THE OLIGOCENE OF SOUTHERN AUSTRALIA: ECOSTRATIGRAPHY AND TAXIC OVERTURN IN NERITIC FORAMINIFERA

Graham David Moss

Thesis submitted for the degree of
Doctor of Philosophy
in
The University of Adelaide
(Faculty of Science)

January 1995

Awarded 1995

ABSTRACT

The widening of the Southern Ocean and development of the circum-Antarctic current during the late Eocene and the Oligocene had profound effects on global oceanic circulation and climatic patterns. Environmental perturbations are 3rd order sea-level fluctuations reflected in the Exxon eustatic-cycle chart and glacial cycles that are recorded in deep-sea stable isotope studies, both are at level III timescales (0.5-3Ma). Few palaeobiological studies have attempted to track oscillations within these timescales on continental margins. Do fluctuations in physical environmental parameters, many contingent upon the transformation to a glaciated world, coincide with faunal changes?

This study investigates a late Eocene to Miocene succession of diverse mid-latitude assemblages of foraminifera from carbonates and calcareous muds and sands on the southern Australian margin It contrasts foraminiferal profiles from the restricted St Vincent and Murray Basins with the Otway Basin that was more exposed to oceanic conditions. There are four prominent episodes of environmental change that can be detected using the proxies of oscillations in the deep-sea stable isotope curves and the Exxon sea-level curve: i) The terminal Eocene corresponds to a glaciation and a regression in the local Aldingan Stage, ii) the early/late Oligocene has a second glaciation and a regression at the Willungan/Janjukian Stage boundary, iii) there is a late Oligocene to Miocene succession of transgressions (TB1), with associated regressions and a negative excursion in the oxygen isotope curve, and iv) a glaciation and another regression at the Oligo-Miocene boundary that is followed by a warm ingression in the earliest Miocene.

The first and last appearances of some 450 benthic and 40 planktonic foraminiferal species and the relative abundances of selected taxa were compiled from 12 logged and correlated stratigraphic sections. Using graphic correlation techniques, composites of species ranges were assembled for the St Vincent, Murray and Otway Basins. These composites were then used to construct a grand composite.

The strategy followed well defined steps:

i. Sections were correlated to palaeomagnetic chrons, tropical foraminiferal zones, Antarctic zones and local foraminiferal events. The geochronology was then divided into Intervals based upon the local planktonic events, this formed a framework against which the composite pattern of faunal change could be matched.

ii. Profiles of change in relative abundances and comings and goings were compiled for each section and these were used to identify 3rd order sequence stratigraphic cycles.

iii. Patterns of first and last appearances and cluster analysis identified faunal breaks that were then compared to patterns of change in the sequence stratigraphy and the oxygen isotope curve.

i. There is a major faunal break in the succession of benthic species at the Eocene-Oligocene boundary and this is subsequently followed by a speciation and immigration of taxa. This sweeping event is recorded in both the restricted St Vincent Basin and the more open marine Otway Basin.

ii. The Aldingan-Willungan Stage boundary (lower part of Chron C12r) coincides with increasing faunal change beginning at the maximum flooding surface (TA4.4) in the earliest Oligocene. This is clear from cluster analysis that shows significant change in faunal composition in all sections from the Otway Basin. This faunal break also coincides with a lithological change to a chert-carbonate association in the St Vincent and Gambier Basins, implying a nutrient change as a forcing factor.

iii. Compared to the Eocene-Oligocene boundary, the middle Oligocene regression in the Otway Basin shows less turnover and coincides with the appearance of prominent dolomitization that can be traced further east and to the St Vincent Basin. There is major faunal change at an equivalent level in the Murray Basin following a major regressive episode.

iv. The late Oligocene to Miocene in the Otway Basin records a major transgressive phase, associated with another chert-carbonate association, and shows the incremental addition of new species and a return of warmer water taxa. There appears to be relatively short episode in the early Oligocene, where robust cosmopolitan faunas dominated that was succeeded by increasing endemism, highlighted by increasingly dissimilar assemblages, in the late Oligocene.

v. There is a relatively minor faunal change at the regression and glaciation close to the Oligocene-Miocene boundary.

vi. Transgressive sequence tracts correspond to the alternations of infaunal (for example, Uvigerinidae, Bolivinidae, ***Pullenia*** , ***Cassidulina***, and unilocular taxa) and epifaunal taxa (***Cibicides***, ***Cibicidoides***, ***Anomalinoides***, miliolids and ***Gyroidinoides***) and were often preceded by type 1 sequence boundaries, suggesting a recolonization with reorganised benthic assemblages.

vii. Highstands, when preserved in the stratigraphic record and most often before minor sea-level falls, have higher numbers of infauna and display reduced taxic overturn.

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

SIGNED:..DATE:....21/2/95..............................

'To see a world in a grain of sand,
A heaven in a wild flower,
To hold infinity in the palm of your hand,
And eternity in an hour.'

From *Auguries of Innocence* - William Blake

Acknowledgements

I would like to thank: Dr Brian McGowran for suggesting this fiercely challenging project in the first place, considerable discussion to reach the final product and most importantly the most intellectually profound period of my life; Amanda Circosta and Dr Qianyu Li for nurturing me; Karen Lablack, Dr Neville Alley and Brian Logan of Mines and Energy South Australia for logistical support; Rick Barrett for assistance with the preparation of plates; Marcus Brownlow for patient support with multivariate analysis; Dr Neville Exon and the Australian Geological Survey Organisation (Marine Geoscience Division) for a heuristic interregnum in the Indian Ocean; Drs. Pat James and Vic Gostin for timely strategical support; Drs. Richard Jenkins and David McKirdy for help with keeping me honest; Hew Rosser, John Terlet, Ken Crocker, Vanessa Hutchens and Roman Polewski of the Centre for Electron Microscopy and Microstructure Analysis (Adelaide) for continuous assistance; Jane Eblen for support through the years; friends and colleagues from the Dept. of Geology and Geophysics who fortify me; The Smiths; Dr R.H. Blyth; and finally my family especially Val and Stan, the eternal sufferers … apparently the destiny of all parents.

This is a contribution to a long and inspiring tradition of southern Australian and New Zealand studies and I would like to pay particular tribute to the work of Dr N. H. Ludbrook, J. M. Lindsay, the late Dr. N. de B. Hornibrook and my friends Brian McGowran and Amanda Circosta. The project was initially funded by an Australian Post-graduate Research Award.

CHAPTER 5

LIST OF FIGURES

Facing pages...

APPENDICES LIST

Outline of thesis

Chapter 1 introduces the problems that this research addresses within the context of recent studies of the distribution of foraminiferal faunas in neritic environments, focussing on sea level change. Chapter 2 outlines environmental perturbations involving climate and oceanic circulation change associated with the Eocene to Miocene global transformation that are considered distal causes of extinction and speciation. In Chapter 3 the chronostratigraphic framework is discussed to which observations of species comings and goings are anchored. Correlation is a key theme as the information comes from disparate sedimentary basins on the southern Australian margin. With this infrastructure in place Chapter 4 describes biofacies changes, of taxa classified according to infaunal and epifaunal morphotypes, from each of the studied locations and an interpretation of the sequence stratigraphic signals. Chapter 5, starting from records of simple presence and absence of species in each sample from each section, builds a composite succession of faunas from each basin that can finally be matched to the sequence stratigraphy and the oxygen isotope curve. Composites are constructed using graphic correlation and patterns are analysed using cluster analysis. Finally, Chapter 6 concludes with a summary of the findings of this study.

CHAPTER 1

INTRODUCTION

1. THE PROBLEM

1.1 Introduction

Correlations of taxic overturn in foraminifera with changes in the physical environment have mostly focussed on pelagic sections that tend to be comparatively complete and therefore permit a closer tracking of assemblages through time. The input from neritic studies has been relatively poor, but with the combination of a firm chronostratigraphy and advances in understanding of benthic assemblage succession, subsumed under ecostratigraphy, recent contributions have provided valuable insights. This study describes patterns from the benthic foraminiferal succession in the excellent Eocene to Miocene extratropical carbonate record on the southern Australian margin at a crucial time in Cainozoic climate history. As Miller (1994) has pointed out, the margins of continents are recorders of the processes that control sedimentation including sea level change. But, they also record the responses of benthic foraminifera to processes occurring at a variety of different timescales in different parts of the geobiosphere. These may include facies changes at the scale of Milankovitch climatic oscillations (20-400 kyrs) to environmental changes due to supercycle sea level fluctuations (3-50 Ma) (Arthur & Garrison, 1986; Vail et al., 1991). Matching biotic and abiotic patterns of change may say something about the processes involved.

