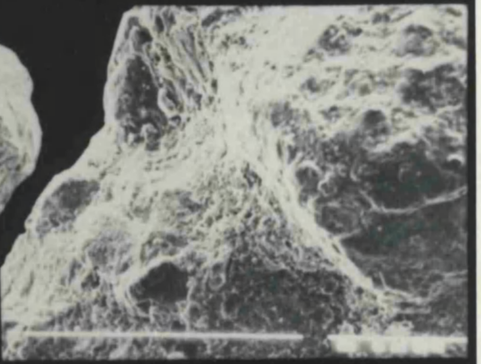
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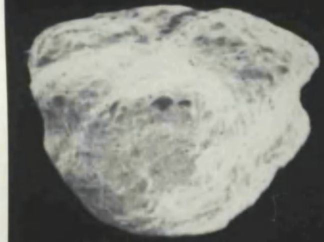
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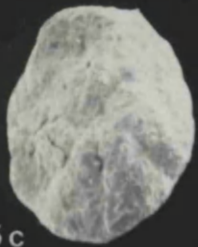
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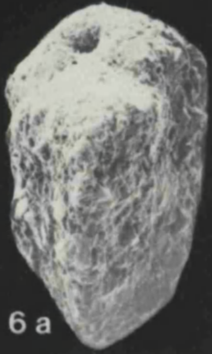
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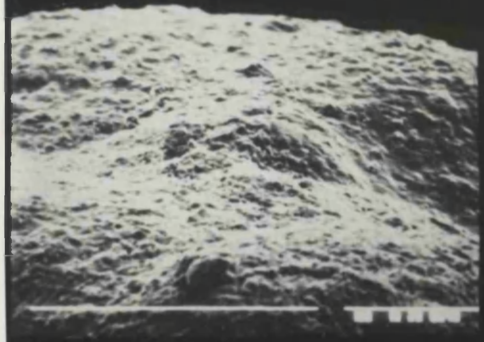
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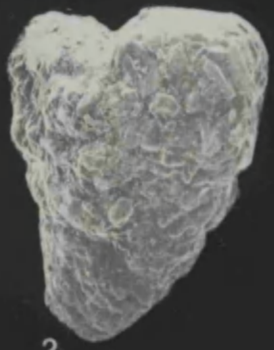
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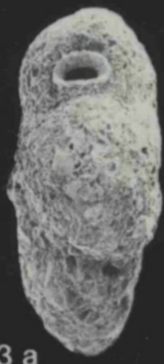
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4 b


5 a


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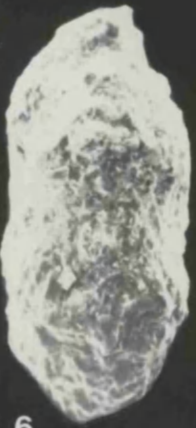
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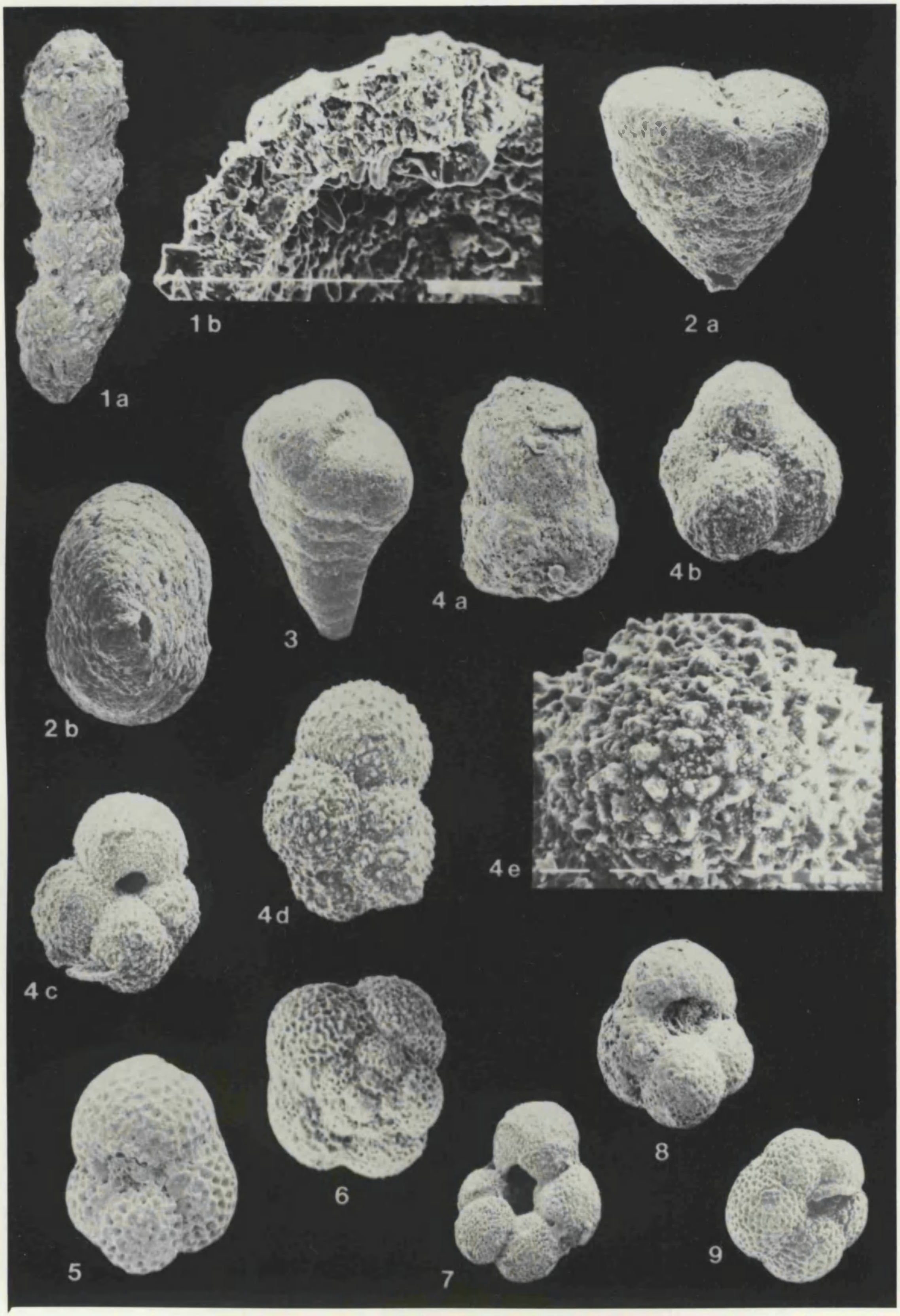
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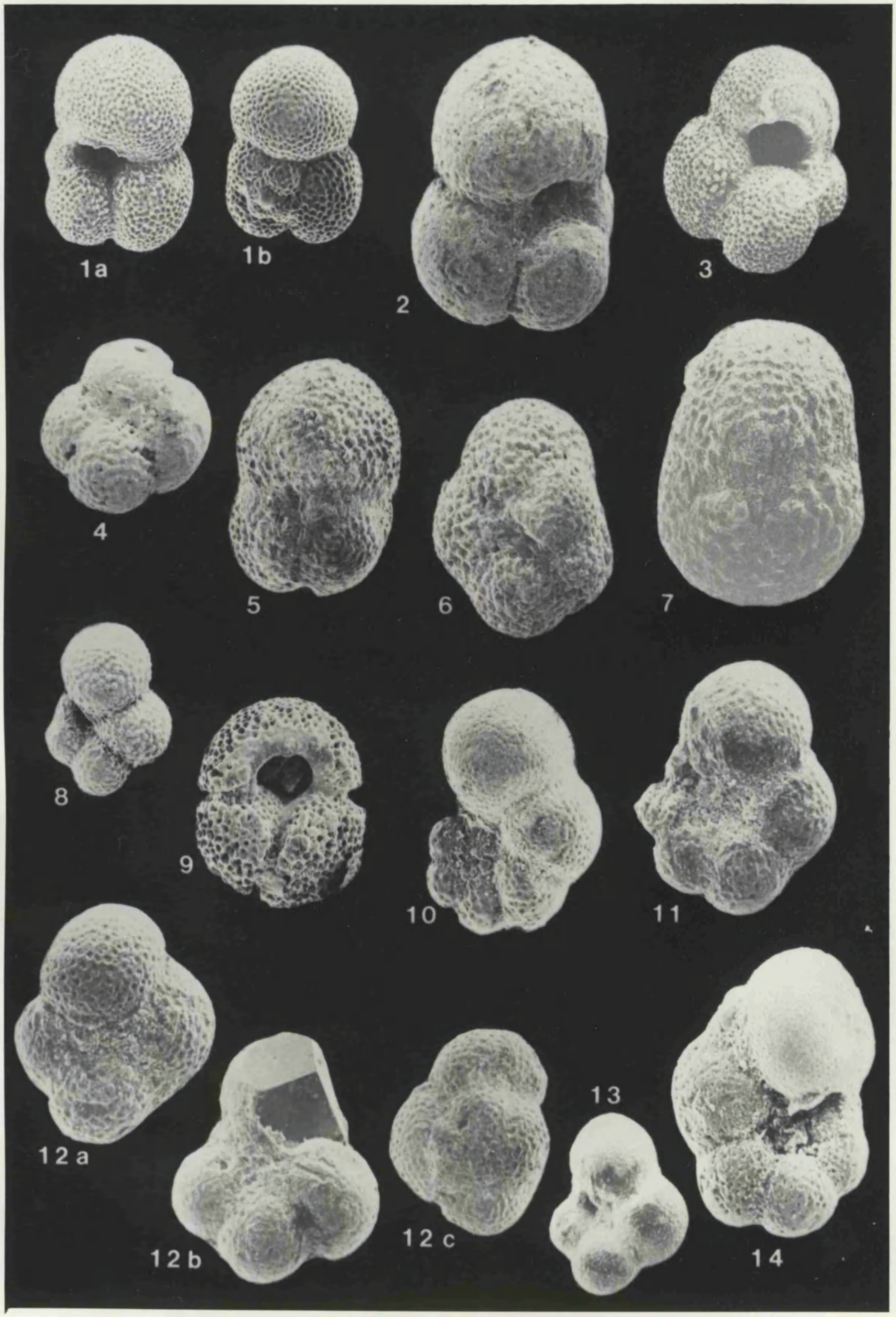
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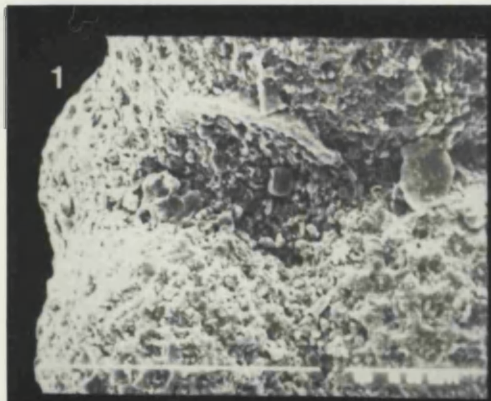

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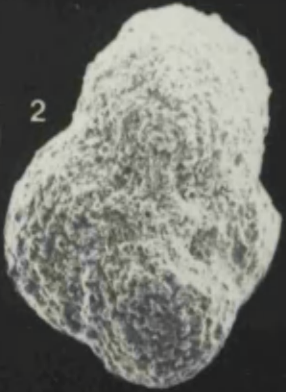

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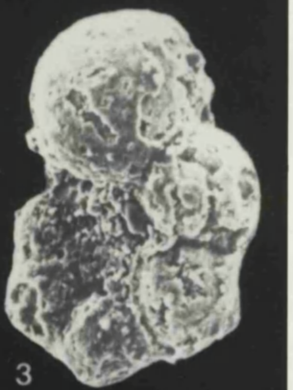

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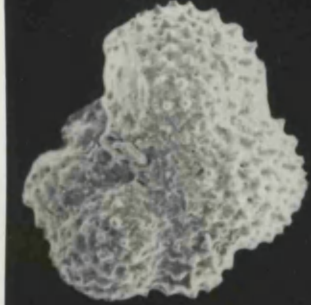

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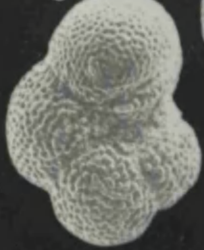

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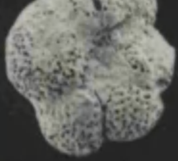

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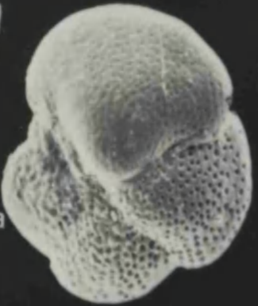

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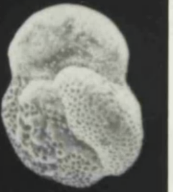

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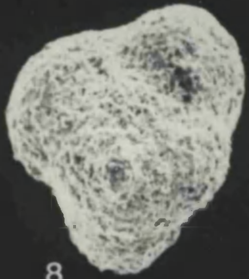

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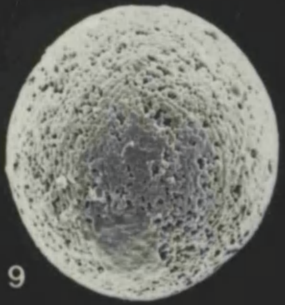
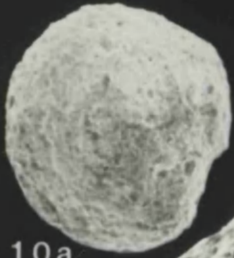
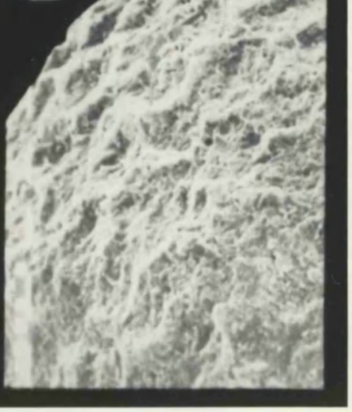


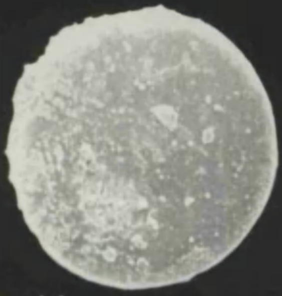
9



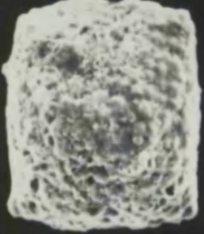
10 a



10 b



11



12

Specimen Sizes, and Depository.

Depository: U.C.L.=University College London.
P*****=The Natural History Museum Catalogue Numbers.

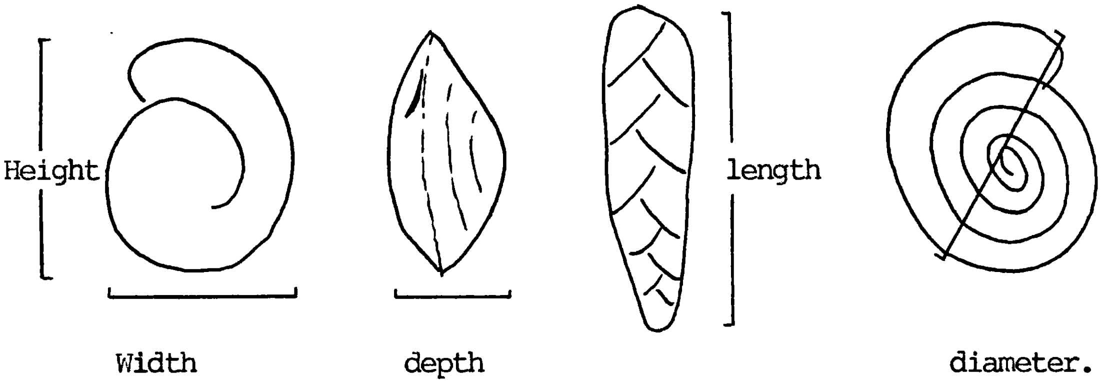


Plate & fig.	Species.	Length. mm	Height. mm	Width. mm	Depth. mm	Depository.
Pl.1.						
fig. 1a.	Quinqueloculina imperialis		0.48	0.44		U.C.L.
1b.	Q. imperialis porterensis		0.47	0.44		P52221.
2.	Q. ludwigi		0.39	0.19		U.C.L.
3.	Cornuspira involvens		0.6	0.5		P52223.
4.	Osangularia plummerae		0.4	0.26		P52222.
5.	Gyroidinoides sp.		0.18	0.13		U.C.L.
6a.	Same specimen as 6b.					
6b.	Aragonia aragonensis		0.31	0.22		"
7.	Cassidulina carapitana		0.56	0.45		"
8.	Pullenia quinqueloba		0.36	0.29		"
9.	Haynesina sp.		0.51	0.40		"
10.	Pseudononion boueanus		0.55	0.33		"
11.	Chilostomelloides oviformis		0.78	0.48		"
12a.	Anomalinoides dorri		0.42	0.30		"
12b.	" "		0.57	0.45		"
Pl.2.						
fig. 1.	Anomalinoides dorri		0.35	0.27		U.C.L.
2a.	A. capitatus		0.57	0.41		"
2b.	Same specimen as 2a.					