Biostratigraphy in the marine record depends upon the recognition of biozones (the appearance, abundance changes and disappearance of taxa) but little is known about the controls on the durations of biozones based upon the main groups of microfossils or why there may be an 'average' duration. Another related and more long-term aim of closely studying organisms through geological time is to address the gap between available data and an extensive body of theory on causes of evolutionary change (for discussions see Van

Valen, 1973; Berggren, 1978; Stenseth and Maynard Smith, 1984; Vrba & Eldredge, 1984; Vrba, 1985; Allmon and Ross, 1990). Can the timescales of turnover patterns in the benthic foraminifera on continental margins say anything about the relative importance of change in the physical environment?

Charles Darwin in *Origin of Species* regarded the question of climatic change as a dominant control in evolutionary change with scepticism, and said (p.140, 1964):

> ...But the degree of adaptation of species to the climates in which they live is often overrated...We have reason to believe that species in a state of nature are closely limited in their ranges by the competition of other organic beings quite as much as, or more than, by adaptation to particular climates,

...but empirical testing of either proposition was hampered by a lack of experimental constraint. A pivotal question remains: Is it possible to extrapolate mechanisms operating at ecological timescales (e.g. industrial melanism in European moths) to patterns of taxic change at geological timescales?

The problem of accurately recording physical environmental and biotic change and to chronologically correlate them was an obstacle. One side of the equation has been partially solved by developments in the disciplines of geochemistry and geophysics that have enabled a sophisticated estimation of past physical environmental parameters. Stable isotopes and seismic stratigraphy have become proxies for temperature, ice volume, productivity and sea level change; though disentangling which signal correlates with what requires further refinement (Miller et al., 1991). The other side has benefited by advances in techniques that could temporally isolate these events, such as, radiometric and geomagnetic correlation (Prothero, 1994b).

Biotic change in this study means biofacies, cladogenetic and temporary migratory events. The focus is at the level of 3rd order sequence stratigraphic cycles (0.5-3 million years). Species are recognized as individuals occupying discrete temporal and geographical domains and records are the simple presence and absence of taxa, and so there is therefore no attempt to investigate phylogenetic transition (anagenesis).

Questions addressed by this research include:

1. Are sea level and temperature change prominent controls on the foraminiferal succession in neritic environments at the scale of third order timescales?
2. If sea level change is important, what parts of 3rd order sea level cycles are most significant?

Proximate controls on biotas may be associated with oxygen crises and changes in substrate forced by transgressions and maximum marine encroachment (Baird & Brett, 1991; Fürsich et al., 1991; Sageman et al., 1991; Savrda et al., 1991; Vail et al., 1991). More significant perturbations may accompany the reduction or expansion of available habitat during regressions (Johnson, 1974; Jablonski, 1980, 1985).

3. Do patterns of turnover, in response to sea level change, differ during times of warm equable climates ('greenhouse') and times of steeper latitudinal temperature gradients with increased seasonality and intensified oceanic mixing ('icehouse')?

1.2 Proximate causes of faunal change

A variety of workers have argued that sea level change is a significant control on the faunal succession on continental shelves (Newell, 1967; Berry & Boucot, 1973; Johnson, 1974; Buzas & Culver, 1984; Fürsich et al., 1991; Gaskell, 1991; Mancini & Tew, 1991; McGhee et al., 1991; McGowran et al., 1992). Others have argued that sea level fluctuation had a trivial impact and proposed temperature as a more important proximate cause of extinction (Stanley, 1984a,b; Raffi et al., 1985). A few studies have confronted specific aspects of sea level cycles, such as the relative importance of transgressive and regressive events at the scale of short-term (3rd order) fluctuations, as opposed to the effects of lower frequency cycles, e.g. supposed 2nd order cycles (Rollins et al., 1979; Jablonski, 1980; Hallam, 1987; Fürsich et al., 1991; Olóriz et al., 1993). While some have investigated sea level change by observing assemblages characteristic for particular depths (Vella, 1962; Berggren and Aubert, 1983; Inoue, 1989; Barbin & Keller-Grünig, 1991; Murray, 1991a). Investigations of the coincidence of evolutionary events and sea level fluctuation have sometimes struggled because of complications introduced by differential rates of sedimentation, the presence of hiatuses on continental margins and lack of chronological control (Loutit et al., 1988; Leckie et al., 1992).

Species-area effects have been key themes in discussions about the relative significance of sea level change as a causal mechanism behind taxic evolution and many of the ideas have been cloned from the seminal ecological work on island biogeography of MacArthur and Wilson (1967). Theories link diversity change with the reduction or expansion of available substrate and resources. Hallam (1978, p.23) argued that 'times of low sea level or regression increase environmental stress and cause extinction rates to increase'. While Buzas and Culver (1984) recorded shorter durations for species observed at shallower depths and in a later study (Buzas and Culver, 1989) they concluded that the geographic distribution of foraminiferal species on a continental margin controlled their temporal distribution ; the more extensive the geographic distribution of a species the more likely it would be to have a longer duration. Geographic isolation appears to be the precursor to extinction or, as Stanley (1984b) put it, the reduction of the distribution and abundance of a taxon to zero. It is implied that there is a quantitative relationship between the magnitude of environmental perturbation, ie. the absolute reduction of shelf space, and the number of species that become extinct.

Hypotheses about adaptative strategies of organisms have been frequently summarized in terms of the adaptive specialization and generalization (e.g. Jackson, 1974; Hallam, 1978,1987; Jablonski, 1980; Sjoerdsma and Van der Zwaan, 1992). Jablonski (1980) argued that species of molluscs adapted to eurytopy (broad tolerance range) and having high dispersal capabilities, as well as greater geographic ranges and geologic durations, are characteristic of the nearshore end of the nearshore-offshore gradient. McGhee et al. (1991) echoed this assertion by suggesting that shallow-water, nearshore communities seem to be more immune to sea level change and, at the time of a regression, species inhabiting basin centres become fragmented and undergo allopatric speciation, while basin margin species experience habitat expansion with consequent population increases and geographical dispersal. Johnson (1974) apparently concluded the opposite suggesting that 'perched' faunas, stenotopic taxa uniquely adapted to equable and stable environments, were characteristic of shallow epicontinental seas and much more susceptible to extinction. They may be extremely susceptible to even modest changes in sea level (Hallam, 1990). Perhaps a general rule is too simplistic an argument for a explanation of extinction events in disparate fossil groups from differing geographic localities. As Jablonski (1985) has pointed out, turnover at times of global regression may be remarkably different in faunas occupying shallow epicontinental seas as opposed to those from conical oceanic islands.

1.3 Preconditioning of the biosphere

Hallam (1978, 1987, 1990) argued that there is a strong correlation between the stasis of the environment, ie. a prolonged transgression or highstand in sea level, and the likelihood that stenotopy (narrow tolerance range) is established in biotas within that environment, making the taxa vulnerable to extinction during the next regressive episode. Earlier Bretsky (1969) had concluded, from an analysis of Paleozoic benthic communities, that the frequency of the abiotic perturbation is a dominant control. He argued that nearshore species subjected to sea level change had adapted to the labile conditions and therefore exhibited less community turnover coincident with increasing abiotic or biotic perturbation. Offshore species or those subjected to the 'monotonous outer sub-littoral environment' appear to compose the susceptible stenotypic communities. This explanation is contingent upon communities being subjected to frequent changes in abiotic perturbation (sea level change); in other words they are preconditioned. Survival of taxa is seen as hierarchical and higher taxa persist longer because of a larger genetic pool (Vrba & Eldredge, 1984). This is controversial , as it is doubtful whether ecological processes are hierarchical themselves (Rahel, 1990), and that the turnover of species at geological timescales routinely occur within Gould's second tier (Gould, 1985; Bennett, 1990) (table 1).

Some questions that emerge from this are: i) At what scale do faunal changes occur in neritic environments?, ii) What is the relative importance of the frequency and magnitude of transgressive-regressive cycles? and , iii) Is it possible to identify the so-called 'preconditioned configuration' of the biota and physical environment in these neritic settings?

CYCLES AND PROCESSES	PROPOSED BIOTIC RESPONSE
1st Order tectonic events operating on a regional and global scale - ie. ridge volume changes, crustal extension	Phanerozoic supercycles — Mass extinction events — Control on the longevity of 'higher' taxa
2nd Order (3-50Ma) tectonic and ocean basin volume changes resulting from subsidence/uplift, major episodes of continental flooding	mass extinction periodicity hypotheses some of above and below
3rd Order (0.5-3Ma) glacio-eustasy controlled by climate change, resulting in; water volume changes (3rd Order sequence stratigraphic signals)	control of species longevity/species durations (perhaps resulting in foraminiferal zonation), 2nd tier controls (Gould, 1985), changes of diversity-dominance structure in biofacies of habitat specific species (DiMichele, 1994) perhaps also occurring below...
4 to 6th Order (0.1-0.5Ma) eustatic changes resulting in parasequences to sequence tracts and 3rd order cycles	species and community evolution, mass killings, anoxic events and reef drownings etc. — ecological processes (competitive exclusion) especially important at the parasequence level, 1st tier processes (Gould, 1985; Bennett, 1990)

Table 1 Hypothetical responses of the biota to sea level change at different timescales, see sections 1.3 & 1.4 for discussion.

If environmental stasis is rare, and consequently specialized taxa are relatively rare, then it may be expected that the majority of species durations will be shorter, and populations much

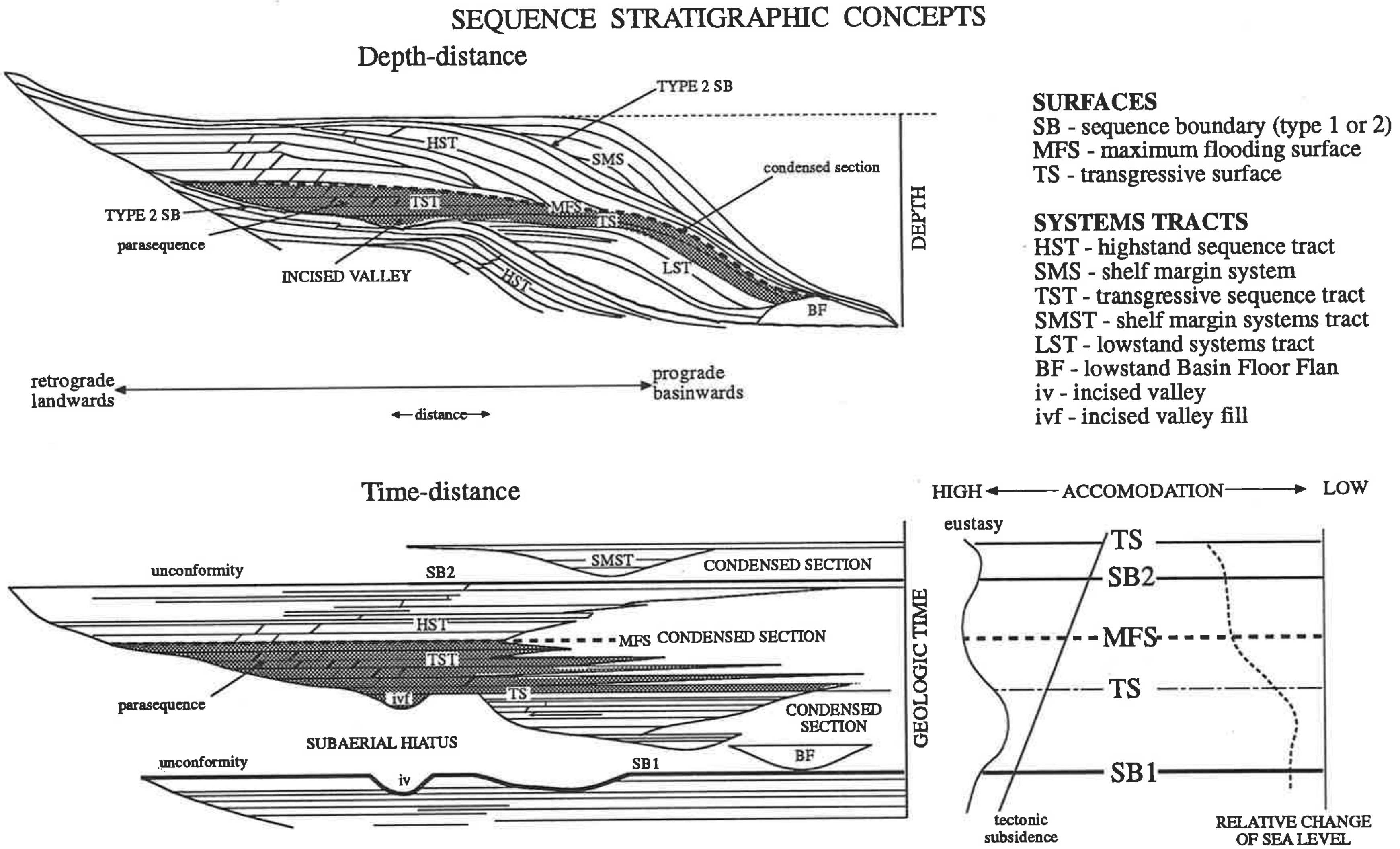


Figure 1 - Sequence stratigraphic concepts; A diagrammatic representation of the relationship through geologic time of the processes of tectonic subsidence and eustasy to patterns of sequence tracts and boundaries within 3rd order cycles. The upper figure shows genetically related packets of sediment versus depth while the lower depicts the same packets versus time as they are deposited on the continental margin. Tectonic subsidence is considered to be uniform, while eustatic rises and falls control the landward and basinward movement of sediment. Adapted from Vail et al.(1991)

higher. Given these assumptions it is of some interest to observe patterns of taxic abundance and duration within a variety of differing timescales. Many studies have attempted to relate ecological to geological timescales, and as Moore (1955) has argued, it may be that palaeontological studies will investigate causes of evolution via analyses of successional change because of the timescales involved. It may also be that ecological models are a poor analogue for past relationships between the biosphere and the physical environment because the present 'icehouse' mode is comparatively rare for the Phanerozoic (Kauffman, 1987; Hallam, 1990).

1.4 Sequence stratigraphic concepts

Sequence stratigraphy is based upon the recognition of genetically related packets of sediment in outcrop and subsurface data, including seismic profiles. Characteristic isochronous deposits can be identified on sedimentilogical, biostratigraphical and geochemical evidence that record facies changes and, by extrapolation, sea level change in different parts of the sedimentary basin. Figure 1 shows an ideal representation of chronologically equivalent packets labelled with sequence stratigraphic terminology. The upper figure shows packets of sediment on a basin margin with the vertical axis representing depth and the horizontal axis by distance. While in the lower figure the vertical axis represents time so that the packets are disarticulated into isochronous levels. Gaps are hiatuses that result from erosion or non-deposition at times of rapid sea level fall (SB1) or times of maximum encroachment of the sea and therefore reduced sedimentation (MFS). The packages of sediment are each a result of changes in relative sea level, contingent upon variations in ocean/basin volume and continental topography, that in turn changes the amount of accomodation available for sedimentation. Variations in sea level also result in base-level changes that determine the source of sedimentation to the continental shelf, e.g.when the base-level is low, terrigenous supply increases and when it is high, offshore marine supply increases.

A *Lowstand Systems Tract* (LST) is produced when the relative sea level is lowest, producing a low base-level, and therefore increased terrigenous input. Characteristic sedimentilogical features on continental margins include, incised valleys, sediment slumping, turbidites and features characteristic of fluvial/deltaic processes. The shelf is expected to become more heterogeneous, faunas become patchy and provinciality is favoured as topographic features may determine habitat variability. Hallam (1992) argues that brief lowstands do not appear to correlate with prominent extinction events in the Phanerozoic record.