2c.	Same specimen as 2d.			
2d.	Anomalinoides capitatus	0.41	0.35	U.C.L.
3.	A. semicribratus	0.16	0.12	"
4a.	A. acuta	0.38	0.3	"
4b.	" "	0.4	0.34	"
5a.	A. acuta anomalinoides	0.31	0.24	"
5b.	" " "	0.34	0.26	"
5c.	" " "	0.35	0.29	"
6a.	Cibicidoides alleni subsp.A	0.39	0.32	"
6b.	" " "	0.44	0.35	"
6c.	" " "	0.51	0.45	"

Pl.3.

fig. 1a.	Cibicidoides alleni subsp.B	0.68	0.54	U.C.L.
1b.	" " "	0.76	0.6	"
2a.	C. eocaenus	0.4	0.37	"
2b.	" "	0.39	0.37	"
3a.	Heterolepa mexicanus	0.56	0.44	"
3b.	" "	0.76	0.68	"
3c.	" "	0.64	0.44	"
4a.	H. dutemplei peelensis	0.38	0.27	"
4b.	" " "	0.4	0.28	"
5.	Melonis affinis	0.29	0.23	"
6a.	Pulsiphonina prima	0.24	0.21	"
6b.	" "	0.24	0.2	"
7a.	Stensioina beccariiformis	0.3	0.22	"
7b.	" "	0.43	0.36	"
8.	Ceratobulimina contraria	0.32	0.23	"
9a.	Buccella frigida	0.3	0.28	"
9b.	" "	0.34	0.28	"

Pl.4.

fig. 1a.	Siphonina reticulata	0.41	0.38	U.C.L.
1b.	" "	0.42	0.39	"
2a.	Asterigerina staeschi	0.46	0.38	"
2b.	" "	0.44	0.38	"

3a.	*A. querichi*	0.6	0.56		U.C.L.
3b.	" "	0.4	0.34		"
4.	*Gyroidina octocamerata*	0.28	0.23		"
5.	*G. angustiumbilicata*	0.25	0.19		"
6.	*G. soldanii mamillata*	0.27		0.34	"
7.	*G. soldanii girardana*	0.57		0.4	"
8a.	*Oridorsalis umbonatus*	0.31	0.26		"
8b.	" "	0.3	0.27		"
9.	*Rotaliatina bulimoides*	0.22		0.34	"
10a.	*Alabamina wilcoxensis*	0.38	0.28		"
10b.	" "	0.43	0.38		"
Pl.5.					
fig. 1.	*Alabamina wilcoxensis*	0.52	0.41		U.C.L.
2.	*A. obtusa*	0.46	0.37		"
3.	*Elphidium excavatum*	0.41	0.33		"
4.	*E. inflatum*	0.56	0.43		"
5a.	*Eponides karsteni*	0.29	0.25		"
5b.	Same specimen as 5a.				
5c.	*E. karsteni*	0.33	0.32		"
5d.	" "	0.59		0.31	"
6a.	*Planulina costata*	0.72	0.58		"
6b.	" "	0.6	0.44		"
7.	*Cibicidina cunobelini*	0.46	0.37		"
8a.	*Cibicides lobatulus* s.l.	0.64	0.49		P52226.
8b.	" " "	0.67	0.57		P52225.
9a.	*C. westi*	0.51	0.45		U.C.L.
9b.	" "	0.5		0.23	"
Pl.6.					
fig. 1a.	*Cibicides anglica*	0.43	0.34		P52224.
1b.	" "	0.41	0.32		U.C.L.
2a.	*C. tenellus*	0.8		0.37	"
2b.	" "	0.56	0.41		"
2c.	" "	0.57	0.45		"
3a.	*C. pseudoungerianus*	0.59	0.51		"

3b.	" "		0.61	0.51	U.C.L.
4a.	C. ungerianus		0.55	0.45	"
4b.	" "		0.49	0.41	"
5.	C. pygmaeus		0.29	0.24	"
6.	Praeglobobulimina ovata	0.45		0.19	P52230.
7.	Bulimina elongata		0.48	0.17	U.C.L.
8a.	B. trigonalis		0.35	0.14	"
8b.	" "	0.3		0.12	"
8c.	" "	0.52		0.18	"

Pl.7.

fig. 1.	Cassidulinoides bradyi		0.18	0.12	U.C.L.
2a.	Uvigerina batjesi	0.43		0.13	P52229.
2b.	" "	0.28		0.12	U.C.L.
3.	U. pygmaea langeri	0.38		0.18	"
4.	Uvigerina sp.1	0.6		0.32	"
5a.	U. macrocarinata	1.1		0.58	"
5b.	" "	0.52		0.32	"
6a.	Trifarina bradyi	0.23		0.16	"
6b.	Same specimen as 6a.				
7a.	Turrilina brevispira	0.28		0.18	"
7b.	" "	0.21		0.13	"
8a.	T. alsatica	0.2		0.12	"
8b.	" "	0.18		0.12	"

Pl.8.

fig. 1.	Sphaeroidina bulloides		0.32	0.28	U.C.L.
2.	Brizalina anglica	0.36		0.11	P52228.
3.	B. cookei	0.31		0.14	U.C.L.
4.	Stilostomella paleocenica	0.88		0.14	P52193.
5a.	Same specimen as 5b.				
5b.	S. adolphina	0.59		0.8	U.C.L.
5c,d.	Same specimen as 5b.				
6.	S. spinescens	0.67		0.19	"
7.	Pseudonodosaria sp.1	0.63		0.31	P52203.
8.	Pseudonodosaria sp.2	0.41		0.33	U.C.L.

9.	*Pseudonodosaria* sp.3	1.3		0.31	U.C.L.
10.	*Saracenaria* sp.	0.68		0.46	P52200.
11.	*Marginulina* cf. *attenuata*	0.6		0.16	P52201.
12.	*Percultazonaria wetherellii*	2.5		0.6	P52199.

Pl.9.

fig. 1a.	*Percultazonaria wetherellii*	0.59		0.32	P52204.
1b.	" "	0.52		0.37	U.C.L.
2.	*P. wetherellii* var.	0.4		0.23	"
3.	*Vaginulinopsis* aff. *jonesi*	1.16		0.3	"
4.	*V. praelonga*	1.54		0.74	"
5.	*Lenticulina* cf. *pseudovortex*		0.94	0.76	P52206.
6.	*L. subangulata*		0.92	0.72	P52207.
7.	*Lenticulina* sp.1		0.82	0.62	P52205.
8.	*L. cultrata*		0.76	0.58	U.C.L.
9a.	*L. multiformis*		1.26	0.91	"
9b-c.	Same specimen as 9a.				
10.	*L. calcar*		1.0	0.9	"

Pl.10.

fig. 1.	*Dentalina multilineata*	0.94		0.18	"
2.	*D. elegantissima* var.B	2.52		0.32	P52195.
3.	*D. inornata*	0.57		0.08	P52190.
4a.	*Nodosaria latejugata*	1.74		0.77	U.C.L.
4b.	" "	2.24		0.72	P52197.
5.	*N.* aff. *raphanus*	1.16		0.3	P52194.
6.	*Nodosaria* sp.2	0.98		0.2	P52189.
7.	*Nodosaria* sp.3	1.52		0.24	P52191.
8.	*N. consobrina*	1.31		0.17	U.C.L.
9a.	*Plectofrondicularia seminuda* (broken specimen).	0.38		0.17	"
9b.	*P. seminuda* " "	0.4		0.13	"
10a.	*Rhabdammina discreta*	1.05		0.47	"
10b.	Same specimen as 10a.				
11a.	*Rhizammina indivisa*	0.45		0.2	"
11b.	" "	0.18		0.04	"

Pl.11.

fig. 1a.	*Rhizammina indivisa*	0.46		0.08		U.C.L.
1b.	" "	0.61		0.09		"
2a.	*Dendrophyra* cf. *latissima*			0.19	0.09	"
2b.	" " "	0.4		0.24		"
2c.	" " "	0.24		0.09		"
3.	*Psammosphaera fusca*	0.33		0.34		"
4.	*Placentammina placenta*	0.46		0.39		"
5.	*P. complanata*	0.37		0.22		"
6a.	*Ammodiscus cretaceus*		Diameter 0.8			"
6b.	" "		" 0.57			P52209.
7.	*A. planus*		" 0.13			U.C.L.
8a.	*Ammolagena clavata*	0.28		0.16		"
8b.	" "	0.34		0.18		"

Pl.12.

fig. 1.	*Glomospira gordialis*		0.46	0.39		U.C.L.
2.	*G. irregularis*		0.48	0.38		"
3a.	*Glomospirella* cf. *diffundens*		Diameter 0.29			"
3b.	Same specimen as 3a.					
4a.	*Repmanina charoides*				0.34	"
4b.	" "			0.26	0.27	"
5.	*Rzehakina epigona* (broken)	0.19		0.21		"
6a.	*Spirosigmoilinella compressa*	0.61		0.25		"
6b.	" "	0.51		0.23		"
7a.	*Kalamopsis grzybowski*	0.33		0.06		"
7b.	" "	0.75		0.09		"

Pl.13.

fig. 1.	*Kalamopsis grzybowski*	0.8		0.1		U.C.L.
2.	*Hormosina pilulifera*	0.44		0.23		"
3.	*H. ovulum*	0.51		0.41		"
4a.	*Cribrostomoides subglobosus*		0.48	0.36		"
4b.	" "		0.8	0.6		"
5a.	*Haplophragmoides kirki*		0.23		0.18	"
5b.	" "		0.24		0.17	"

5c.	Same specimen as 5b.				
5d.	*H. kirki*	0.29		0.17	U.C.L.
6.	*Haplophragmoides walteri*	0.34	0.28		"

Pl.14.

fig. 1.	*Haplophragmoides* sp.	0.68	0.49		P52213.
2a.	*Labrospira scitula*	0.7	0.58		U.C.L.
2b.	Same specimen as 2a.				
3.	*Lituotuba lituiformis*	0.65	0.52		"
4a.	*Ammobaculites* cf. *jarvisi*	0.46	0.38		P52211.
4b.	" " "	1.46		0.4	U.C.L.
4c.	" " "	0.8		0.37	"
5.	*Ammomarginulina macrospira*	0.28	0.21		"
6a.	*Eratidus foliaceus*	0.26	0.16		"
6b.	" "	0.21	0.15		"
7a.	*Adercotryma agterbergi*	0.39		0.29	"
7b.	" "	0.35	0.28		"
7c.	" "	0.38	0.27		"
8a.	*Cystammina pauciloculata*	0.37	0.23		"
8b.	" "	0.32	0.24		"

Pl.15.

fig. 1a.	*Praecystammina globigerinaeformis*	0.45	0.37		U.C.L.
1b.	Same specimen as 1a.				
2.	*Thalmannammina walteri*	0.5	0.52		"
3a.	Same specimen as 3b.				
3b.	*Reticulophragmium amplectens*	0.77		0.31	"
3c.	Same specimen as 3b.				
3d.	*R. amplectens*	0.37	0.33		"
4.	*Reticulophragmium* sp.1	0.64	0.5		"
5a.	*R. placenta*	0.7	0.54		"
5b.	" "	0.43		0.25	"
5c.	" "	1.04		0.4	"
5d.	" "	0.76	0.54		"
5e.	" "	0.86	0.85		"

Pl.16.

fig.	1a.	Same specimen as Pl.15, fig.5a.					
	1b.	*Reticulophragmium placenta*		1.02		0.41	U.C.L.
	2a.	*R. rotundidorsata*		0.51	0.37		"
	2b.	" "		0.56		0.4	"
	2c.	" "		0.53		0.39	"
	3a.	*R. paupera*		0.64	0.6		"
	3b.	" "		1.02		0.3	"
	4a.	*Sabellovoluta humboldti*		1.57	1.0		"
	4b-c.	Same specimen as 4a.					

Pl.17.

fig.	1.	*Reticulophragmium placenta*		0.4	0.3		U.C.L.
	2.	*R. amplectens*		0.26	0.21		"
	3.	*Cyclammina* cf. *garcillasoi*		0.94	0.73		"

Pl.18.

fig.	1.	*Cyclammina* cf. *garcillasoi*		0.96	0.76		U.C.L.
	2.	*Bolivinopsis rosula*	0.32		0.12		"
	3a.	*Spiroplectammina navarroana*	0.65		0.16		"
	3b.	" "	0.8		0.16		"
	4a.	*S. spectabilis*	0.79		0.24		"
	4b.	" "	0.82		0.2		"
	4c.	" "	0.56		0.16		"
	4d.	" "	0.4		0.18		"
	5a.	*Spiroplectinella adamsi*	1.08		0.47		P52219.
	5b.	" "	0.44		0.39		U.C.L.
	6.	*S. carinata*	0.92		0.6		U.C.L.
	7a.	*S. deperdita*	0.63		0.35		"
	7b.	" "	0.55		0.36		"
	7c.	" "	0.9		0.66		"
	8.	*S. wilcoxensis*	0.8		0.46		"

Pl.19.

fig.	1.	*Spiroplectinella wilcoxensis* (broken)	0.6		0.5		U.C.L.

2.	*S. excolata*	0.6		0.56		U.C.L.
3a.	*Siphotextularia* sp.1	0.68		0.45		"
3b.	" "	0.71			0.47	"
4a.	*Trochammina subvesicularis*		0.34		0.17	"
4b.	" "		0.33	0.28		"
4c.	" "		0.31	0.32		"
4d.	" "		0.32	0.29		"
5a.	*T. ruthvenmurrayi*		0.53		0.4	"
5b.	" " "		0.6	0.52		"
5c.	" " "		0.62	0.52		"
6a.	*Gaudryina hiltermanni*	0.88		0.54		P52238.
6b.	Same specimen as 6a				0.7	"
6c.	*G. hiltermanni*	1.34		0.46		U.C.L.
7.	*Dorothia principiensis*	0.68		0.2		"
8.	*D. eocenica*	0.63		0.16		"
9.	*Marssonella oxycona*	0.56		0.36		"

PL.20.

fig. 1.	Same specimen as Pl.19, fig.9.					
2.	*Marssonella* sp.	0.86		0.7		P52218.
3a.	*Karreriella (Karreriella) siphonella*	0.92			0.4	P52216.
3b.	" " "	0.94		0.38		P52217.
4a.	*Karreriella (?Meidamonella) mexicana*	0.55		0.34		U.C.L.
4b.	Same specimen as 4a.					
5a.	*Karreriella (?Karrerulina) danica*	0.77			0.27	P52212.
5b.	" " " "	0.79		0.32		U.C.L.
6.	*Karreriella (Karrerulina) horrida*	0.31		0.13		"
7a.	*Karreriella (Karrerulina) conversa*	0.49		0.14		"
7b.	" " " "					
8.	*Karreriella (karrerulina) ?lenis*	0.27		0.12		"

9.	*Martinotiella communis*	0.79		0.19		U.C.L.
10.	*Clavulinoides anglicus*	1.16		0.3		"

Pl.21.

fig. 1a.	*Clavulinoides anglicus*	1.24		0.36		P52214.
1b.	" "	1.11		0.34		U.C.L.
2a.	*Textularia* sp.	0.35		0.39		"
2b.	Same specimen as 2a				0.28	"
3.	*T. chapmani*	0.44		0.3		"
4a.	*Globastica daubjergensis*		0.21	0.16		"
4b.	" "		0.18	0.17		"
4c.	" "		0.19	0.15		"
4d.	" "		0.16	0.12		"
4e.	" "		0.17	0.13		"
5.	*Globigerina ampliapertura*		0.2	0.15		"
6.	*G. ciperoensis*		0.19	0.17		"
7.	" "		0.3	0.24		"
8.	*G. eocaena*		0.32	0.27		"
9.	*G.* cf. *falconensis*		0.26	0.24		"

PL.22.

fig. 1a.	*Globigerina (Subbotina) triloculinoides*	0.31	0.26	P52231.
1b.	" " "	0.32	0.23	P52234.
2.	*G. praebulloides occlusa*	0.26	0.19	U.C.L.
3.	*G. praebulloides praebulloides*	0.38	0.32	"
4.	*Catapsydrax unicavus unicavus*	0.29	0.29	"
5.	*Globigerinoides quadrilobatus trilobus*	0.39	0.28	"
6.	*Globorotaloides suteri*	0.22	0.18	"
7.	*Sphaeroidinellopsis subdehiscens*	0.48	0.36	"
8.	*Tenuitella munda*	0.16	0.12	"
9.	*Globigerapsis index index*	0.35	0.29	"
10.	*Pseudohastigerina wilcoxensis*	0.23	0.17	"
11.	*"Globanomalina" compressa*	0.17	0.12	"
12a.	*"Globanomalina" pseudobulloides*	0.16	0.14	"

12b.	" "	0.17	0.12	U.C.L.
12c.	" "	0.19	0.16	"
13.	*"Globanomalina" varianta*	0.3	0.24	"
14.	*G. danica*	0.19	0.13	"

Pl.23.

fig. 1.	*Eoglobigerina trivialis*	0.14	0.12	U.C.L.
2.	*E.* cf. *trivialis*	0.2	0.16	"
3.	*Biglobigerinella* cf. *aspera*	0.13	0.1	"
4.	*Accarinina* aff. *pentacamerata*	0.16	0.15	"
5.	*Neogloboquadrina continuosa*	0.34	0.29	"
6.	*N. mayeri*	0.28	0.23	"
7a.	*Globorotalia scitula praescitula*	0.22	0.19	"
7b.	" " "	0.23	0.19	"
8.	*Globoconusa conusa*	0.21	0.17	"
9.	*Cenosphaera* sp.	Diameter	0.1	P52237.
10a.	*Cenodiscus lenticularis*	"	0.43	U.C.L.
10b.	" "	"	0.42	"
11.	*Coscinodiscus* sp.2	"	0.37	P52236.
12.	Diatom sp.3		0.14	U.C.L.

Specimen Counts.

01=core sample; 02=side-wall; 03=ditch-cutting; 04=land section.

Sample type	Depth/ sample no.	Total specimen count.	Sample type	Depth/ sample no.	Total specimen count.
LAND SECTIONS-Parliament Hill Site.			29/10-1 Continued.		
04	PH1	242	03	5530'	30
04	PH2	179	03	5800'	25
04	PH3	254	03	5810'	63
04	PH4	280	03	5950'	52
			03	6000'	61
British Library Site.			03	6010'	23
04	BL1	5	03	6100'	74
04	BL2	4	03	6210'	56
04	BL3	0	03	6310'	20
04	BL4	2	03	6360'	61
04	BL5	1	03	6460'	75
			03	6510'	55
NORTH SEA WELLS-Northern, 25/10-1.			03	6560'	0
01	5501'	76	03	6610'	109
01	5510'	156	03	6660'	106
01	5648'	13	03	6710'	108
01	5886'	238	03	6760'	156
			03	6810'	35
Central N. Sea, 29/7-1.			03	6850'	27
02	7000'	0	03	6940'	74
02	7100'	4	03	6950'	90
02	7200'	20	03	7010'	107
02	7300'	18	03	7030'	25
02	7400'	12	03	7080'	115
02	7500'	22	03	7130'	44
02	7607'	1	03	7210'	79
02	7751'	11	03	7360'	79
02	7801'	6	03	7460'	70
02	7901'	0	03	7610'	130
02	8001'	1	03	7660'	113
02	8150'	13	03	7740'	114
02	8251'	9	03	7750'	158
02	8318'	9	03	7780'	59
02	8400'	22	03	7910'	19
02	8450	19	03	8010'	43
02	8490'	19	03	8060'	9
02	8500'	9	03	8070'	16
02	8600'	16	03	8090'	0
02	8620'	4	03	8100'	12
			03	8110'	6
29/10-1			03	8120'	16
03	4810'	38	03	8160'	8
03	4820'	41	03	8180'	13
03	4850'	1	03	8250'	102
03	4870'	31	03	8280'	63
03	4900'	46	03	8340'	3
03	5000'	31	03	8360'	9
03	5210'	23	03	8370'	6
03	5510'	66	03	8380'	3

Sample type	Depth/ sample no.	Total specimen count.
29/10-1	Continued.	
03	8390'	6
03	8400'	0
03	8450'	4
03	8460'	15
03	8490'	3
03	8500'	38
03	8580'	70
03	8590'	52
03	8610'	67
03	8620'	106
03	8630'	75
03	8640'	75
03	8700'	69
03	8750'	32
03	8790'	25
03	8800'	47
03	8850'	59
03	8860'	46
03	8900'	28
03	8950'	54
03	8980'	72
03	9010'	48
03	9020'	61
03	9030'	35
03	9040'	46
03	9060'	70
03	9080'	111
03	9090'	147
03	9110'	116
21/30-1.		
03	3490'	73
02	3550'	103
02	3602'	0
02	3610'	30
02	3650'	233
03	3670'	79
03	3730'	35
03	3750'	40
03	3790'	2
03	3817'	1
03	3820'	39
03	3880'	20
02	3893'	2
03	3910'	14
02	4210'	47
02	4248'	5
03	4270'	73
03	4330'	54
02	4350'	4

Sample type	Depth/ sample no.	Total specimen count.
21/30-1	Continued.	
02	4369'	36
03	4580'	47
03	4640'	41
03	4700'	41
03	4750'	33
02	4772'	2
03	4810'	80
03	4860'	38
03	4900'	26
03	4960'	17
02	4978'	2
02	5010'	0
03	5020'	15
03	5080'	28
03	5110'	5
03	5140'	15
03	5160'	14
03	5190'	10
02	5202'	15
03	5220'	12
03	5250'	7
02	5300'	21
03	5310'	17
03	5370'	14
03	5400'	17
02	5420'	36
03	5430'	6
02	5470'	47
03	5490'	15
03	5520'	29
02	5562'	9
02	5600'	11
03	5610'	16
02	5650'	40
02	5670'	18
03	5700'	28
02	5710'	26
02	5730'	14
02	5750'	35
03	5760'	23
03	5790'	18
02	5800'	28
03	5850'	18
02	5900'	24
03	5910'	25
03	5970'	27
02	6002'	3
02	6045'	66
02	6067'	16
02	6087'	42

Sample type	Depth/ sample no.	Total specimen count.
21/30-1 Continued.		
02	6100'	4
02	6107'	126
02	6210'	178
02	6312'	14
02	6352'	3
02	6379'	30
02	6390'	63
02	6440'	6
02	6443'	0
02	6454'	0
02	6472'	2
02	6485'	2
02	6620'	0
02	6690'	93
02	6712'	21
02	6732'	88
02	6747'	0
02	6770'	16
02	6850'	61
02	6890'	33
21/11-1.		
03	2130'	189
03	2190'	88
03	2210'	36
03	2220'	24
03	2230'	25
03	2240'	37
02	2247'	44
02	2250'	0
02	2256'	9
02	2265'	89
03	2310'	92
03	2370'	143
03	2390'	99
02	2408'	1
03	2430'	25
03	2490'	2
03	2550'	18
03	2610'	32
03	2670'	22
03	2730'	22
03	2790'	30
03	2810'	51
03	2820'	45
03	2850'	48
03	2910'	26
03	2970'	28
02	3002'	56
03	3030'	23

Sample type	Depth/ sample no.	Total specimen count.
21/11-1 Continued.		
03	3090'	65
03	3150'	25
03	3160'	17
03	3170'	27
03	3180'	23
03	3190'	22
03	3200'	12
03	3210'	34
03	3270'	27
02	3306'	8
03	3330'	30
03	3390'	21
03	3450'	13
03	3510'	8
03	3570'	18
02	3602'	0
03	3630'	4
03	3690'	1
02	3750'	5
03	3770'	16
03	3790'	12
02	3810'	8
03	3830'	8
02	3850'	9
02	3869'	0
03	3870'	10
02	3881'	0
03	3890'	10
03	3900'	11
03	3930'	4
03	3990'	7
02	4004'	0
03	4050'	6
03	4110'	15
03	4170'	9
03	4220'	4
03	4290'	8
02	4347'	1
03	4350'	9
03	4410'	5
02	4504'	0
03	4530'	1
02	4554'	0
03	4590'	14
03	4650'	14
02	4656'	0
03	4670'	6
02	4750'	21
03	4770'	17
03	4830'	16

Sample type	Depth/ sample no.	Total specimen count.
21/11-1 Continued.		
02	4856'	10
03	4890'	104
02	4901'	48
02	4945'	32
03	4950'	117
02	5000'	61
03	5010'	78
02	5050'	32
03	5070'	72
02	5106'	26
03	5130'	70
02	5150'	71
03	5190'	65
03	5200'	26
03	5210'	57
02	5219'	21
03	5220'	109
03	5230'	77
02	5234'	18
02	5237'	142
03	5240'	72
03	5250'	81
02	5254'	45
02	5281'	63
03	5290'	82
02	5293'	150
02	5299'	5
03	5300'	35
02	5305'	55
02	5310'	36
02	5350'	4
03	5370'	34
02	5398'	4
03	5430'	33
02	5449'	13
03	5490'	52
14/29-1.		
03	1580'	31
03	1640'	20
03	1670'	81
03	1760'	167
03	1820'	5
03	1880'	2
03	1940'	0
03	2000'	12
03	2060'	0
03	2120'	3
03	2180'	11
03	2240'	7

Sample type	Depth/ sample no.	Total specimen count.
14/29-1 Continued.		
03	2300'	24
03	2360'	46
03	2420'	28
03	2480'	35
03	2540'	0
03	2590'	3
03	2630'	6
03	2690'	1
03	2750'	6
03	2810'	5
03	2870'	7
03	2930'	6
03	2970'	0
03	3050'	1
03	3110'	1
03	3170'	0
03	3230'	0
03	3290'	0
03	3350'	0
03	3410'	1
03	3470'	0
03	3530'	0
03	3570'	0
03	3650'	0
03	3710'	1
03	3770'	0
03	3830'	0
03	3890'	0
03	3950'	1
03	4010'	0
03	4100'	0
03	4130'	0
03	4220'	4
03	4280'	3
03	4340'	35
02	4350'	55
03	4400'	23
03	4460'	43
02	4494'	3
03	4520'	35
03	4580'	50
02	4600'	14
03	4640'	60
03	4700'	25
03	4760'	38
03	4820'	42
02	4878'	0
03	4880'	44
03	4940'	45
03	5000'	29

14/29-1 Continued.

Sample type	Depth/ sample no.	Total specimen count.
02	5030'	0
03	5060'	13
03	5120'	20
02	5173'	0
03	5240'	11
03	5270'	3
03	5360'	5
03	5420'	1
02	5445'	0
03	5480'	2
03	5540'	8
02	5544'	0
03	5570'	5
03	5600'	7
02	5630'	33
03	5690'	29
02	5742	19
03	5750'	34
02	5770'	27
03	5810'	25
03	5870'	17
02	5882'	0
02	5928'	27
03	5930'	7
03	5990'	12
03	6050'	9
02	6051'	24
03	6170'	5
03	6290'	7
03	6410'	6
03	6470'	21
03	6490'	14
03	6510'	11

Southern N. Sea: 49/19-1.

03	1020'	0
03	1050'	3
03	1080'	1
03	1110'	15
03	1140'	34
03	1170'	43
03	1200'	22
03	1230'	92
03	1260'	196
03	1320'	14
03	1350'	25
03	1380'	11
03	1440	26

49/9-1.

Sample type	Depth/ sample no.	Total specimen count.
02	1288'	44
02	1306'	62
02	1356'	59
02	1389'	36
02	1423'	12
02	1535'	71
02	1583'	28
02	1630'	20
02	1697'	105
02	1737'	83
02	1930'	69
02	2026'	49
02	2071'	28
02	2167'	41
02	2232'	16
02	2298'	12
02	2380'	16
02	2400'	42
02	2463'	54
02	2528'	26
02	2580'	8
02	2647'	29
02	2670'	52
02	2698'	40
02	2730'	29

DEPTH
IN FEET
BELOW
DERRICK
FLOOR

5500
5750

5886.00	5648.00	5510.00	5501.00	A/B	SIPM CODE	REG NO.	SCIENTIFIC NAME			INDEX	REG NO.
ST 01	ST 01	ST 01	ST 01								
			\	A	03010116	1	RECURVOIDES	WALTERI GR	BENTHONIC FORAMINIFERA	03010070	7
			•	A	03010152	2	ADERCOTRYMA	AGTERBERGI		03010072	8
			\	A	03020201	3	RHIZAMMINA	INDIVISA		03010073	27
		○	\	A	03010106	4	AMMOMARGINULINA	MACROSPIRA		03010074	24
		○	•	A	03040111	5	HAPLOPHRAGMOIDES	KIRKI		03010077	28
		\	•	A	03060118	6	TROCHAMMINA	GLOBIGERINAEFORMIS		03010078	29
■		●	●	A	03010070	7	RHABDAMMINA	DISCRETA GR		03010079	30
○		\	\	A	03010072	8	DENDROPHYRA	LATISSIMA		03010082	21
•		•	•	A	03010083	9	GLOMOSPIRA	IRREGULARIS		03010083	9
•		\	\	A	03010101	10	SPIROPLECTAMMINA	NAVARROANA		03010084	22
\		\	•	A	03010114	11	CRIBROSTOMOIDES	SUBGLOBOSUS		03010087	31
•			•	A	03010121	12	PARATOCHAMMINOIDES	IRREGULARIS		03010088	25
•		○	\	A	03010123	13	KARRERIELLA KARRERUL	CONVERSA		03010089	32
\		\	○	A	03010124	14	KARRERIELLA KARRERUL	HORRIDA		03010101	10
•			\	A	03010168	15	GLOMOSPIRA	SERPENS		03010106	4
\		\	\	A	03010170	16	TROCHAMMINA	SPP.		03010114	11
○		○	\	A	03023101	17	AMMODISCUS	CRETACEUS		03010116	1
○			•	A	03023201	18	GLOMOSPIRA	GORDIALIS		03010118	23
•		○	\	A	03040113	19	HAPLOPHRAGMOIDES	WALTERI		03010121	12
○			•	A	03050103	20	SPIROPLECTAMMINA	SPECTABILIS		03010123	13
		•		A	03010082	21	LITUOTUBA	LITUIFORMIS		03010124	14
		•		A	03010084	22	GLOMOSPIRELLA	DIFFUNDENS CF.		03010129	33
		○		A	03010118	23	PRAECYSTAMMINA	GLOBIGERINAEFORMIS		03010131	34
\	•	○		A	03010074	24	DENDROPHYRA	EXCELSA GR		03010133	35
○		\		A	03010088	25	REPMANINA	CHAROIDES		03010152	2
•		○		A	03040608	26	CYCLAMMINA	GARCILASSOI CF.		03010158	36
•				A	03010073	27	DENDROPHYRA	ROBUSTA		03010168	15
\				A	03010077	28	PLACENTAMMINA	PLACENTA		03010170	16
\				A	03010078	29	PLACENTAMMINA	COMPLANATA		03020201	3
\				A	03010079	30	REOPHAX	SP.1		03023101	17
\				A	03010087	31	AMMODISCUS	PLANUS		03023201	18
○				A	03010089	32	KALAMOPSIS	GRZYBOWSKII		03023301	37
●				A	03010129	33	RZEHAKINA	MINIMA		03040111	5
\				A	03010131	34	RETICULOPHRAGMOIDES	JARVISI		03040113	19
○				A	03010133	35	HYPERAMMINA	SUBNODOSIRORMIS GR		03040608	26
•				A	03010158	36	REOPHAX	SUBNODULOSA		03050103	20
\				A	03023301	37	AMMOLAGENA	CLAVATA		03060118	6
	○			A	70100101	38	COSCINODISCUS	SP.1	OTHER FOSSILS	70100101	38

AB5 AB4 — 5501.00 / 5510.00 AB2 — 5886.00	AGGLUT. FORAM ZONATION	BIOSTRATIGRAPHIC SUBDIVISION
	CALC. FORAM ZONATION	
PK3 — 5648.00	PLANKTONIC FORAM ZONATION	
		TIME-STRATIGRAPHIC SUBDIVISION

SYMBOL LEGEND

- □ CAVED
- REWORKED
- ▥ BARREN SAMPLE (NF)
- • 1 SPECIMEN
- \ 2 -5 SPECIMENS
- ○ 6 -20 "
- ● 21-100 "
- ■ & 100 "

SAMPLE TYPES (ST) :

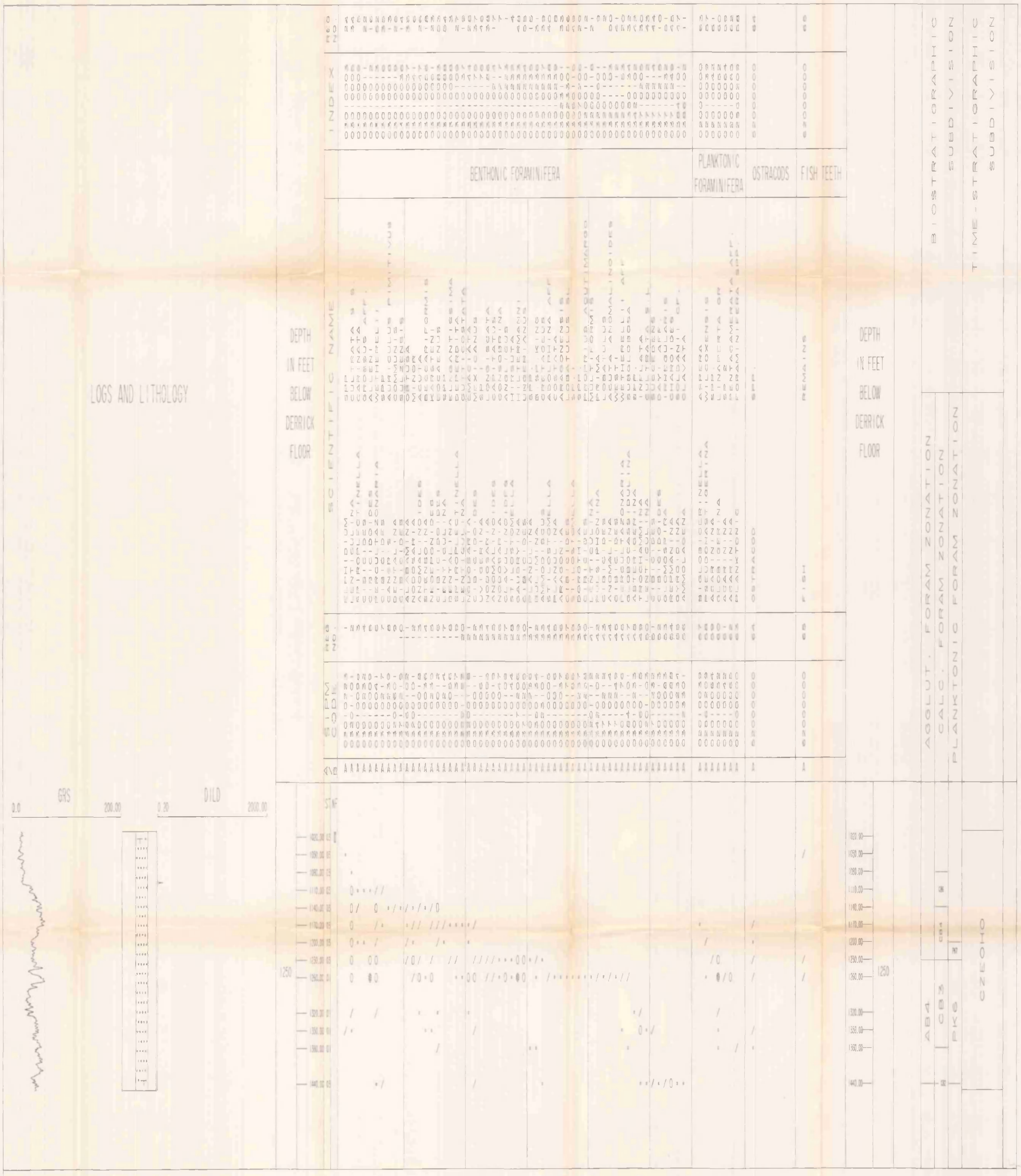
01 CORE SAMPLE

UNIVERSITY COLLEGE LONDON. C.N.S. STUDY
N 25/10-1

DISTRIBUTION CHART FOR 25/10-1
INTERVAL
5501 - 5886'

PLOT SCALE 1: 2500

AUTHOR: G. GILLMORE
REPORT NO.:
ENCL. 8
DATE: 28/7/1989
DRAW.NO.:



SYMBOL LEGEND

- 0 CAVED
- REWORKED
- ▯ BARREN SAMPLE (NF)
- • 1 SPECIMEN
- / 2-5 SPECIMENS
- O 6-20 "
- ● 21-100 "
- ▮ > 100 "

SAMPLE TYPES (ST) :

03 WET DITCH CTG

REMARKS

ONLY GAMMA RAY AND RESISTIVITY LOGS AVAILABLE OVER THIS INTERVAL.