A rising sea level raises the base level, terrigenous input decreases, accomodation increases and marine sedimentation proceeds landward (retrogrades). The result is a *Transgressive Sequence Tract* (TST) with sands, muds and carbonates deposited in the previously incised valleys. The location of faunas on the shelf is crucial; carbonates close to the shelf margin may be drowned while nearshore environments may expand vertically and landward. Changes in faunal assemblages and abundance are expected to show evidence of deepening-upward (Armentrout, 1992). Vail and colleagues (1991) controversially, as they do not provide any evidence or explanation, suggest that this is typically the part of a 3rd order cycle that coincides with stage boundaries and the most faunal change. The claim for faunal change may be substantiated by Rey and others (1993) who provide some evidence from Liassic deposits of the Aquitaine basin of 'faster species renewal' in the TST when compared to the highstand systems tract. If this is the case, one possible explanation may be that this is related to the oxygen crisis associated drowning by deep waters (Hallam, 1992), although Fürsich and others (1991) attributed more importance to substrate changes during transgressions and oxygen crises with regressions as controls on a succession of Jurassic molluscs. The former hypothesis has recently been supported by Brett and Baird (1992) who concluded, from data collected from the Middle Devonian Hamilton Group in the Appalachian Basin, that major faunal changes were associated with condensed early highstands while sequence boundaries appeared to have little effect. Contemporary studies of the sea level change have focussed on fluctuations in oxygen and nutrient supply as a dominant control on faunal change (McGowran & Beecroft, 1987; Sageman et al, 1991; Sjoerdsma and Van der Zwaan, 1992; Van der Zwaan and Jorissen, 1993).

The rate of regression is suggested to be critical in determining the magnitude of the impact on the continental shelf. Valentine and Jablonski (1991) could find no evidence that Pleistocene sea level fluctuations had a significant impact on extinction rates, and this is a time according to Haq et al. (1987) when no 'major' sequence boundaries (type 1) are recorded. The last was recorded close to the Plio-Pleistocene boundary where Raffi and others (1985) suggested cooling, not sea level fall, was responsible for heavy extinctions of bivalves on North Atlantic margins.

The common placement of stage boundaries at planktonic zonal boundaries means that condensed sections and hiatuses often become the defining criteria, while in fact stages often span sequence boundaries (Baum & Vail, 1988). Mancini & Tew (1991) concluded, from studies on the on the eastern Gulf Coastal Plain of North America, that planktonic foraminiferal P Zone boundaries generally match the early stage of transgressive sequence tracts but they could also correspond to any sequence stratigraphic surface depending on local variables such as tectonics or distance from the shoreline. While Loutit and Kennett (1981) concluded that stage boundaries in the New Zealand Tertiary most consistently corresponded to sequence boundaries of the the sea level curves of Vail et al. (1977). Recently Martin and others (1993) have attempted to match ecostratigraphic and sequence stratigraphic signals and concluded that ecozones were distributed at sequence boundaries. The definition of a stage, coinciding with the Global Stratotype Section and Point (GSSP), more appropriately may include an integration of the concept of an assemblage biozone, that is, stage boundaries coincident with episodes of faunal (assemblage) turnover that are correlatable to a regional (and possibly global) extent (Johnson, 1972; Waterhouse, 1976; Miller, 1986; Whittaker et al., 1991) (section 4.1).

At the maximum encroachment of the sea, the *maximum flooding surface* (MFS), the base level is at its highest point and sedimentation rate is at its minimum on the continental shelf, such that sediment starvation results in a *condensed section.* The condensed section may result in a maximum in the diversity and abundance of fossils, a concentration of foraminiferal events, organic matter and authigenic minerals, particularly glauconite (Loutit et al., 1988). The concentration of events, due to a severely reduced rate of sedimentation or the presence of an erosional surface, can clearly interfere with any investigation of turnover of biotas in neritic environments coincident with climatic change, these problems may be overcome by employing graphic correlation (See Macleod, 1991 for an example from the deep-sea).

The *Highstand Systems Tract* (HST) is composed of the vertical and lateral buildup of sediments during a decrease in the relative rise in sea level. Prograding complexes result from upward and outward building fluvial sedimentation during a relative stillstand of sea level (Vail et al., 1991). Each 3rd order cycle is bounded on top and below by a sequence boundary (SB). A type 1 SB results from subaerial exposure and erosion and a switch to progradation in deposition. The canyon cutting and valley incisions that may mark a type 1 SB and may be directly overlain by deltaic or estuarine deposits. There is a rapid fall in sea level such that eustatic fall far exceeds basin subsidence. A type 2 SB lacks evidence of subaerial erosion and is suggested to be a result of basin subsidence exceeding eustatic fall. Although there may be no relative fall of sea level at the shoreline it is marked by an episode of basinward shift in facies (Van Wagoner et al., 1988). Gaskell (1991), studying patterns of evolutionary turnover in benthic foraminifera from the Gulf Coast of Texas, concluded that extinction rates during the Eocene to Oligocene were only significant at type 1 sequence boundaries. These are characterised by episodes of maximum offlap and often complete exposure of the continental shelf and prominent erosional surfaces (Haq et al., 1987). She also argued that type 2 sequence boundaries, characteristic of a gradual regression, resulted in incomplete exposure and did not produce increased extinction rates and that species-area effects had ultimately had little impact. It is clear that the determination of the precise location of sequence boundaries, transgressions and maximum marine encroachment is crucial in estimations of possible impacts. Even with the hazards of fitting first and last appearances to a linear timescale, there seems to be ample evidence that the change in habitat associated with transgressive and regressive sequences forces faunal turnover and diversity change (Moore, 1954; Kauffman, 1977; Rollins et al., 1979; Armentrout, et al. 1990; Armentrout, 1992).

Parasequences are 4th to 6th order cycles occurring over durations of 0.1 to 0.5 Ma and may be related to Milankovitch orbital forcing (Vail et al., 1991). During transgressive sequences parasequences retrograde but during highstand they prograde basinwards (Fig. 1). Miller and Kent (1987) have cautioned that the resolution of synchronous turnover events at these durations is extremely difficult because of the lack of biostratigraphic control in shallow water environments. The establishment of a 'solid' chronostratigraphy allowing correlations over a wide area is crucial to the premise that the signals are a response to allocyclic phenomena. Though biostratigraphic correlations of individual parasequences are beyond the available data, the recognition and correlation of distinctive biofacies patterns may assist interpretations of sequence stratigraphic signals.

CHAPTER 2

THE PROGRESSION TO THE MODERN OCEAN

2.1 The Eocene-Oligocene transition and oceanic change

The focus of this study is to compare patterns in stratigraphy and the foraminiferal succession in neritic environments with climate and sea level. The Cainozoic is punctuated by one of the most significant climatic revolutions since the end of the Cretaceous. Wolfe (1978) coined the term the 'Terminal Eocene Event' (TEE) to describe the climatic shift, although it is now recognized to have been a transitionary period involving a series of steps lasting some 10 million years from the middle Eocene through the Oligocene. As Prothero (1994a) has suggested it may be more appropriate to call it the 'Oligocene deterioration' as there were only minor faunal and climatic changes at the Eocene-Oligocene boundary. Changes in a suite of physical environmental parameters resulted in a major resetting of oceanic and terrestrial constraints. The palaeoceanographic transformation was ultimately tectonically driven, coincident with widespread volcanism (Kennett et al., 1985), and was contingent upon the isolation of the Antarctic continent. With the increase in spreading rate from 10mm/yr to 20mm/yr in the late Eocene-early Oligocene (around 44.5 million years ago), the southern Australian margin moved from around 60° to 55° south (Veevers et al., 1991) and a deep passage was established south of the South Tasman Rise allowing the development of the circum-Antarctic current (Murphy and Kennett, 1986) (Fig. 2.1). As a consequence latitudinal thermal gradients steepened and oceanic circulation was invigorated. Kennett and Stott (1990) suggested that the transition involved a change from a two-layered ocean in the early Paleogene (Proteus), with warm saline waters derived from low-latitudes, to a three-layered ocean with surficial cool waters overlying intermediate warm saline waters formed at low latitudes that in turn overlay cold and dense deep-water of Antarctic origin (Proto-Oceanus). Along with these changes the carbonate compensation depth is estimated to have dropped by as much as 2 kilometres close to the Eocene/Oligocene boundary (Heath, 1969; Van Andel and Moore, 1974; Mallet & Heezen, 1977).