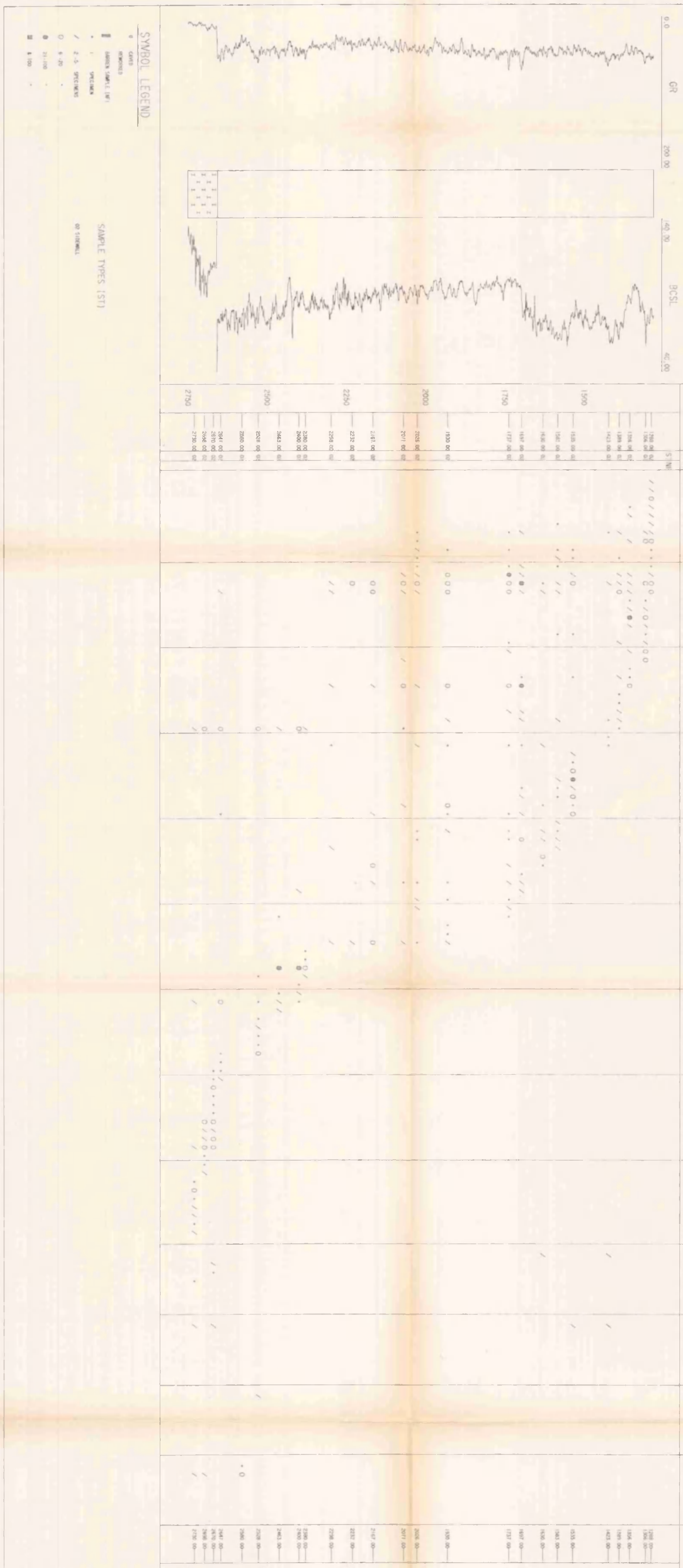
UNIVERSITY COLLEGE LONDON C.N.S. STUDY

49/19-1

DISTRIBUTION CHART FOR 49/19-1
INTERVAL
1020 - 1440'

PLOT SCALE 1 : 2500

AUTHOR: G. GILLMORE	ENCL. 7	DATE: 20/7/1989
REPORT NO.:		DRAW NO.:



DEPTH IN FEET BELOW DERRICK FLOOR

A/B	SIPM CODE	REG NO.	SCIENTIFIC NAME			INDEX	REG NO.
▸	03420102	1	PULSIPHONINA	PRIMA	BENTHONIC FORAMINIFERA	03010003	14
▸	03850407	2	MELONIS	AFFINE		03010005	46
▸	03900101	3	CERATOBULIMINA	CONTRARIA		03010006	24
▸	03050408	4	TEXTULARIA	CHAPMANI		03010012	13
▸	03840101	5	GLOBOCASSIDULINA	SUBGLOBOSA		03010018	7
▸	03010030	6	GYROIDINA	SOLDANII MAMILLATA		03010020	19
▸	03010018	7	ANOMALINOIDES	ACUTA		03010021	76
▸	03010068	8	BRIZALINA	COOKEI		03010030	6
▸	03010137	9	SPIROPLECTINELLA	DEPERDITA		03010032	44
▸	03200101	10	NODOSARIA	MINOR		03010036	70
▸	03700102	11	ORDORSALIS	UMBONATUS		03010041	48
▸	03201103	12	LENTICULINA	CULTRATA S.L.		03010047	20
▸	03010012	13	CIBICIDOIDES	EOCAENUS		03010053	39
▸	03010003	14	NODOSARIA	LONGISCATA		03010054	33
▸	03010162	15	SPIROSIGMOILINELLA	SP1		03010056	37
▸	03010182	16	ANGULOGERINA	GRACILIS GP		03010059	53
▸	03350110	17	TURRILINA	ALSATICA		03010060	36
▸	03860104	18	SVRATKINA	PERLATA		03010061	22
▸	03010020	19	ANOMALINOIDES	SEMICRIBRATUS		03010068	8
▸	03010047	20	NODOSARIA	CONSOBRINA		03010070	30
▸	03110307	21	SPIROSIGMOILINELLA	COMPRESSA		03010073	59
▸	03010061	22	UVIGERINA	SP 1		03010085	41
▸	03010208	23	STILOSTOMELLA	SPINESCENS AFF		03010088	66
▸	03010006	24	KOROBKOVELLA	GROSSERUGOSA		03010091	58
▸	03200118	25	NODOSARIA	EMACIATA		03010093	56
▸	03710214	26	ANOMALINA	ACUTA ANOMALINOIDES		03010096	63
▸	03710249	27	CIBICIDES	WESTI		03010099	60
▸	03850902	28	PULLENIA	QUINQUELOBA		03010100	45
▸	03710215	29	CIBICIDES	SULZENSIS		03010116	61
▸	03010070	30	RHABDAMMINA	DISCRETA GR		03010119	83
▸	03010206	31	BRIZALINA	SPP		03010123	64
▸	03900401	32	HOEGLUNDINA	ELEGANS		03010124	65
▸	03010054	33	STILOSTOMELLA	PALAEOCENICA AFF.		03010127	47
▸	03010184	34	PRAEGLOBOBULIMINA	OVATA		03010137	9
▸	03900102	35	CERATOBULIMINA	WOODI		03010144	54
▸	03010060	36	ANGULOGERINA	GRACILIS		03010156	69
▸	03010056	37	DENTALINA	ELEGANTISSIMA		03010162	15
▸	03710201	38	HETEROLEPA	DUTEMPL PRAECINCTUS		03010177	50
▸	03010053	39	STILOSTOMELLA	ADOLPHINA		03010182	16
▸	03860203	40	GYROIDINA	SOLDANII		03010184	34
▸	03010085	41	PSAMMOSPHAERA	FUSCA		03010185	42
▸	03010185	42	UVIGERINA	JACKSONENSIS		03010186	49
▸	03360110	43	UVIGERINA	BATJESI		03010190	72
▸	03010032	44	GYROIDINA	OCTOCAMERATA AFF.		03010192	51
▸	03010100	45	REWORKED CRETACEOUS	BENTHONICS		03010196	73
▸	03010005	46	STILOSTOMELLA	ADOLPHINA AFF.		03010197	74
▸	03010127	47	KARRERIELLA MEIDAM	SIPHONELLA CHILOST		03010198	81
▸	03010041	48	PERCULTAZONARIA	WETHERELLI		03010206	31
▸	03010186	49	STILOSTOMELLA	SP.1		03010207	52
▸	03010177	50	DOROTHIA	SP 2		03010208	23
▸	03010192	51	QUINQUELOCULINA	IMPEH. PORTERENSIS		03010209	84
▸	03010207	52	GYROIDINA	SP 1		03010210	85
▸	03010059	53	ANGULOGERINA	FLUENS		03010211	86
▸	03010144	54	STILOSTOMELLA	HIRSUTA		03010214	71
▸	03201101	55	LENTICULINA	CULTRATA S.S.		03010217	60
▸	03010093	56	RETICULOPHRAGMIUM	PLACENTA		03023101	62
▸	03060115	57	TROCHAMMINA	INFLATA		03023201	66
▸	03010091	58	RETICULOPHRAGMIUM	AMPLECTENS		03050408	4
▸	03010073	59	DENDROPHYRA	ROBUSTA		03060115	57
▸	03010217	60	CIBICIDES	SPP		03071001	87
▸	03010116	61	RECURVOIDES	WALTERI GR		03110307	21
▸	03023101	62	AMMODISCUS	CRETACEUS		03200101	10
▸	03010096	63	RETICULOPHRAGMIUM	SP 1		03200111	75
▸	03010123	64	KARRERIELLA KARRERUL	CONVERSA		03200118	25
▸	03010124	65	KARRERIELLA KARRERUL	HORRIDA		03201101	55
▸	03023201	66	GLOMOSPIRA	GORDIALIS		03201103	12
▸	03201112	67	LENTICULINA	MULTIFORMIS		03201112	67
▸	03010088	68	REPMANINA	CHAROIDES		03350110	17
▸	03010156	69	CIBICIDOIDES	DAYI		03360110	43
▸	03010036	70	STENSIOINA	BECCARIFORMIS		03420102	1
▸	03010214	71	LENTICULINA	SPP		03700102	11
▸	03010190	72	CIBICIDES	PROPRIUS		03710201	38
▸	03010196	73	SIGMOMORPHINA	SP 1		03710214	26
▸	03010197	74	PULSIPHONINA	SPP		03710215	29
▸	03200111	75	NODOSARIA	TORSICOSTATA		03710232	77
▸	03010021	76	OSANGULARIA	EXPANSA		03710249	27
▸	03710232	77	CIBICIDES	SUCCEDENS		03710255	78
▸	03710255	78	CIBICIDES	EKBLOMI		03840101	5
▸	03870201	79	OSANGULARIA	CORDIERIANA GROUP		03850407	2
▸	03010099	80	SPIROPLECTINELLA	WILCOXENSIS		03850902	28
▸	03010198	81	TAPPANINA	SELMENSIS		03860104	18
▸	03880106	82	ANOMALINOIDES	DANICA		03860203	40
▸	03010119	83	TROCHAMMINA	RUTHVEN MURRAYI		03860205	88
▸	03010209	84	VALVALABAMINA	LENTICULA		03870201	79
▸	03010210	85	VERNEUILINA	MUENSTRII		03880106	82
▸	03010211	86	GAVELINELLA	COMPLANATA		03880901	89
▸	03071001	87	MARSSONELLA	OXYCONA		03900101	3
▸	03860205	88	GYROIDINOIDES	NITIDA		03900102	35
▸	03880901	89	STENSIOINA	POMMERANA		03900401	32
▸	02010100	90	REWORKED CRETACEOUS	PLANKTONICS	PLANKTONIC FORAMINIFERA	02010029	91
▸	02010029	91	GLOBANOMALINA	PSEUDOBULLOIDES		02010039	93
▸	02010053	92	GLOBIGERINA	TRILOCULINOIDES		02010053	92
▸	02010039	93	BIGLOBIGERINELLA	ASPERA		02010100	90
▸	52000000	94	OSTRACOD	SPP	OSTAROCODS	52000000	94
▸	62000000	95	FISH	REMAINS	FISH TEETH	62000000	95
▸	70100101	96	COSCINODISCUS	SP.1	OTHER FOSSILS	70100100	97
▸	70100100	97	COSCINODISCUS	SPP.		70100101	96

DEPTH IN FEET BELOW DERRICK FLOOR

BIOSTRATIGRAPHIC SUBDIVISION

AGGLUT. FORAM ZONATION: AB6

CALC. FORAM ZONATION: CB2, CB5, CB6

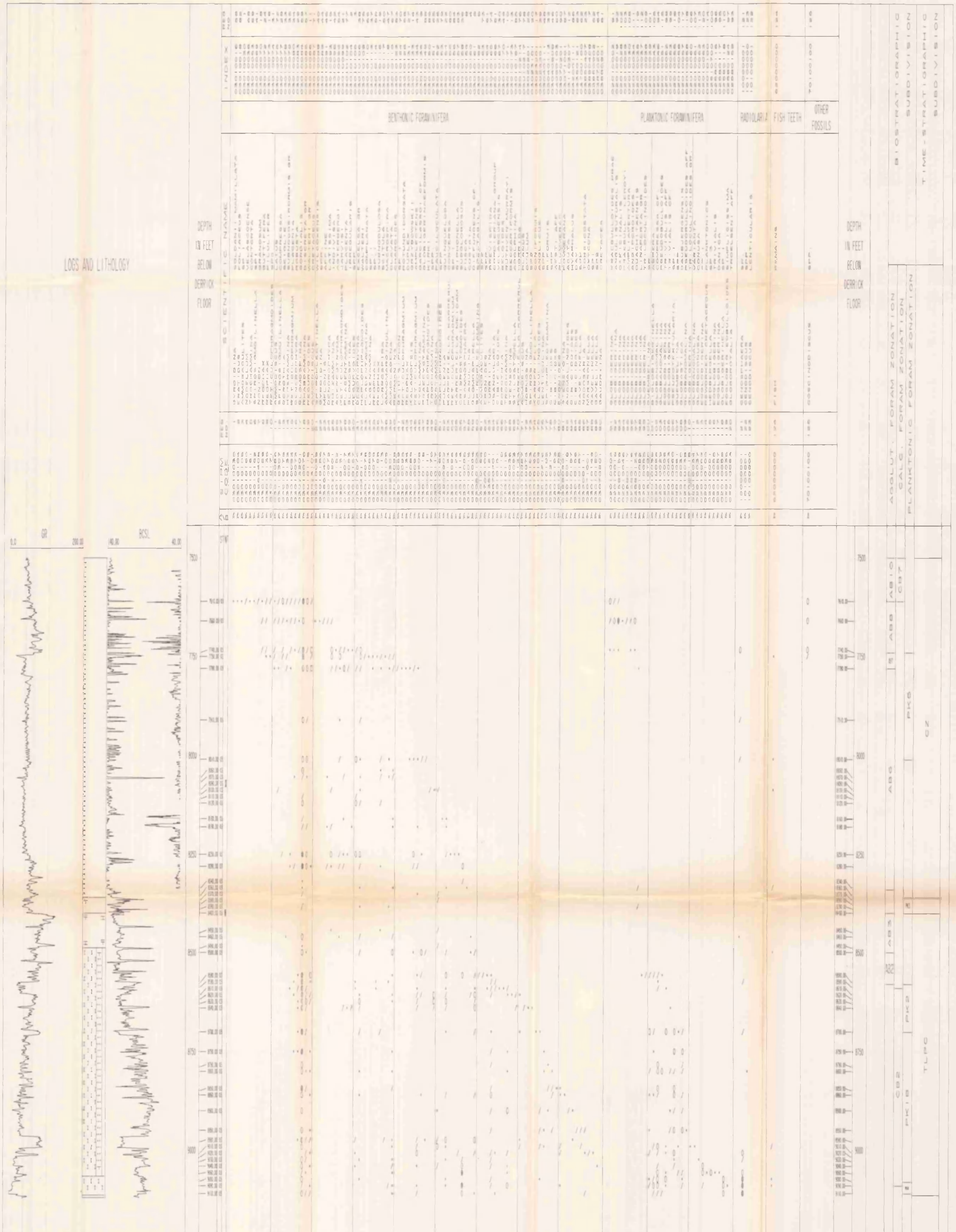
PLANKTONIC FORAM ZONATION

TIME-STRATIGRAPHIC SUBDIVISION: KU, TTQQ

UNIVERSITY COLLEGE LONDON C.N.S. STUDY

DISTRIBUTION CHART
TERTIARY
SHELL/ESSO WELL 49/9-1
PLOT SCALE 1: 2500

AUTHOR: G. GILLMORE
ENCL. 6
DATE: 28/7/1989
REPORT NO.:
DRAW NO.:



SYMBOL LEGEND

0 CAVED

REWORKED

▌ BARREN SAMPLE (BF)

• 1 SPECIMEN

/ 2-5 SPECIMENS

0 6-20 "

● 21-100 "

█ > 100 "

SAMPLE TYPES (ST)

02 SIDEWALL SAMPLE

03 WET DITCH CTG

UNIVERSITY COLLEGE LONDON, C.N.S. STUDY

29/10-1

DISTRIBUTION CHART FOR 29/10-1

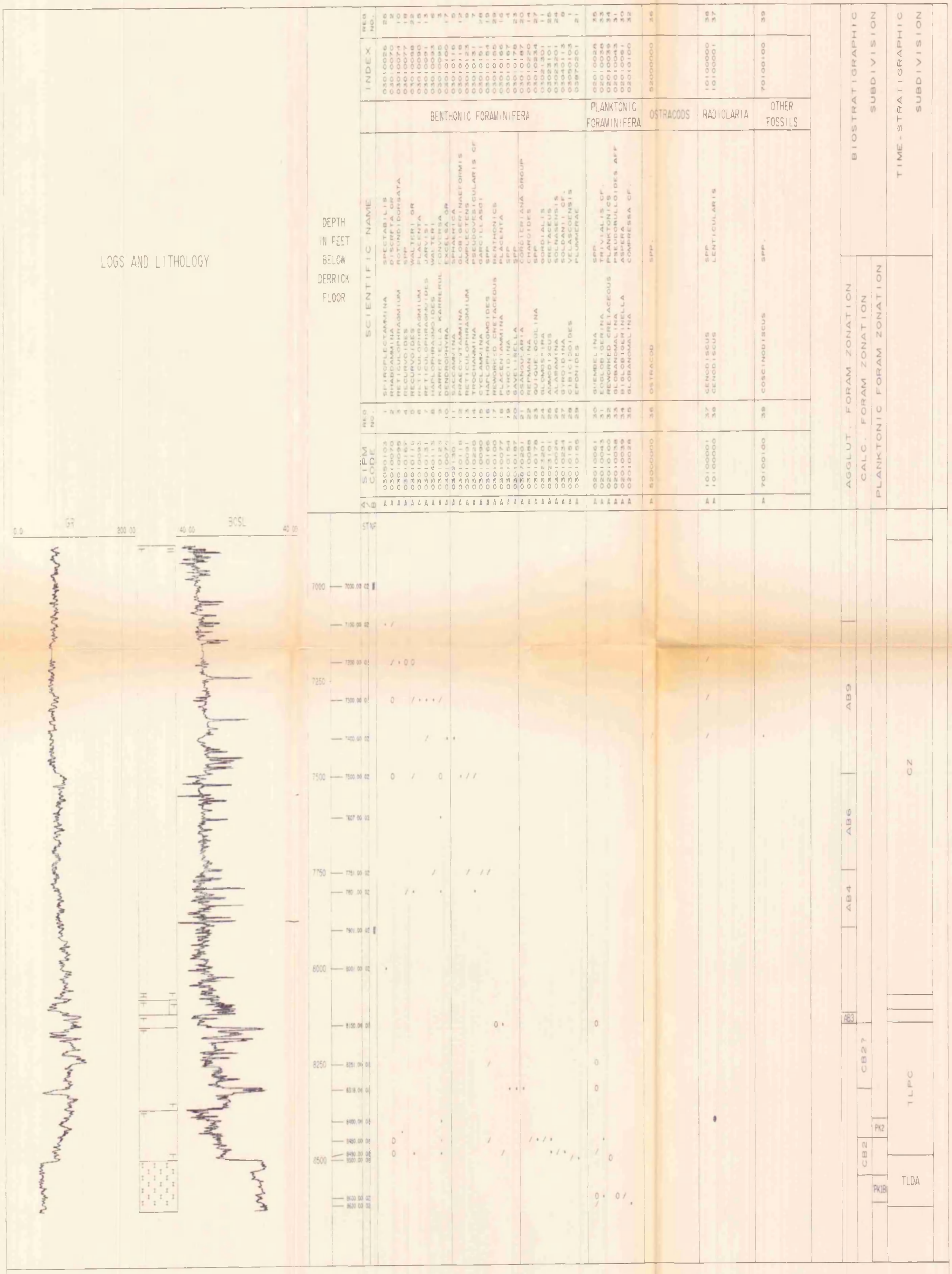
INTERVAL

7500 - 9110'

(CHART 2 OF 2)

PLOT SCALE 1 : 2500

AUTHOR: S. GILLMORE	ENCL. 5B	DATE: 20/7/1989
REPORT NO.:		DRAWING NO.:



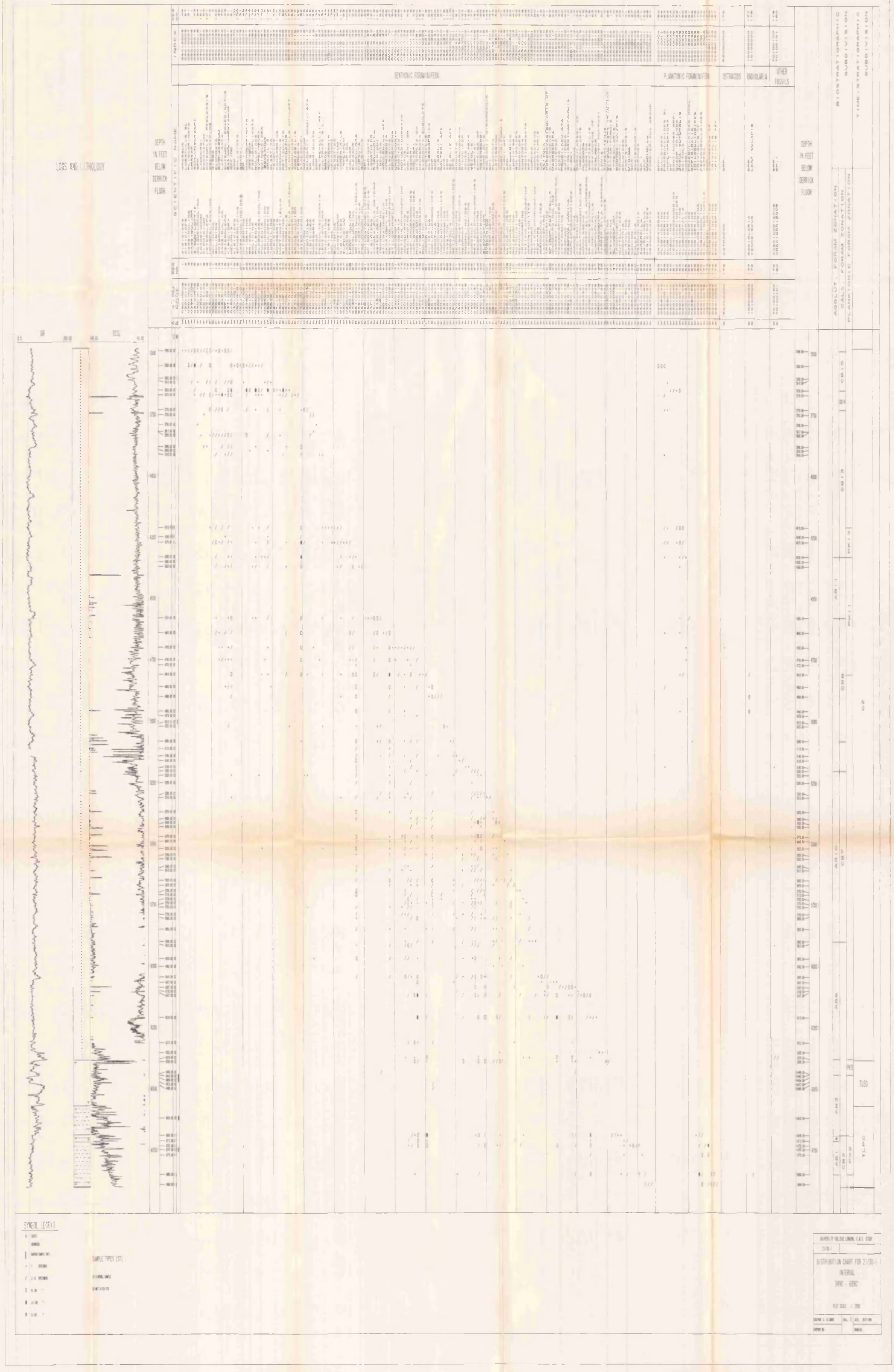
SYMBOL LEGEND

- 0 CAVED
- REWORKED
- ▮ BARREN SAMPLE (NF)
- • 1 SPECIMEN
- / 2 -5 SPECIMENS
- O 6 -20 "
- ● 21-100 "
- ■ ≥ 100 "

SAMPLE TYPES (ST) :

02 SIDEWALL SAMPLE

UNIVERSITY COLLEGE LONDON. C.N.S. STUDY		
29/7-1		
DISTRIBUTION CHART FOR 29/7-1 INTERVAL 7000 - 8620' PLOT SCALE 1: 2500		
AUTHOR: G. GILLMORE	ENCL. 4	DATE: 28/7/1989
REPORT NO.:		DRAW NO:



UNIVERSITY COLLEGE LONDON, C.A.S. STUDY

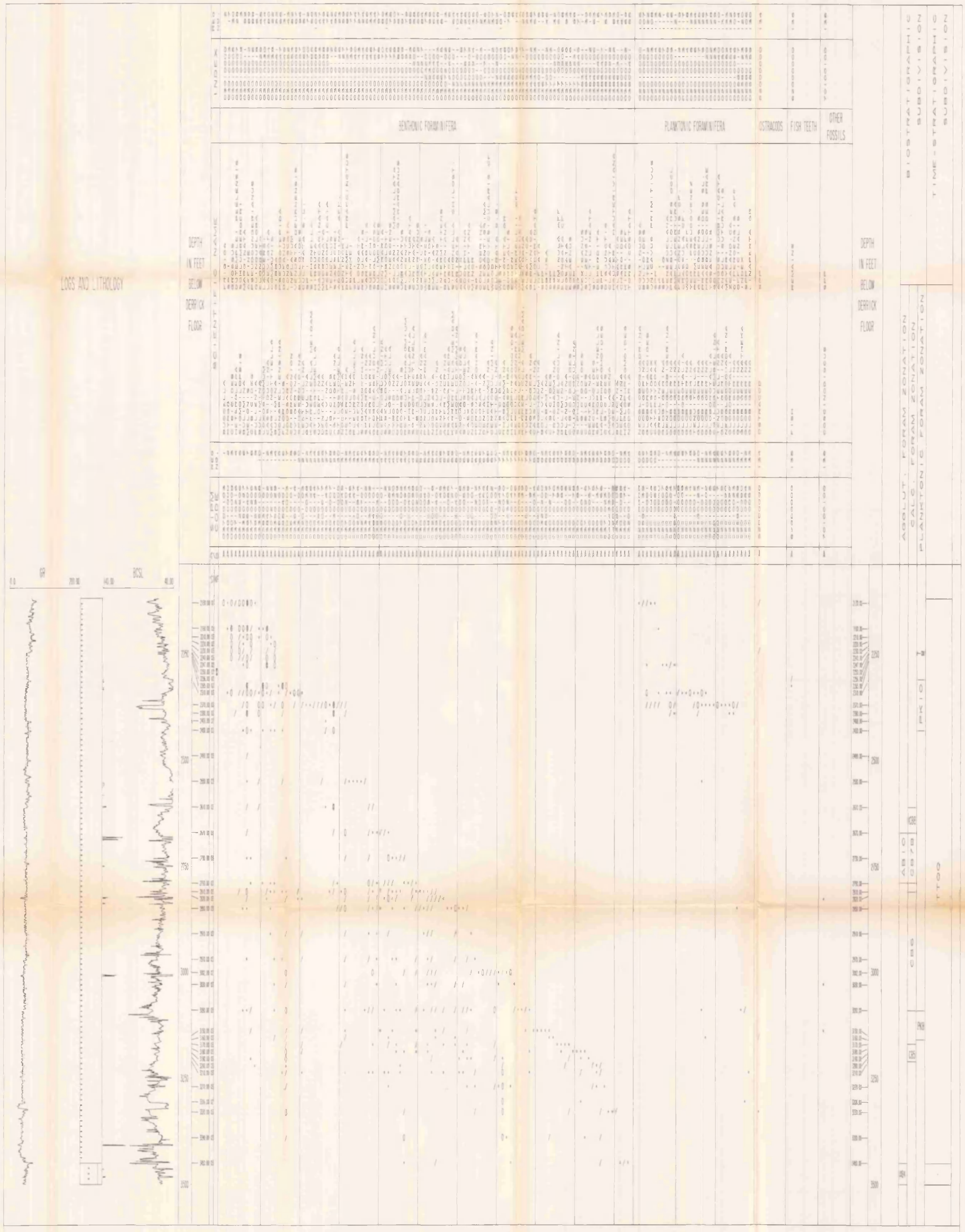
21/30-1

DISTRIBUTION CHART FOR 21/30-1

INTERVAL

3490 - 6890'

PLOT SCALE 1 : 2500



SYMBOL LEGEND

- CAVED
- REWORKED
- | BARREN SAMPLE (NT)
- • 1 SPECIMEN
- / 2-5 SPECIMENS
- 0 6-20 "
- 21-100 "
- >100 "

SAMPLE TYPES (ST) :

02 SIDEWALL SAMPLE

03 WET DITCH CTG.

UNIVERSITY COLLEGE LONDON, C.N.S. STUDY

21/11-1	SAVIN

DISTRIBUTION CHART FOR 21/11-1

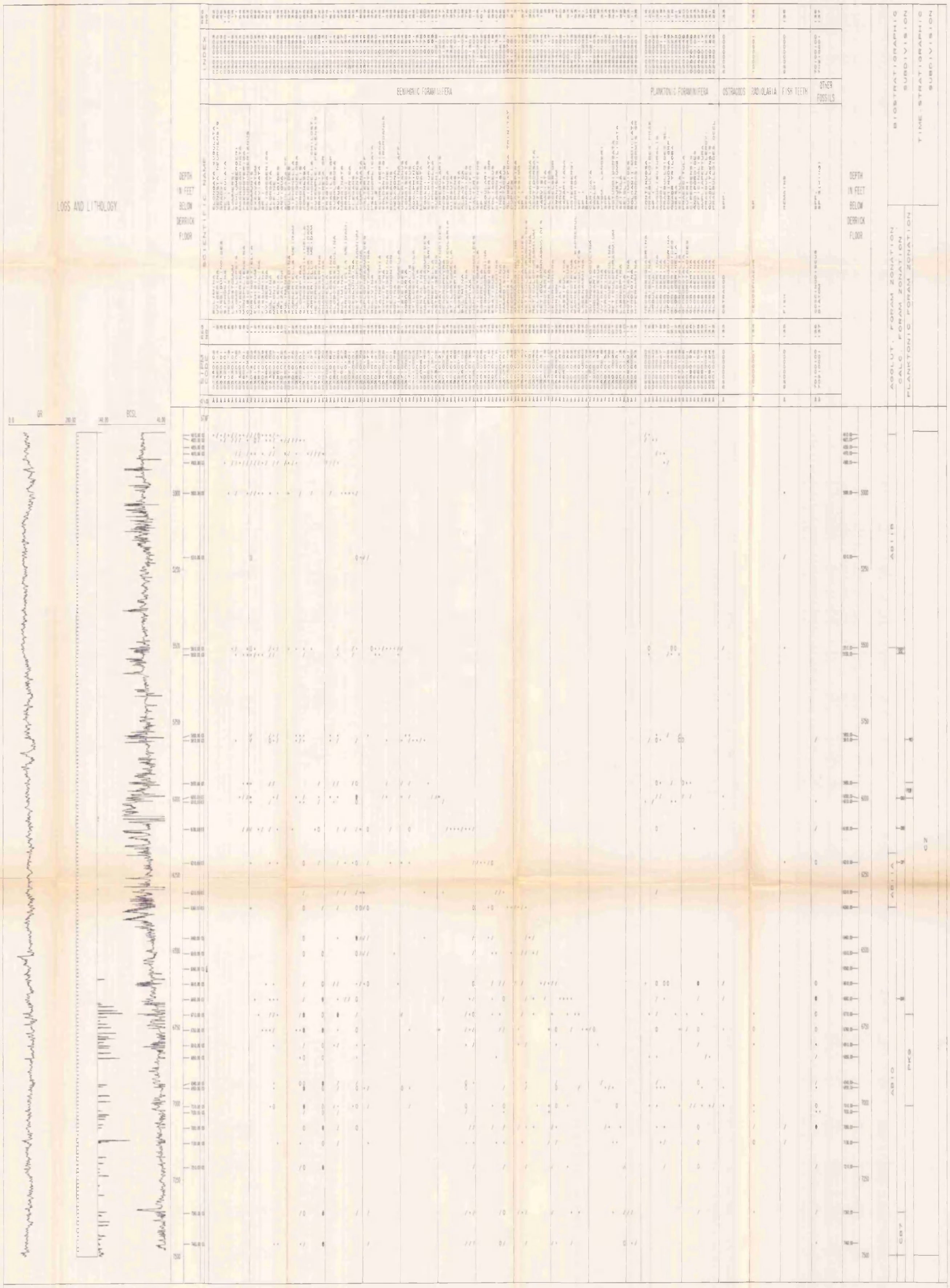
INTERVAL

2130 - 3500'