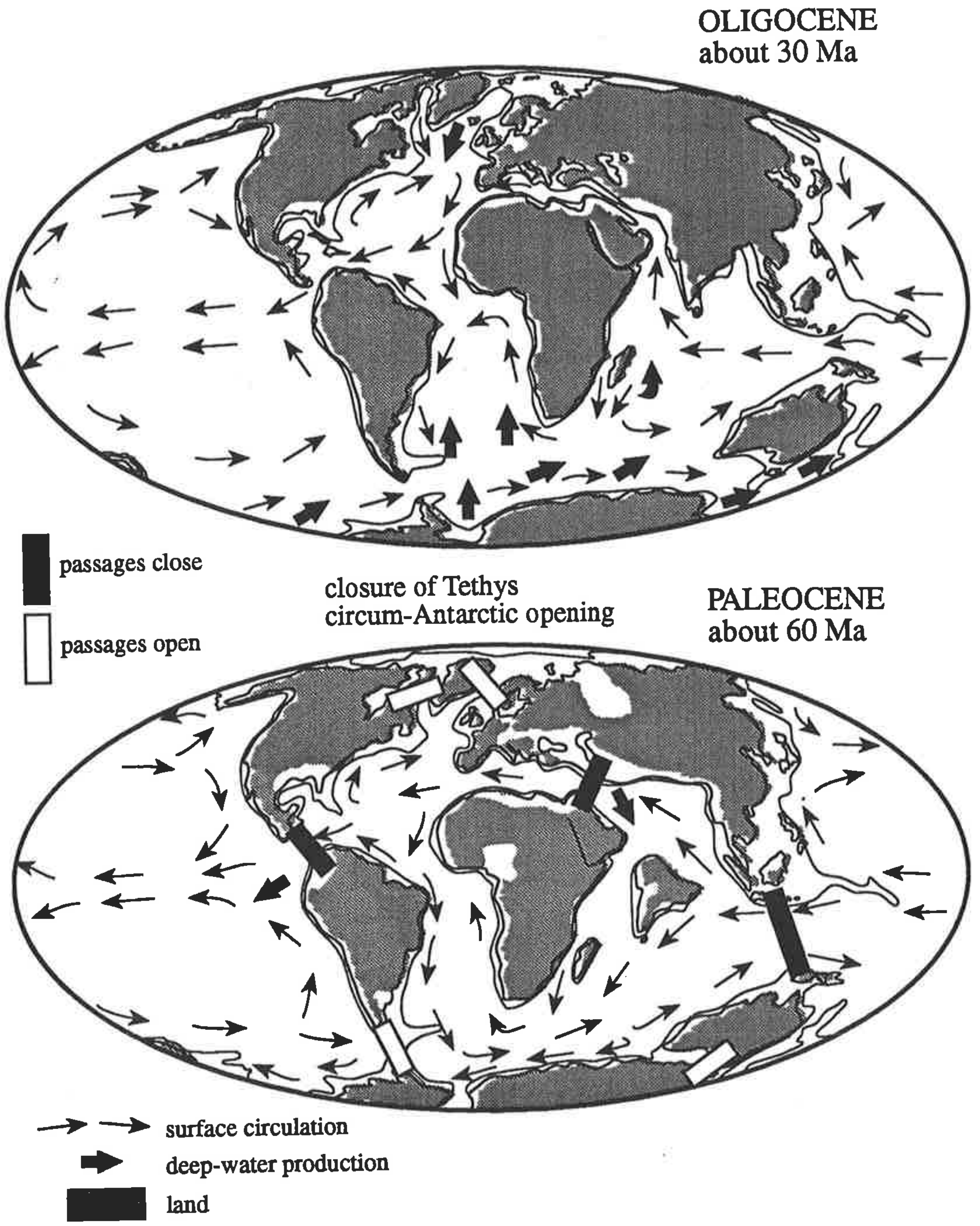


Figure 2.1 The separation of Australia and Antarctica from the Paleocene to the early Oligocene (After Haq & Van Eysinga, 1987; Seibold & Berger, 1993; McGowran, 1994).

Figure 2.1 shows the development of deep and surface-water oceanic circulation patterns resulting from Australia-Antarctic separation. With the closure of Tethys and the development of deep-water passages south of the Tasman Rise and later through Drake Passage and the Scotia Sea, southern hemisphere oceanic circulation patterns were dominated by the circum-Antarctic current and deep-water production. The transfer of warm-water masses from lower latitudes increased precipitation leading to the development of permanent icecaps on the increasingly isolated Antarctic landmass. During this interval the southern Australian margin has been rapidly moving towards lower latitudes and consequently recording palaeoclimatic and palaeoceanographic change.

Miller and others (1987) argued that global temperatures dropped from around 13°C in the early Eocene to around 5°C in the early Oligocene. At about the time of the earliest Oligocene the $\delta^{18}O$ curve, derived from both benthic and planktonic foraminifera, shifted rapidly to positive values signifying the decrease in bottom and surface water temperatures (Miller 1992; Frakes et al., 1994). More recent research has argued that deep-water cooling occurred over a series of three steps from the middle Eocene, suggested to be an increase of 1.0‰ in $\delta^{18}O$ near the early-middle Eocene boundary (Chron C22n-C21n), followed by an increase of 1.0‰ near the middle-late Eocene boundary (timing not constrained,Chron C18n to early C17n; around 42-41Ma), and finally benthic and most planktonic foraminiferal records from the Atlantic, Pacific and Indian Oceans show the largest increase of around 1.3‰ in the early Oligocene (Miller et al., 1992). This may have involved influxes of northern, derived from North Atlantic Deep Water (NADW) from the Arctic Ocean as the Norwegian-Greenland Sea opened in the early Oligocene, and moderately nutrient-rich southern cold-water masses (Miller, 1992; Prothero, 1994a, 1994b). The early-middle Eocene cooling corresponds to an intensification of planktonic foraminiferal turnover, with a replacement of thermophilic surface-dwelling forms with cold-adapted sub-surface taxa (Keller et al., 1992) (Table 2). At around this time an episode of accelerated extinction in bathyl benthic foraminifera occurred at Maud Rise in the Southern Ocean, in the middle of a trend of decreasing diversity and a relative increase in epifaunal species (Thomas, 1992). While Aubry (1992) suggests there was a 'profound' turnover in calcareous nannoplankton at this important boundary.

Hambrey et al. (1991) and Barron et al. (1991), citing the presence of ice-rafted debris from ODP sites on Kerguelen Plateau and in the Weddel Sea, concluded (from diatom stratigraphy) that there was evidence for a continental-sized ice sheet on East Antarctica in the late-middle Eocene. They also suggested that earliest Oligocene glaciation had developed into a major ice sheet in the 'mid' Oligocene. The timing of an established permanent Antarctic ice-cap has remained controversial. Bartek and others (1992) argued that a change in the mode of sedimentation in the late Oligocene, along with the presence of an angular unconformity recognized from seismic records from the Ross Sea area, was enough evidence to corroborate a late Oligocene ice sheet. They suggest the ice sheet was unstable and has 'waxed and waned' since then, implying that glacio-eustacy had from the late Eocene-early Oligocene become the primary control of global sea level fluctuations. A point suggested in an earlier work by Kerr in 1984. This is supported by copious seismic and subsurface data that suggests that the late-early Oligocene to early-late Oligocene records a major fall of eustatic sea level (Loutit & Kennett, 1981; Greenlee & Moore, 1988; Bartek et al., 1991). Although quantitative estimates of the fall are contentious as records probably depend upon continental margin physiography (McGinnis et al., 1993). The important point is that there is a consensus on the timing and that the fall, corresponding to a type 1 sequence boundary on the Exxon chart, has been recorded over a wide area including: on the southern Australian margin (Carter & Landis, 1972), in New Zealand (Field et al., 1988), and in the deep-sea (Miller et al., 1991; Schröder-Adams, 1991).

2.2 Extraterrestrial impacts?

The resounding legacy of the work of Alvarez and others (1980) in their investigations of iridium anomalies at the Cretaceous-Tertiary boundary was the rejuvenated interest in rare events in geology. This led to detailed investigations of shocked quartz phenomena that provided further convincing evidence of episodic major bolide impacts (Owen & Anders, 1988). Mass extinction was suggested to be linked to bolide impact at the Cretaceous-Tertiary boundary. A thorough scrutiny of possible bolide impacts coincident with faunal turnover patterns failed to convincingly correlate evidence of impacts (iridium, microtektites) with any extinction events (Asaro, 1982; Ganapathy, 1982; Glass, 1986; Keller, 1986; Hut et al., 1987). Glass & Crosbie (1982) argued that a North American microtektite layer, based on K-Ar and fission-track dating, was around 34 Ma and only corresponded to the last appearance of several species of Radiolaria. And Keller and others (1983) have suggested that latest Eocene microtektites may in fact have concentrated at particular horizons due to carbonate dissolution and selective winnowing, thus abrogating any confident chronological correlation with any extinction events. The conclusion is that there is little evidence to correlate faunal change to impact events at the end of the Eocene.