(CHART 1 OF 2)

PLOT SCALE 1 : 2500

AUTHOR: G. GILLMORE	ENCL. 25	DATE: 28/3/1989
REPORT NO.:		DRAWING NO.:



SYMBOL LEGEND

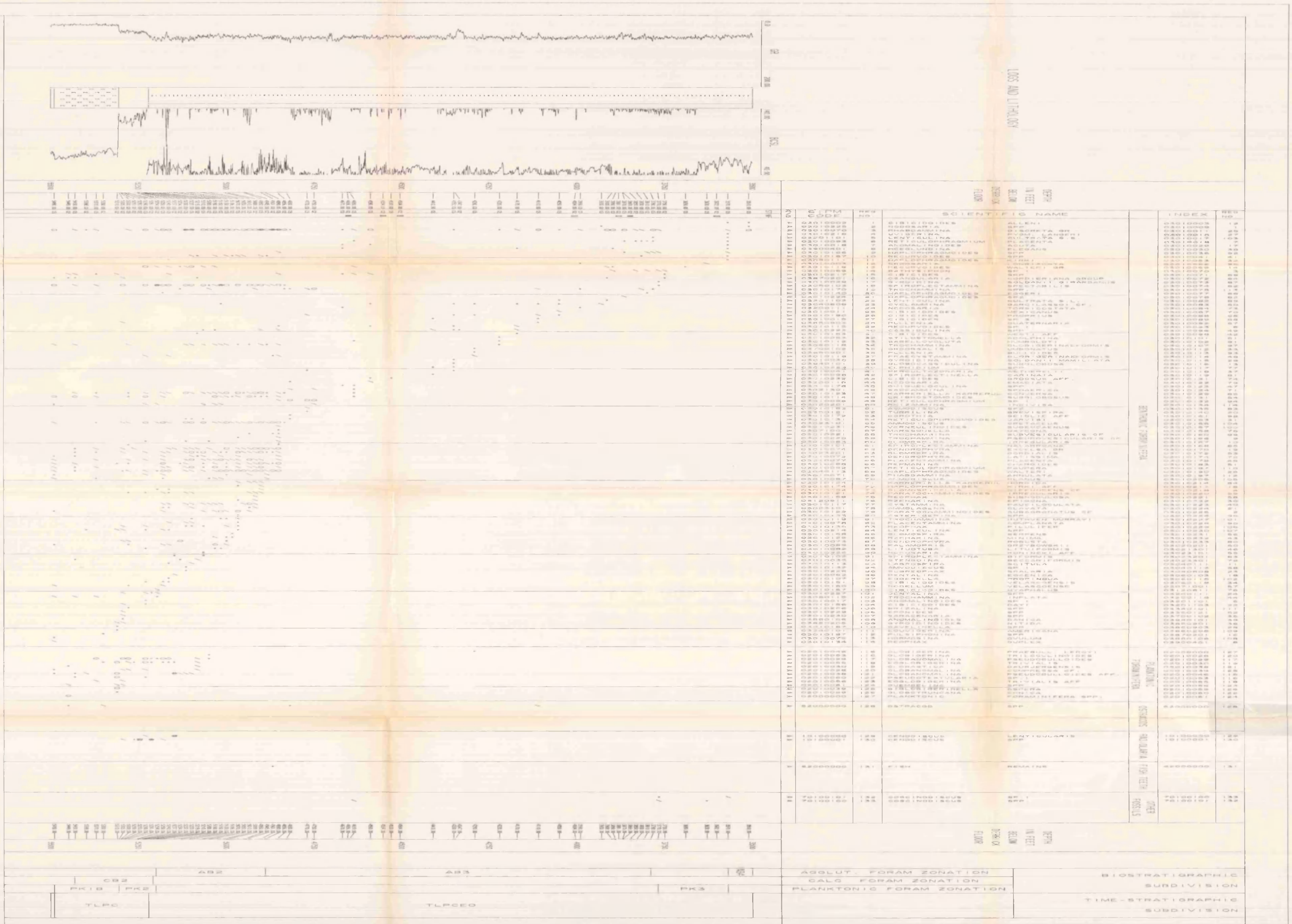
- CAVED
- REWORKED
- BARREN SAMPLE (BF)
- · 1 SPECIMEN
- / 2-5 SPECIMENS
- 0 6-20 "
- ▮ 21-100 "
- ▮ >100 "

SAMPLE TYPES (ST) :

UNIVERSITY COLLEGE LONDON, C.N.S. STUDY

29/10-1

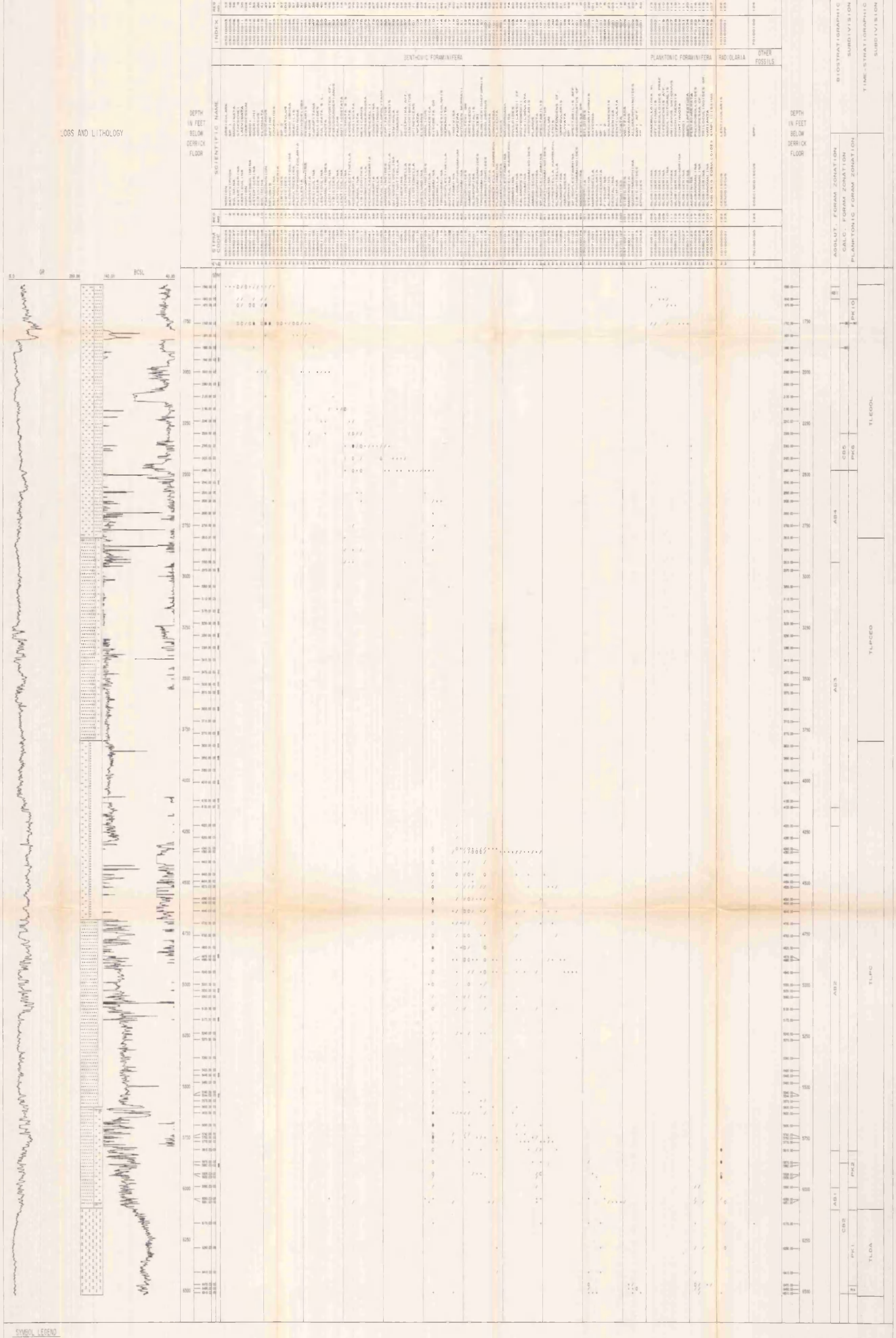
DISTRIBUTION CHART FOR 29/10-1
INTERVAL
4810 - 7500'
(CHART 1 OF 2)
PLOT SCALE 1:2500



UNIVERSITY COLLEGE LONDON C.A.S. STUDY

21/11-1

DISTRIBUTION CHART FOR 21/11-1
INTERNAL
3500 - 5490'
(CHART 2 OF 2)
PLOT SCALE 1:2500



SYMBOL LEGEND

- O CAVED
- REWORKED
- ▮ GAPPED SAMPLE (?)
- • 1 SPECIMEN
- / 2-5 SPECIMENS
- O 6-20 "
- ● 21-100 "
- ■ > 100 "

SAMPLE TYPES (ST) :

SS SIDEWALL SAMPLE

DS WET DITCH CTS

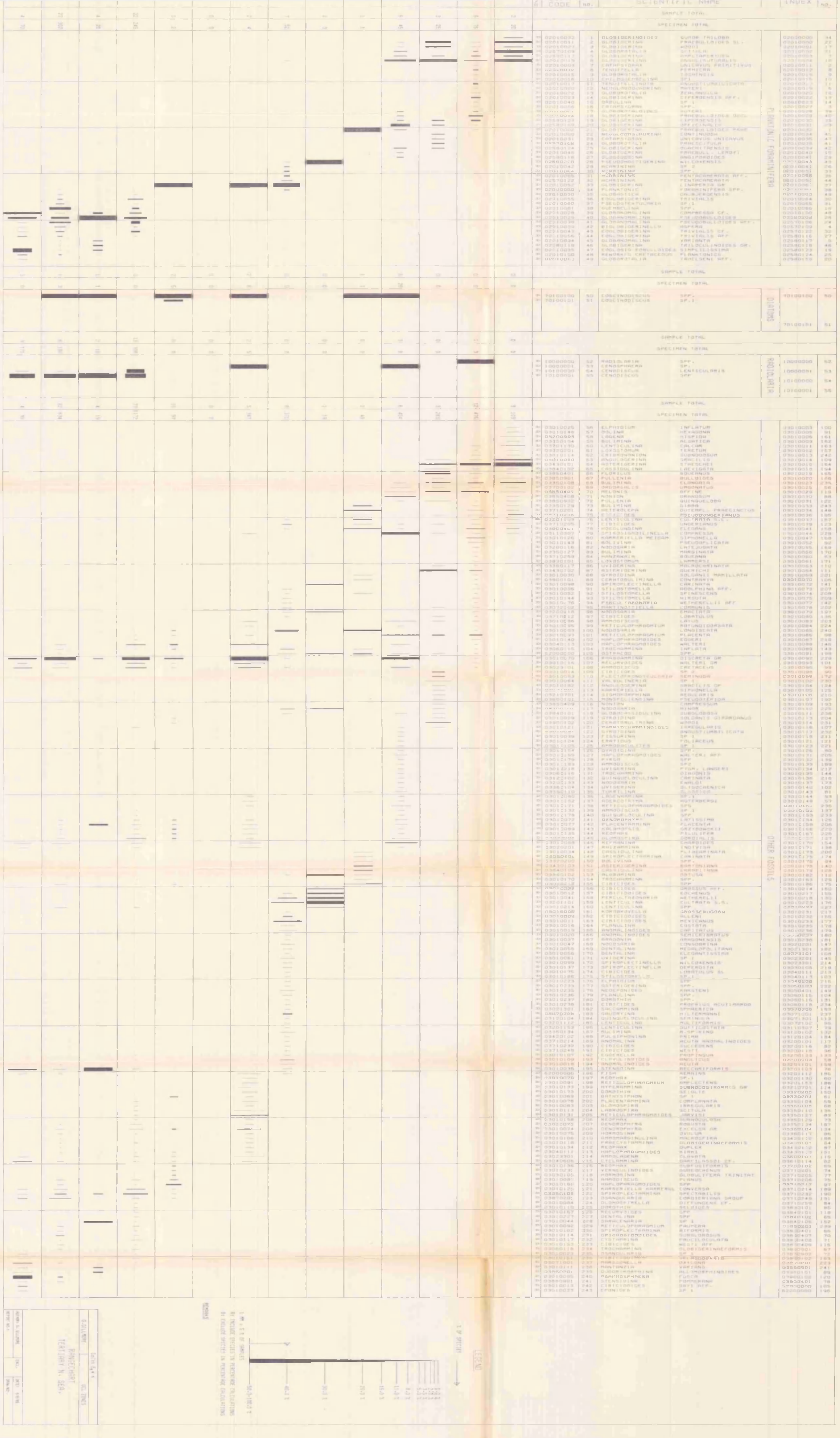
UNIVERSITY COLLEGE LONDON, C.A.S. STUDY

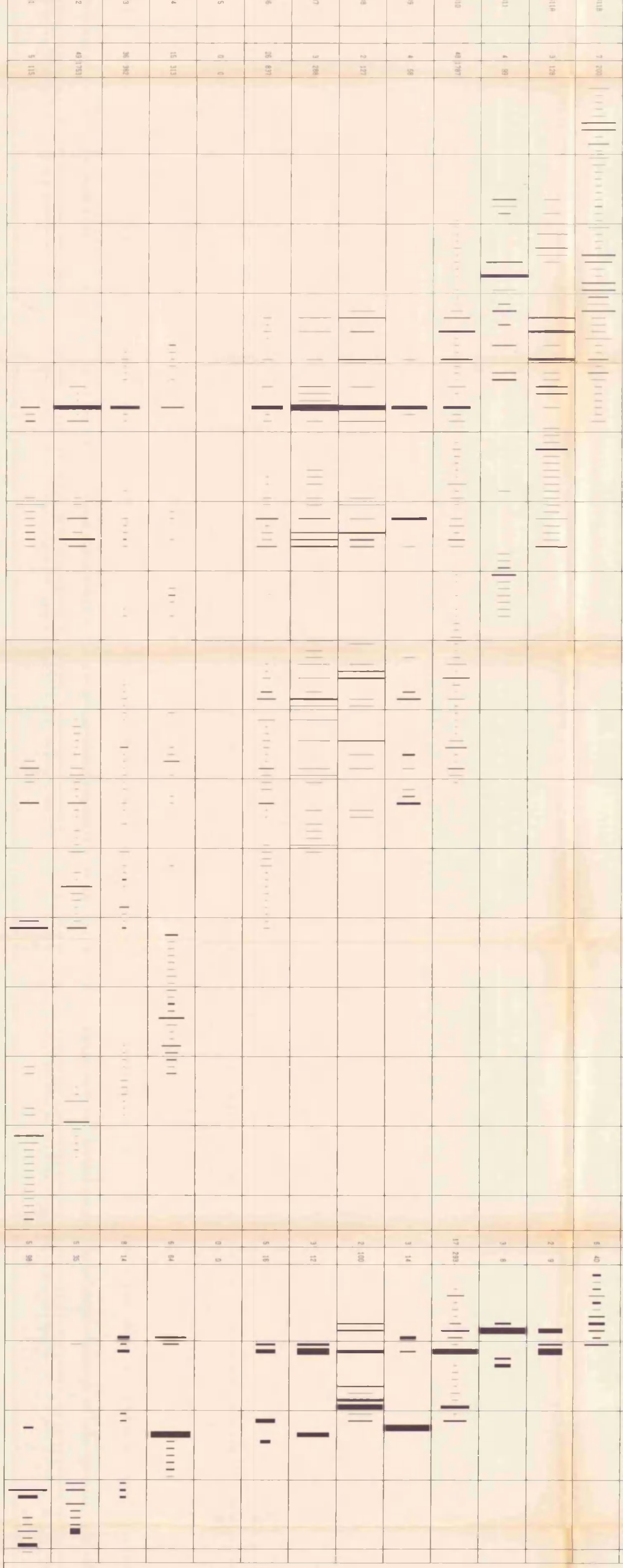
14/29-1

DISTRIBUTION CHART FOR 14/29-1
INTERVAL
1580 - 6510'