2.3 Previous studies of faunal succession from the Eocene through the Oligocene: Migration, evolution and recolonization?

2.3.1 Deep sea studies

The maturing idea that the Terminal Eocene was not an event but rather a series of events, reflecting the transition from a halothermal to thermohaline driven ocean and to the development of the 'psychrosphere', was chiefly derived from deep sea studies. Corliss (1979, 1981), Corliss et al. (1984), Keller (1983) and Keller (1986) surveyed the Eocene-Oligocene boundary at several DSDP sites in the Indian, Southern, Pacific and Atlantic oceans. Keller (1986) and Keller and others (1992) concluded that Eocene warm-water fauna were progressively replaced by Oligocene cool-water forms with key steps being the end of the middle Eocene and early Oligocene. Corliss (1979, 1981) and Corliss and Keigwin (1986) concluded a drop in bottom-water temperature (of around 2-4°C) had a gradual effect on deep-sea benthic foraminifera. And Boltovskoy and Guissani (1990) reported a faunal break or turnover in unilocular benthic foraminifera between the Eocene and the Oligocene in both the Atlantic and Pacific Oceans. But, from evidence provided by deep sea foraminifera recorded from DSDP cores in the eastern Atlantic and western Pacific oceans (that showed the most important correlatable episode of faunal turnover occurred below the Eocene-Oligocene boundary), they could find little evidence for coeval episodes of accelerated of faunal change afterwards (Boltovskoy & Boltovskoy, 1988). As Kennett and Stott (1991) have suggested there appears to be a decoupling of the deep-sea benthos from surface-water plankton patterns of change. The message is that it may be misleading to use a single set of data to investigate patterns of palaeoceanographic change.

AGE	EVENT	*SOURCE*
Middle Oligocene (28Ma)	Turnover in low-latitude Planktonic foraminifera	*Keller et al. (1992)*
	Global turnover in calcareous nannofossils	*Aubry (1992)*
	Peaks in the abundance of biserial heterohelicid species at high latitudes	*Boersma&Premoli Silva (1989)*
Early Oligocene (33Ma)	'Homogeneous' cosmopolitan low diversity foraminiferal faunas common.	*Boersma et al. (1987)*
	Major turnover in benthic foraminifera in neritic environments.	*McGowran & Beecroft (1989), McGowran et al (1992), Gaskell (1991), Fordyce (1989, 1992)*
	Earliest appearance of filter feeding mysticetes in middle to high latitudes.	
	Turnover of ostracods Faunas and the appearance of complex carapace architecture	*(Benson, 1975, Benson et al., 1985)*
	The last episode of widespread turnover in deep-sea foraminifera.	*Boltovskoy&Boltovskoy (1988)*
	Extinction of hantkeninids	
Eocene-Oligocene boundary (34Ma)	Long ranging benthic taxa established and buliminids begin to dominate in the Kerguelen Plateau region.	*Schröder-Adams (1991)*
Middle/late Eocene boundary (near 37Ma)	Extinction of molluscan species over entire late Eocene in U.S. Gulf Coast	*Hansen (1987, 1992)*
	Intensified turnover in planktonic foraminifera in the South Atlantic	*Keller et al. (1992)*
	Largest turnover of planktonic foraminifera for the Paleogene, warm surface water forms replaced by cooler, surface- and intermediate-water forms.	*Boersma et al. (1987)* *Keller et al. (1992)*
	Profound turnover in calcareous nannoplankton	*Aubry (1992)*
	Turnover in lower bathyal benthic foraminifera. Step occurred at 46.4-44.6Ma.	*Thomas (1992)*

Table 2 A summary table of some important marine faunal changes characterising the Eocene-Oligocene transition.

2.3.2 Terrestrial agreement?

Clearly, correlating data from different realms will provide substantial evidence for secular changes in climate. Wolfe (1971, 1978) from studies of vegetational assemblage and foliar physiognomic change have indicated that the end of the Eocene marked a profound climatic event at middle to high latitudes in the Northern Hemisphere. Wolfe (1978) inferred that there was a critical shift in temperature equability and the range in the mean annual temperature shifted dramatically from 3-5°C in the middle Eocene to around 21-25° in the Oligocene. Seasonality, accompanied by cooling, had become an important constraint in terrestrial habitats globally (Kemp, 1978; Martin, 1989; Christophel, 1990; Martin, 1991; Macphail et al., 1991; Leopold et al., 1992; Wolfe, 1992; Macphail et al., 1993). Interiors were becoming more arid and the vegetation, that mammalian faunas were coadapted with, changed with the physical environment (Collinson & Hooker, 1987; Legendre & Hartenberger, 1992). A consequence of this was that land mammal faunas (Stehlin, 1909; Prothero, 1985, 1989; Hooker, 1992; Legendre & Hartenberger, 1992) and amphibians and reptiles (Hutchinson, 1992) suffered significant extinctions over the extended interval of the middle Eocene-Oligocene transition. The African continent appears to be an exception where there is little evidence for significant floral or faunal change at this time (Rasmussen et al., 1992). Prothero and Swisher (1992) have summarized North American mammalian changes (the best record) as major at the middle-late Eocene boundary, minor in the late Eocene, an increase in the early Oligocene and absent in the middle Oligocene. In summary, the terrestrial mammal and floral records from North America, Europe, Asia and South America can be relatively well correlated and these data provide convincing evidence of a global shift in climate in a stepwise fashion from the late-middle Eocene to the early Oligocene.

2.3.3 Fluctuations in ocean productivity

Recently arguments have resurfaced proposing changes in resource supply as a major driving force behind taxic evolution (Hoffman and Kitchell 1984; Hallock and Glenn, 1986; Hallock, 1987; Corfield and Shackleton, 1988 ; McGowran, 1990; Hallock et al., 1991; Loubere, 1991). In one study Stanley and colleagues (1988) investigated two clades of planktonic foraminifera differentiated by their positions in the water column. They concluded that the bottom dwelling globorotalid clade exhibited accelerated speciation and extinction rates (shorter species durations) compared to the surface dwelling globigerinid clade (possessing symbiotic algae). This was interpreted as evidence that globorotalids were subjected to fluctuating resource supply and numbers were low, therefore distribution was fragmented. Corfield and Shackleton (1988) argued that taxonomic turnover in Paleogene planktonic foraminifera was more a function of flux in resource supply (evidence from $\delta^{13}C$ curve) than 'intervening' stable episodes. Earlier Valentine (1971) had discussed the relationship between modes of selection (r & K selection) and the relative stability of resource supply. He hypothesized variable resource supply as a determinant to diversity patterns. The connection between environmental stability and evolutionary stasis remains an interesting theory, but again this invokes the controversy whether an ecological paradigm can be expanded to geological timescales.

Cooling of low latitude surface-waters had been less dramatic but there had still been prominent turnover of benthic species (Keller, 1983; Boersma et al, 1979; Hallock et al, 1991). Hallock (1987) and Hallock and others (1991) recently argued that eutrophic conditions predispose to low diversities and elevated abundances, while oligotrophic conditions result in higher diversities and lower populations (r and K selection respectively). The conclusions stem from the concept of the ***Trophic Resource Continuum*** (TRC) that argues that as oceanic mixing increases so does the tendency towards mesotrophic or eutrophic conditions. As a result opportunists dominate in rapidly fluctuating numbers (Hallock et al., 1991).

The early Oligocene is generally represented by decreased diversity in calcareous nannofossils following an interval of intensified extinction in the latest Eocene (Aubry, 1992). Aubry also observes that the Eocene-Oligocene boundary is difficult to recognize at high latitudes in the southern hemisphere, where there appears to be no significant difference between late Eocene and early Oligocene assemblages. While Boersma et al. (1987)

concluded that early Oligocene planktonic foraminifera formed a homogeneous and cosmopilitan low diversity fauna. The record of calcareous nannoplankton are interpreted to reflect a progressive eutrophication of the oceans coincident with cooling in the early Oligocene (Aubry, 1992).