PLOT SCALE 1: 2500

AUTHOR: [illegible] | ENCL. 1 | DATE: [illegible]
REPORT NO.: | DRWG NO.:


CODE
NO.
SCIENTIFIC NAME
INDEX
NO.
SAMPLE TOTAL
SPECIMEN TOTAL
02010032 1 GLOBIGERINOIDES QUADR TRILOBA
02010011 2 GLOBIGERINA PRAEBULLOIDES SL.
02010027 3 GLOBIGERINA WOODI
02570109 4 GLOBOROTALIA SCITULA
02580117 5 GLOBIGERINA AMPLIAPERTURA
02010015 6 GLOBIGERINA ANGULISUTURALIS
02010003 7 CATAPSYDRAX UNICAVUS PRIMITIVUS
02010012 8 TENUITELLA PERMICRA
02010015 9 GLOBOROTALIA TOSAENSIS
02010018 10 CHILOGUEMBELINA SP1
02010017 11 TENUITELLINATA ANGUSTIUMBILICATA
02010020 12 NEOGLOBOQUADRINA MAYERI
02010022 13 GLOBOROTALIA ZEALANDICA
02010023 14 GLOBIGERINA CIPEROENSIS AFF.
02010040 15 ORBULINA SP 1
02010056 16 CATAPSYDRAX SPP.
17 GLOBOROTALOIDES SUTERI
18 GLOBIGERINA PRAEBULLOIDES OCCL
02580123 19 GLOBIGERINA CIPEROENSIS
02580159 20 GLOBIGERINA OFFICINALIS
02010002 21 GLOBIGERINA PRAEBULLOIDES PARE
02010000 22 NEOGLOBOQUADRINA CONTINUOSA
02010031 23 CATAPSYDRAX UNICAVUS UNICAVUS
02570108 24 GLOBOROTALIA PRAESCITULA
02580124 25 GLOBIGERINA OUACHITAENSIS
02010045 26 GLOBIGERINA PRAEBULL. LEROYI
02580116 27 GLOBIGERINA ANGIPOROIDES
02580208 28 PSEUDOHASTIGERINA WILCOXENSIS
02010042 29 ACARININA SP 2
02010064 30 ACARININA SPP.
02010065 31 ACARININA PENTACAMERATA AFF.
02570122 32 ACARININA PENTACAMERATA
02010052 33 GLOBIGERINA LINAPERTA GR
02000000 34 PLANKTONIC FORAMINIFERA SPP.
02010030 35 GLOBASTICA DAUBJERGENSIS
02010055 36 EOGLOBIGERINA TRIVIALIS
02010060 37 PSEUDOTEXTULARIA SP.1
02010061 38 GUEMBELINA SPP.
02010028 39 GLOBANOMALINA COMPRESSA CF.
02010029 40 GLOBANOMALINA PSEUDOBULLOIDES
41 GLOBANOMALINA PSEUDOBULLOIDES AFF.
42 BIGLOBIGERINELLA ASPERA
43 EOGLOBIGERINA TRIVIALIS CF.
02010056 44 EOGLOBIGERINA TRIVIALIS AFF
02010034 45 GLOBANOMALINA VARIANTA
02580118 46 GLOBIGERINA TRILOCULINOIDES GR.
02010035 47 EOGLOBIG EOBULLOIDES SIMPLICISSIMA
02010150 48 REWORKED CRETACEOUS PLANKTONICS
02010063 49 GLOBOROTALIA TROELSENI AFF.
PLANKTONIC FORAMINIFERA
70100100 50 COSCINODISCUS SPP.
70100101 51 COSCINODISCUS SP.1
DIATOMS
10000000 52 RADIOLARIA SPP.
10000001 53 CENOSPHAERA SP.
10100000 54 CENODISCUS LENTICULARIS
10100001 55 CENODISCUS SPP
RADIOLARIA
03010025 56 ELPHIDIUM INFLATUM
57 OOLINA HEXAGONA
03200903 58 LAGENA HISPIDA
03150104 59 BULIMINA ALSATICA
60 LENTICULINA CALCAR
61 LOXOSTOMUM TERETUM
62 CRIBRONONION SUBNODOSUM
03010080 63 ANGULOGERINA GRACILIS
64 ASTERIGERINA STAESCHEI
65 CASSIDULINA LAEVIGATA
66 FLORILUS BOUEANUS
67 PULLENIA BULLOIDES
68 BULIMINA ELONGATA
69 ORBORSALIS UMBONATUS
03850407 70 MELONIS AFFINE
71 NONION GRANOSUM
OTHER FOSSILS
LEGEND
% OF SPECIES
50.0-100.0 %
40.0 %
30.0 %
20.0 %
15.0 %
11.0 %
8.0 %
5.0 %
1 MM = 5 % OF SAMPLES
A: INCLUDE SPECIES IN PERCENTAGE CALCULATIONS
B: EXCLUDE SPECIES IN PERCENTAGE CALCULATIONS
REMARKS
D.GILLMORE
OCL ZONES
RANGECHART
TERTIARY N. SEA.
AUTHOR: D. GILLMORE
ENCL.
DATE:
REPORT NO.:
DRAW.NO.:



ZONATION

SAMPLE TOTAL

SPECIMEN TOTAL

AGGLUTINATED BENTHONIC FORAMS.

A/B	SIPM CODE	REG NO.	SCIENTIFIC NAME		INDEX	REG NO.
B	03010127	1	KARRERIELLA MEIDAM	SIPHONELLA CHILOST.	03010003	98
B	03010139	2	KARRERIELLA MEIDAM.	MEXICANA	03010005	39
B	03010141	3	REOPHAX	SP 2	03010009	123
B	03010142	4	BRIZALINA	ANTIQUA	03010011	139
B	03010182	5	ANGULOGERINA	GRACILIS GP	03010012	124
B	03120606	6	SIGMOILOPSIS	SCHLUMBERGERI	03010016	125
B	03310101	7	SPHAEROIDINA	BULLOIDES	03010018	140
B	03330101	8	CASSIDULINOIDES	BRADYI	03010019	126
B	03350123	9	BULIMINA	ACULEATA CF.	03010021	152
B	03350127	10	BULIMINA	MARGINATA	03010026	156
B	03360117	11	UVIGERINA	MACROCARINATA	03010029	20
B	03420101	12	SIPHONINA	RETICULATA	03010030	87
B	03600101	13	MONSPELIENSINA	PSEUDOTEPIDA	03010036	142
B	03700103	14	BUCCELLA	FRIGIDA	03010039	21
B	03710216	15	HETEROLEPA	DUTEMPLEI PEELENSIS	03010040	157
B	03820103	16	STAINFORTHIA	SCHREIBERSIANA	03010041	141
B	03010060	17	ANGULOGERINA	GRACILIS	03010046	158
B	03010143	18	BOLIVINA	PSEUDOPLICATA	03010047	127
B	03850401	19	FLORILUS	BOUEANUS	03010052	52
B	03010029	20	GYROIDINA	SOLDANII GIRARDANUS	03010060	17
B	03010039	21	FISSURINA	SP 1	03010061	128
B	03010138	22	KARRERIELLA MEIDAM.	BRADYI	03010062	159
B	03010148	23	OOLINA	HEXAGONA	03010066	68
B	03010169	24	HAPLOPHRAGMOIDES	WALTERI AFF	03010069	107
B	03072102	25	MARTINOTTIELLA	COMMUNIS	03010070	47
B	03350108	26	BULIMINA	ELONGATA	03010072	60
B	03360104	27	UVIGERINA	OLIGOCAENICA	03010073	61
B	03430101	28	ASTERIGERINA	STAESCHEI	03010074	99
B	03610103	29	ELPHIDIUM	EXCAVATUM	03010075	108
B	03710206	30	CIBICIDES	PSEUDOUNGERIANUS	03010077	44
B	03830101	31	LOXOSTOMUM	LAMMERSI	03010078	45
B	03840102	32	CASSIDULINA	LAEVIGATA	03010079	46
B	03850407	33	MELONIS	AFFINE	03010080	82
B	03010086	34	AMMODISCUS	LATUS	03010083	105
B	03010126	35	KARRERIELLA MEIDAM	SIPHONELLA	03010084	114
B	03110307	36	SPIROSIGMOILINELLA	COMPRESSA	03010086	34
B	03850902	37	PULLENIA	QUINQUELOBA	03010087	121
B	03710205	38	CIBICIDES	UNGERIANUS	03010088	100
B	03010005	39	STILOSTOMELLA	ADOLPHINA AFF.	03010089	101
B	03010093	40	RETICULOPHRAGMIUM	PLACENTA	03010091	88
B	03840101	41	GLOBOCASSIDULINA	SUBGLOBOSA	03010092	150
B	03850901	42	PULLENIA	BULLOIDES	03010093	40
B	03900401	43	HOEGLUNDINA	ELEGANS	03010094	78
B	03010077	44	PLACENTAMMINA	PLACENTA	03010095	83
B	03010078	45	PLACENTAMMINA	COMPLANATA	03010096	115
B	03010079	46	REOPHAX	SP.1	03010098	76
B	03010070	47	RHABDAMMINA	DISCRETA GR	03010099	106
B	03021301	48	SACCAMMINA	SPHAERICA	03010104	53
B	03023201	49	GLOMOSPIRA	GORDIALIS	03010106	57
B	03030105	50	HORMOSINA	GLOBULIFERA TRINITAT	03010108	62
B	03210701	51	SIGMOMORPHINA	REGULARIS	03010109	143
B	03010052	52	STILOSTOMELLA	SPINESCENS	03010110	153
B	03010104	53	ERATIDUS	FOLIACEUS	03010113	92
B	03010130	54	HAPLOPHRAGMOIDES	SP 1	03010114	116
B	03060116	55	TROCHAMMINA	DIAGONIS	03010115	145
B	03010134	56	REOPHAX	DUPLEX	03010116	63
B	03010106	57	AMMOMARGINULINA	MACROSPIRA	03010117	117
B	03010171	58	RETICULOPHRAGMOIDES	SPS	03010118	102
B	03700102	59	ORDORSALIS	UMBONATUS	03010119	118
B	03010072	60	DENDROPHYRA	LATISSIMA	03010121	93
B	03010073	61	DENDROPHYRA	ROBUSTA	03010122	151
B	03010108	62	EGGERELLA	SP 1	03010123	104
B	03010116	63	RECURVOIDES	WALTERI GR	03010124	94
B	03010140	64	HAPLOPHRAGMOIDES	EGGERI	03010126	35
B	03020201	65	RHIZAMMINA	INDIVISA	03010127	1
B	03023101	66	AMMODISCUS	CRETACEUS	03010129	154
B	03040113	67	HAPLOPHRAGMOIDES	WALTERI	03010130	54
B	03010066	68	CHILOSTOMELLOIDES	SP 1	03010131	89
B	03320201	69	LOXOSTOMUM	TERETUM	03010133	90
B	03710259	70	HANZAWAIA	BOUEANA	03010134	56
B	03430102	71	ASTERIGERINA	GUERICHI	03010135	95
B	03710201	72	HETEROLEPA	DUTEMPL. PRAECINCTUS	03010137	129
B	03010144	73	STILOSTOMELLA	HIRSUTA	03010138	22
B	03060115	74	TROCHAMMINA	INFLATA	03010139	2
B	03710212	75	CIBICIDES	LOBATULUS	03010140	64
B	03010098	76	SPIROPLECTINELLA	CARINATA	03010141	3
B	03201103	77	LENTICULINA	CULTRATA S.L.	03010142	4
B	03010094	78	RETICULOPHRAGMIUM	ACUTIDORSATA	03010143	18
B	03350110	79	TURRILINA	ALSATICA	03010144	73
B	03850408	80	NONION	GRANOSUM	03010148	23
B	03010154	81	GYROIDINA	SPP.	03010152	84
B	03010080	82	LAGENAMMINA	SP.1	03010154	81
B	03010095	83	RETICULOPHRAGMIUM	ROTUNDIDORSATA	03010158	109
B	03010152	84	ADERCOTRYMA	AGTERBERGI	03010159	85
B	03010159	85	REOPHAX	GUTTIFERA	03010166	96
B	03010173	86	DOROTHIA	SEIGLIE	03010167	97
B	03010030	87	GYROIDINA	SOLDANII MAMILLATA	03010169	24
B	03010091	88	RETICULOPHRAGMIUM	AMPLECTENS	03010170	119
B	03010131	89	RETICULOPHRAGMOIDES	JARVISI	03010171	58
B	03010133	90	HYPERAMMINA	SUBNODOSIFORMIS GR	03010173	86
B	03200118	91	NODOSARIA	EMACIATA	03010176	130
B	03010113	92	LABROSPIRA	SCITULA	03010182	5
B	03010121	93	PARATOCHAMMINOIDES	IRREGULARIS	03010187	160
B	03010124	94	KARRERIELLA KARRERUL	HORRIDA	03010190	144
B	03010135	95	REOPHAX	PILULIFER	03010205	112
B	03010166	96	HAPLOPHRAGMOIDES	SPP	03010217	120
B	03010167	97	RECURVOIDES	SPP	03010220	103
B	03010003	98	NODOSARIA	LONGISCATA	03010222	146
B	03010074	99	DENDROPHYRA	EXCELSA GR	03010235	131
B	03010088	100	REPMANINA	CHAROIDES	03010236	132
B	03010089	101	KALAMOPSIS	GRZYBOWSKII	03020201	65
B	03010118	102	PRAECYSTAMMINA	GLOBIGERINAEFORMIS	03021301	48
B	03010220	103	TROCHAMMINA	PSEUDOVESICULARIS CF	03023101	66
B	03010123	104	KARRERIELLA KARRERUL	CONVERSA	03023201	49
B	03010083	105	GLOMOSPIRA	IRREGULARIS	03023301	110
B	03010099	106	SPIROPLECTINELLA	WILCOXENSIS	03030105	50
B	03010069	107	BATHYSIPHON	SP 1	03040111	113
B	03010075	108	HORMOSINA	OVULUM	03040113	67
B	03010158	109	REOPHAX	SUBNODULOSA	03040608	111
B	03023301	110	AMMOLAGENA	CLAVATA	03050103	122
B	03040608	111	CYCLAMMINA	GARCILASSOI CF.	03050115	74
B	03010205	112	TROCHAMMINA	PSEODOVESICULARIS CF	03060116	55
B	03040111	113	HAPLOPHRAGMOIDES	KIRKI	03060118	147
B	03010084	114	GLOMOSPIRELLA	DIFFUNDENS CF.	03070206	133
B	03010096	115	RETICULOPHRAGMIUM	SP 1	03071601	155
B	03010114	116	CRIBROSTOMOIDES	SUBGLOBOSUS	03072102	25
B	03010117	117	CYSTAMMINA	PAUCILOCULATA	03110307	36
B	03010119	118	TROCHAMMINA	RUTHVEN MURRAYI	03120606	6
B	03010170	119	TROCHAMMINA	SPP.	03200101	134
B	03010217	120	CIBICIDES	SPP	03200118	91
B	03010087	121	AMMODISCUS	PLANUS	03201101	135
B	03050103	122	SPIROPLECTAMMINA	SPECTABILIS	03201103	77
B	03010009	123	CIBICIDOIDES	ALLENI	03210701	51
B	03010012	124	CIBICIDOIDES	EOCAENUS	03310101	7
B	03010016	125	PLANULINA	COSTATA	03320201	69
B	03010019	126	ANOMALINOIDES	CAPITATUS	03330101	8
B	03010047	127	NODOSARIA	CONSOBRINA	03350108	26
B	03010061	128	UVIGERINA	SP 1	03350110	79
B	03010137	129	SPIROPLECTINELLA	DEPERDITA	03350123	9
B	03010176	130	PERCULTAZONARIA	WETHERELLII AFF	03350126	161
B	03010235	131	NEOEPONIDES	KARSTENI	03350127	10
B	03010236	132	PLANULINA	SPP.	03350134	136
B	03070206	133	GAUDRYINA	HILTERMANNI	03360104	27
B	03200101	134	NODOSARIA	MINOR	03360117	11
B	03201101	135	LENTICULINA	CULTRATA S.S.	03420101	12
B	03350134	136	BULIMINA	B.SP.KING	03420102	137
B	03420102	137	PULSIPHONINA	PRIMA	03430101	28
B	03710232	138	CIBICIDES	SUCCEDENS	03430102	71
B	03010011	139	CIBICIDOIDES	MEXICANUS	03600101	13
B	03010018	140	ANOMALINOIDES	ACUTA	03610103	29
B	03010041	141	PERCULTAZONARIA	WETHERELLII	03700102	59
B	03010036	142	STENSIOINA	BECCARIIFORMIS	03700103	14
B	03010109	143	CLAVULINOIDES	ANGLICUS	03700107	162
B	03010190	144	CIBICIDES	PROPRIUS	03700119	148
B	03010115	145	RECURVOIDES	SP 1	03710201	72
B	03010222	146	CASSIDULINA	SPP	03710205	38
B	03060118	147	TROCHAMMINA	GLOBIGERINAEFORMIS	03710206	30
B	03700119	148	NUTTALLIDES	TRUMPYI	03710211	163
B	03850903	149	PULLENIA	QUATERNARIA	03710212	75
B	03010092	150	RETICULOPHRAGMIUM	PAUPERA	03710216	15
B	03010122	151	PARATOCHAMMINOIDES	SUBCORONATUS CF	03710232	138
B	03010021	152	OSANGULARIA	EXPANSA	03710259	70
B	03010110	153	DOROTHIA	BELOIDES	03820103	16
B	03010129	154	RZEHAKINA	MINIMA	03830101	31
B	03071601	155	CLAVULINA	PARISIENSIS	03840101	41
B	03010026	156	ALABAMINA	SOLNASENSIS	03840102	32
B	03010040	157	FISSURINA	SP 2	03850400	164
B	03010046	158	LENTICULINA	PSEUDOVORTEX CF.	03850401	19
B	03010062	159	DENTALINA	EOCENICA	03850407	33
B	03010187	160	GAVELINELLA	SPP	03850408	80
B	03350126	161	BULIMINA	DENTICULATA	03850901	42
B	03700107	162	EPONIDES	LUNATA	03850902	37
B	03710211	163	CIBICIDES	VOLTZIANA	03850903	149
B	03850400	164	NONION	SPP.	03900401	43