Lipps and Mitchell (1976) argued that changes in trophic resource supply explained evolutionary patterns in marine mammals during the Eocene and Oligocene. And Fordyce (1977, 1980, 1992) summarized the evolutionary succession in mysticetes (baleen filter feeding whales) and odontocetes (modern toothed whales) and concluded that the patterns conform to increases in upwelling and productivity in the Austral region contingent upon the development of the psychrosphere. It appears that marine mammal evolution during the Oligocene points to changes in ocean circulation patterns that were catalytic in the increases in oceanic productivity. Upwelling patterns that influence surface water primary productivity may emerge as a forceful, if not dominant, evolutionary driving mechanism.

Marty et al. (1988) investigating evidence for upwelling on the Pacific margin (on the Peruvian coast) and later McGowran (1989 a,b) discussed the significance of silica-rich sequences coincident with the Terminal Eocene events. The distribution of silica-rich facies in the eastern Pacific and in the Southern Ocean (the Blanche Point Formation in the St Vincent Basin and the Oamaru Diatomite in the South Island of New Zealand) was considered to be evidence of silica enhancement due to oceanic stratification and an expanded oxygen minimum zone. The following shift to steepened latitudinal thermal gradients and intensified oceanic circulation is interpreted to have occurred after this 'silica window' and resulted in upwelling that promoted productivity in the photic zone. The hypothesis that upwelling is driven by global oceanic circulation changes proposes interesting ramifications for trophic resource supply and productivity changes to neritic environments on the southern Australian margin. If it can be established that faunal changes are linked to episodes of nutrient upwelling, then this may contribute to explanations of a biogenic rather than volcanogenic origin of silica occurrence (Jones and Fitzgerald, 1984). This may explain the change from calcareous to mixed siliceous/calcareous oozes detected in the early Oligocene in deep sea cores in the southern Ocean (Shipboard Scientific Party, 1989; Aubry, 1992). A question that may apply to the present study is: Do ecostratigraphic patterns and faunal change in neritic facies during the Eocene-Oligocene reflect changes in trophic supply to the continental shelf?

CHAPTER 3

BIOSTRATIGRAPHIC AND STRATIGRAPHIC FRAMEWORK

PART 1 - CORRELATION: GLOBAL AND REGIONAL

3.1.1 Chronology: The Global Framework

Investigations of the coincidence of changes in the fauna and the physical environment require both sets of information to be constrained by an unambiguous geochronology. The integrated geological timescale for the late Paleogene has evolved through repeated cross-correlations of biostratigraphic events, radiometric dating, palaeomagnetic polarity changes. This chapter summarizes the global chronostratigraphy from the late Eocene to the Miocene and describes the local stratigraphy within the established framework.

Swisher and Prothero (1990) and later Prothero and Swisher (1992), dated Duchesnean through to Whitneyan age volcanics using the $^{40}Ar/^{39}Ar$ single crystal dating technique and correlated the magnetic record to the Eocene-Oligocene boundary to near the top of Chron C13, close to 33.9Ma. As a consequence they forced a rethink of correlations of the North American Land Mammal Ages with the Eocene-Oligocene timescale and this has resulted in an upward shift of dates by some 2 million years. Berggren and others (1992, 1994) have also revised the status of Paleogene geochronology and, based upon Ar-Ar isochron ages obtained from the Appennines and North America and have proposed that the Eocene-Oligocene boundary correlates with Chron C13R.14 in the revised polarity timescale of Cande and Kent (1992), at 34 million years BP. This accords closely with previous estimations by Montanari et al. (1988) of 33.7±0.5 Ma , 33.7±0.4 by Odin et al. (1991) and Odin et al. (1988) of younger than 34.5 Ma, from studies of the Massignano section in the Umbria-Marche-Basin of the northeastern Appennines. This has now become the global type section for the Eocene-Oligocene boundary. The Eocene-Oligocene boundary is near the bottom of Chron C13n at 33.7 Ma, the early/late Oligocene boundary is close to the base of Chron C10n1 at 28.6Ma and the Oligocene-Miocene boundary stays at the bottom of Chron C6Cn2 around 24Ma.

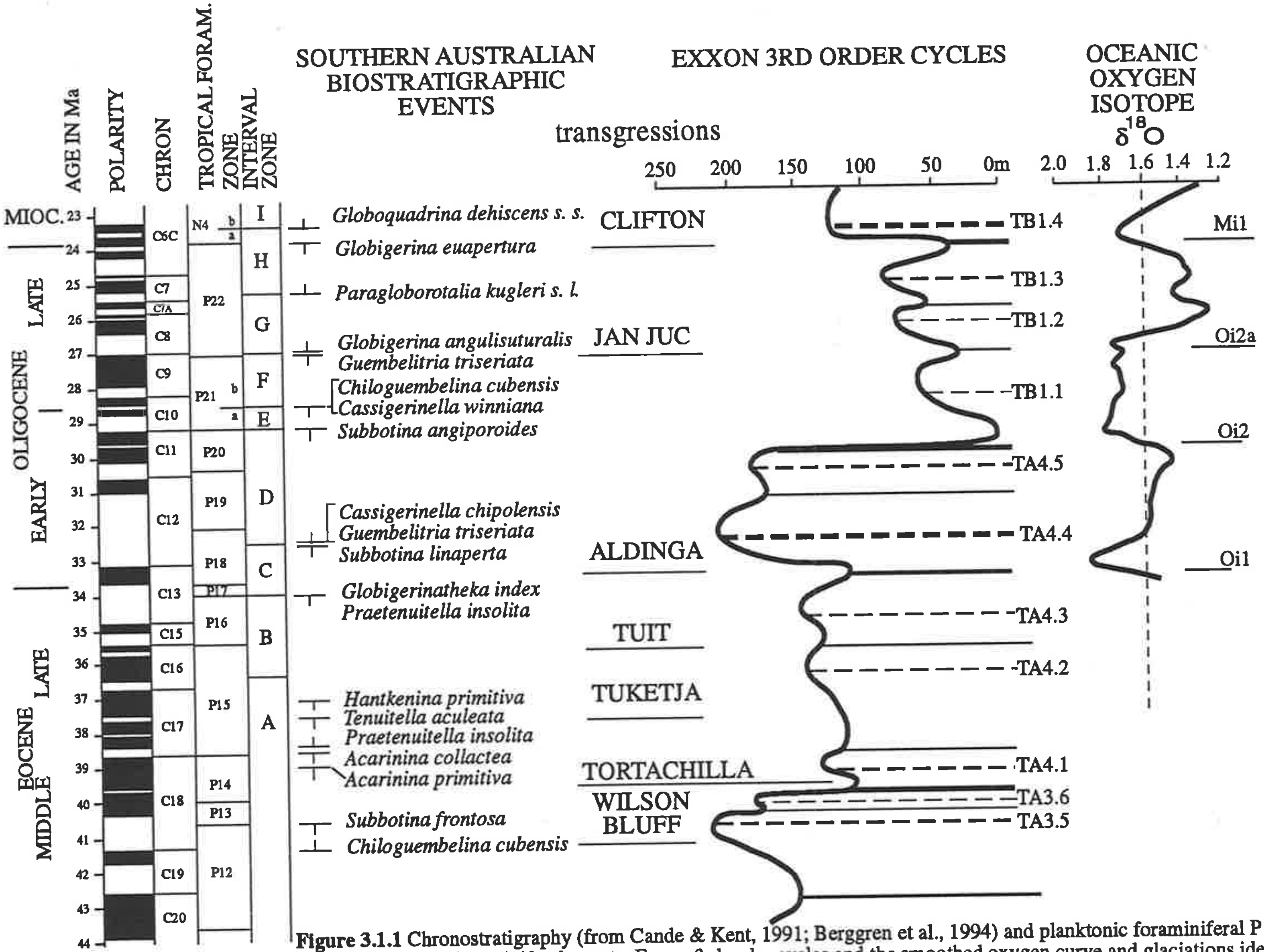


Figure 3.1.1 Chronostratigraphy (from Cande & Kent, 1991; Berggren et al., 1994) and planktonic foraminiferal P Zones correlated to local foraminiferal events, Exxon 3rd order cycles and the smoothed oxygen curve and glaciations identified by Miller et al. (1991)

Figure 3.1.1 shows the magnetic polarity timescale of Cande & Kent (1992) and Berggren et al.(1994) that has been used to construct a framework against which local and published global biostratigraphic events may be matched and used to position observations in this study. Alongside the geomagnetic timescale are the tropical zonations of Berggren & Miller (1988), the only modern discrepancy is the position of the top of Zone P17 that has been moved to conform with later studies and now marks the Eocene-Oligocene boundary at the top rather than the lower part of Chron C13r (Berggren, 1992). These are matched to the Exxon sea level curve of Haq and others (1987) and recorded late Eocene and Oligocene transgressions in southern Australia (McGowran, 1989). Adjacent to this are the correlated oxygen isotope curve and Oligocene and Miocene glaciations (Miller et al., 1991).