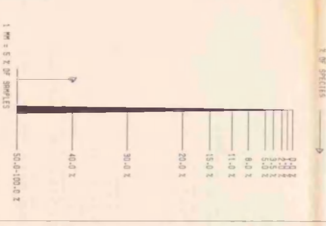
SAMPLE TOTAL

SPECIMEN TOTAL

OTHER FOSSILS

A/B	SIPM CODE	REG NO.	SCIENTIFIC NAME		INDEX	REG NO.
B	02010032	165	GLOBIGERINOIDES	QUADR TRILOBA	02000000	190
B	02010040	166	ORBULINA	SP 1	02010000	167
B	02010000	167	NEOGLOBOQUADRINA	CONTINUOSA	02010001	179
B	02010011	168	GLOBIGERINA	PRAEBULLOIDES SL.	02010002	172
B	02010026	169	GLOBIGERINELLA	OBESA	02010004	178
B	02010027	170	GLOBIGERINA	WOODI	02010011	168
B	02010048	171	NEOGLOBOQUADRINA	OPIMA GRP.	02010019	173
B	02010002	172	GLOBIGERINA	PRAEBULLOIDES PRAE	02010023	177
B	02010019	173	GLOBIGERIINA	ANGULISUTURALIS	02010026	169
B	52000000	174	OSTRACOD	SPP.	02010027	170
B	62000000	175	FISH	REMAINS	02010028	200
B	70100100	176	COSCINODISCUS	SPP.	02010029	196
B	02010023	177	GLOBIGERINA	CIPEROENSIS AFF.	02010032	165
B	02010004	178	GLOBIGERINA	PRAEBULLOIDES OCCL	02010039	201
B	02010001	179	GLOBOROTALOIDES	SUTERI	02010040	166
B	02570109	180	GLOBOROTALIA	SCITULA	02010042	191
B	02580116	181	GLOBIGERINA	ANGIPOROIDES	02010043	197
B	02580117	182	GLOBIGERINA	AMPLIAPERTURA	02010046	185
B	02580124	183	GLOBIGERINA	OUACHITAENSIS	02010048	171
B	02580159	184	GLOBIGERINA	OFFICINALIS	02010052	188
B	02010046	185	GLOBIGERINA	PRAEBULL. LEROYI	02010053	195
B	10000001	186	CENOSPHAERA	SP.	02010055	203
B	10100001	187	CENODISCUS	SPP	02010056	198
B	02010052	188	GLOBIGERINA	LINAPERTA GR	02010061	204
B	70100101	189	COSCINODISCUS	SP.1	02010064	192
B	02000000	190	PLANKTONIC	FORAMINIFERA SPP.	02010065	193
B	02010042	191	ACARININA	SP 2	02510700	199
B	02010064	192	ACARININA	SPP.	02560209	194
B	02010065	193	ACARININA	PENTACAMERATA AFF.	02570109	180
B	02560209	194	PSEUDOHASTIGERINA	WILCOXENSIS	02580116	181
B	02010053	195	GLOBIGERINA	TRILOCULINOIDES	02580117	182
B	02010029	196	GLOBANOMALINA	PSEUDOBULLOIDES	02580118	205
B	02010043	197	EOGLOBIGERINA	TRIVIALIS CF.	02580124	183
B	02010056	198	EOGLOBIGERINA	TRIVIALIS AFF	02580159	184
B	02510700	199	GUEMBELINA	SP.	10000001	186
B	02010028	200	GLOBANOMALINA	COMPRESSA CF.	10100000	202
B	02010039	201	BIGLOBIGERINELLA	ASPERA	10100001	187
B	10100000	202	CENODISCUS	LENTICULARIS	52000000	174
B	02010055	203	EOGLOBIGERINA	TRIVIALIS	62000000	175
B	02010061	204	GUEMBELINA	SPP.	70100100	176
B	02580118	205	GLOBIGERINA	TRILOCULINOIDES GR.	70100101	189

LEGEND



REMARKS

1 MM = 5 % OF SAMPLES

A: INCLUDE SPECIES IN PERCENTAGE CALCULATIONS

B: EXCLUDE SPECIES IN PERCENTAGE CALCULATIONS

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UCL ZONES

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TERTIARY N. SEA.

AUTHOR: G. GILLMORE

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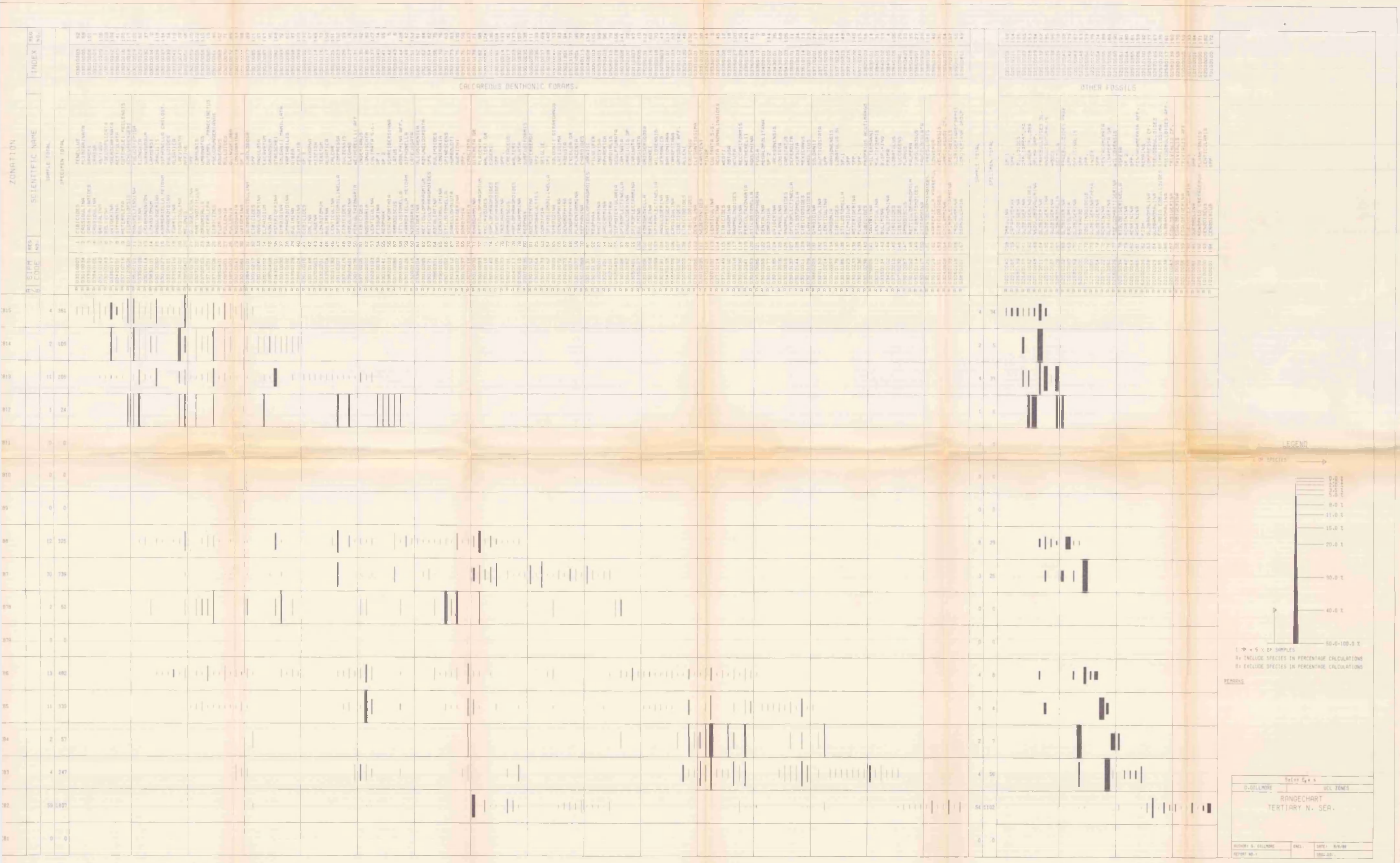

1 MM = 5 % OF SAMPLES

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REMARKS

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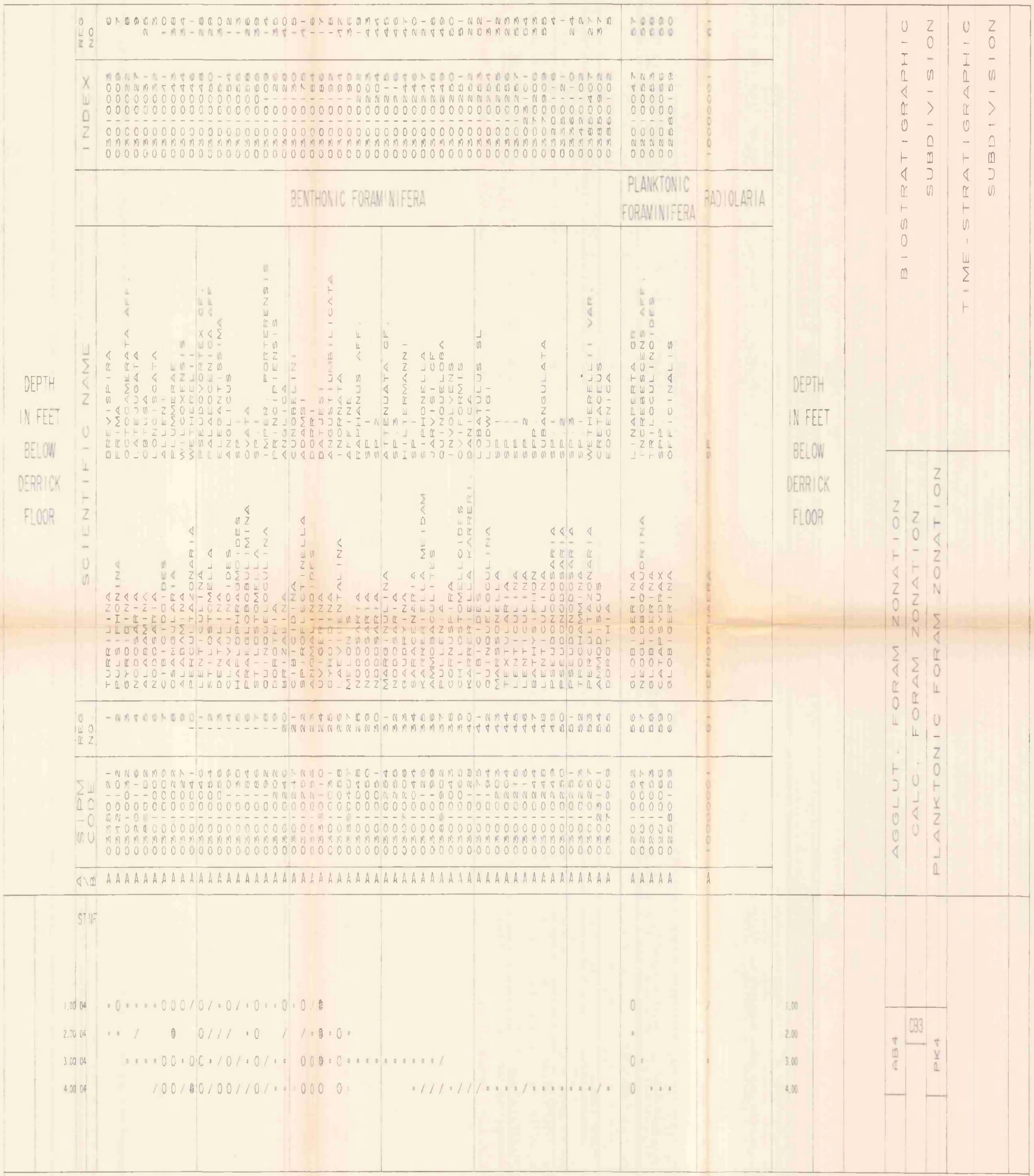

SYMBOL LEGEND

◦	CAVED
	REWORKED
▮	BARREN SAMPLE (NF)
•	1 SPECIMEN
/	2 -5 SPECIMENS
O	6 -20 "
●	21-100 "
▮	& 100 "

SAMPLE TYPES (ST) :

04 SURFACE SAMPLE

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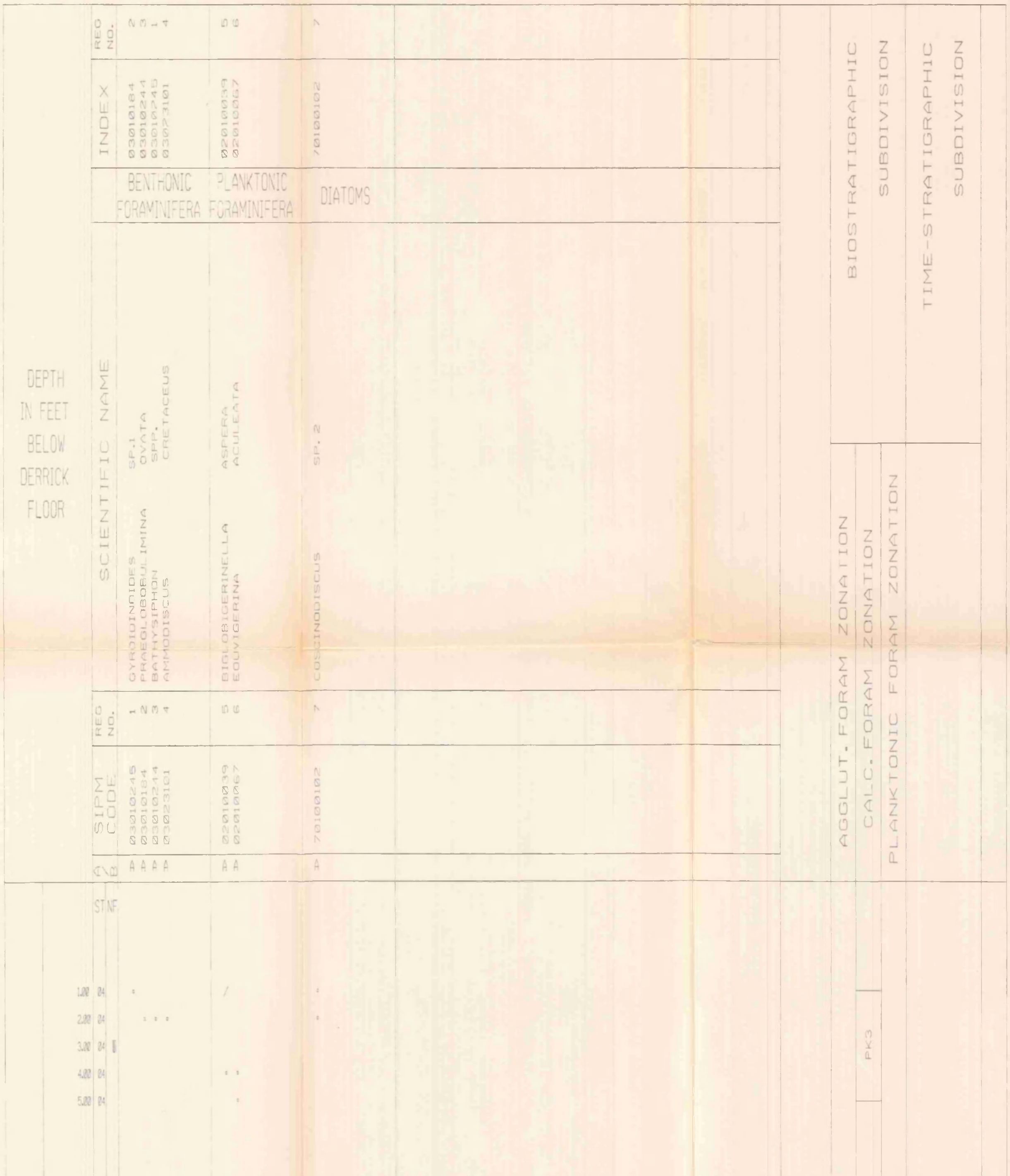

SYMBOL LEGEND

- ∂ CAVED
- REWORKED
- ▮ BARREN SAMPLE (NF)
- · 1 SPECIMEN
- / 2 -5 SPECIMENS
- O 6 -20 "
- ● 21-100 "
- ■ >100 "

SAMPLE TYPES (ST):

04 SURFACE SAMPLE

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