The Australian and New Zealand Stages are matched to the tropical P Zones so that the Aldingan correlates with the Kaiatan, Runangan (Zone P16&17) and the lower part of the Lower Whaingaroan (Zone P18). The Willungan Stage corresponds to the upper part of the Lower Whaingaroan (Zone P19/20) and the Janjukian to the Upper Whaingaroan and Duntroonian, or Zone P21 to Zone N4a inclusive. The attempt to correlate stage boundaries with sequence stratigraphy has been attempted in New Zealand and in the Eocene-Oligocene of North American Gulf Coast Plain. Loutit and Kennett (1981) managed to tie most of the stage boundaries to sequence boundaries, while in Alabama Mancini and Tew (1991) found that stage boundaries occurred at sequence boundaries or within depositional sequences. The Massignano section is truncated suggesting a sequence boundary that corresponds to the top of the Priabonian and base of the Rupelian (Berggren & Prothero, 1992).

Carter (1958) proposed that the southern Australian succession could be based on foraminiferal associations. He established 11 foraminiferal zones ranging from the late Eocene to the late Miocene, and called them faunal units identified on the basis of associations of specific benthic and planktonic taxa. Faunal units 2 to 6 are encompassed by this study (Fig. 3.1.3). The faunal unit 2/3 boundary corresponds the Eocene-Oligocene boundary at the top Zone P17 with the last appearance of *Globigerinatheka index* (Finlay)

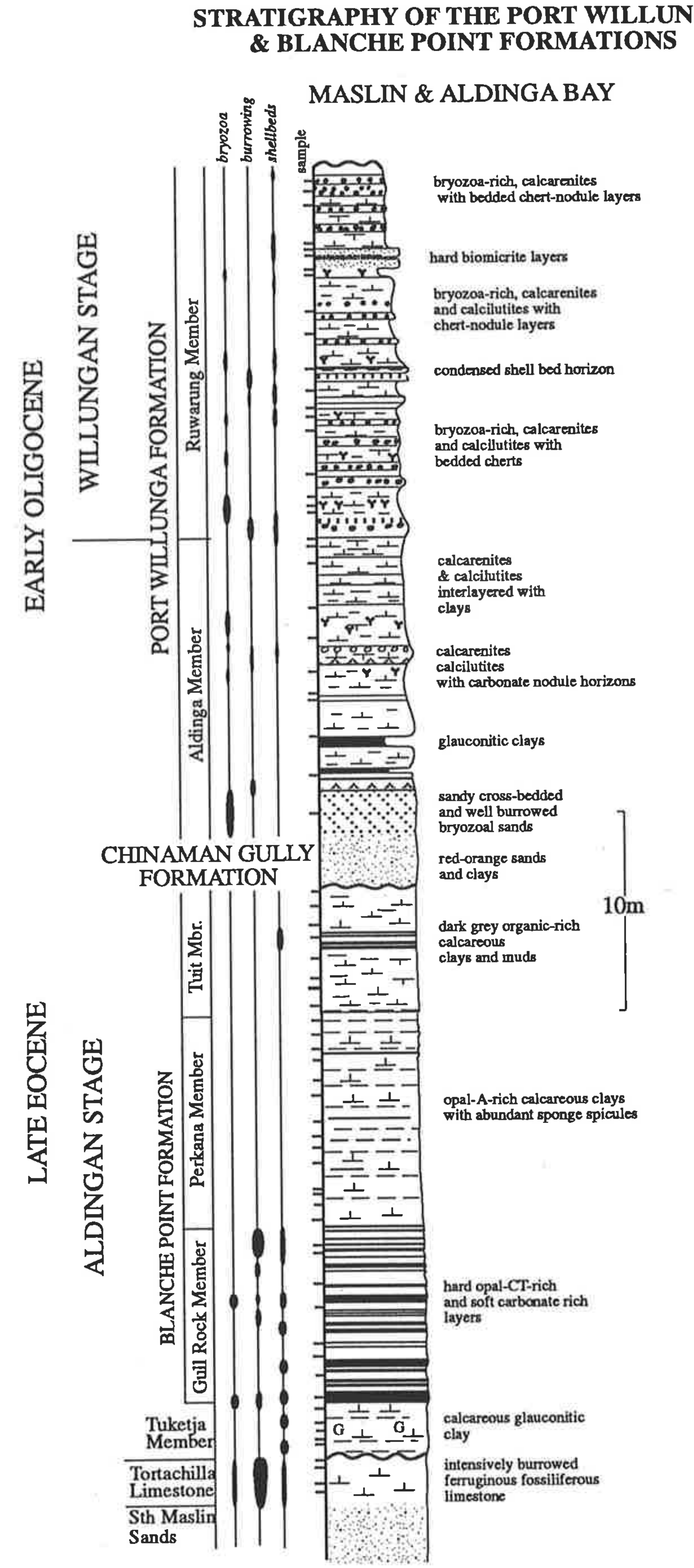


Figure 3.1.2 Stratigraphy of the late Eocene Blanche Point Formation and the type section of the Port Willunga Formation at Maslin and Aldinga Bays in the St Vincent Basin. Vertical bars show changes in relative abundance. Based upon Mack (1989), Moss (1989) and McGowran et al. (1992).

marking the top of unit 2 (Carter, 1964), the boundary between 3 and 4 correlates with the top of Zone P20, and faunal units 4 and 5 are incorporated into the Janjukian Stage.

From a combination of all of these zonal schemes and foraminiferal events the late Eocene to Miocene timescale has been subdivided into 9 biostratigraphic interval zones (Table 3.1). Discussions of ecostratigraphic and faunal change are matched to these intervals as they provide the smallest available 'timeslices' (approximately 3rd order) that can be correlated to the global chronostratigraphic framework.

3.1.3 The Eocene-Oligocene Boundary in South Australia

The Eocene/Oligocene boundary in the Willunga Embayment has been based on various biostratigraphic criteria (Ludbrook, 1963; Lindsay, 1967; Lindsay & McGowran, 1986) and has recently been re-evaluated (Lindsay, 1981; McGowran et al., 1992). Lindsay's previous criteria had included the first appearance of *Cassigerinella chipolensis* (Cushman & Ponton) in the presence of continuing *Cassigerinella winniana* (Howe) and seemed to coincide with the base of *Subbotina linaperta* (Finlay), a previous Eocene-Oligocene boundary marker, at the base of the *Pseudohastigerina micra - C.chipolensis* zone (Lindsay&McGowran, 1986). A cluster of events around this level, including the last appearance of *Subbotina linaperta* (Finlay) and the base of *Turborotalia ampliapertura* (Bolli), appeared to agree quite closely to global placement of the boundary (see tables in McGowran, 1991; McGowran et al., 1992). There was a difficulty reconciling the triumvirate of a type 1 SB on the Exxon cycle chart, ideas of climatic deterioration in the vicinity of the Eocene-Oligocene boundary and a suspiciously uneventful stratigraphic succession. A major lithological and faunal 'event' at the unconformity recognized at the base of the Chinaman Gully Formation, in the Willunga Embayment in the St Vincent Basin, was identified as the type 1 sequence boundary between 3rd order cycle TA4.3 and TA4.4 (McGowran et al., 1992). This stratigraphic level had already been considered by Ludbrook (1963) and Wade (1964) as a likely candidate for a Eocene-Oligocene boundary in South Australia. The stratigraphic column (Fig. 3.1.2) highlights the marked change between the

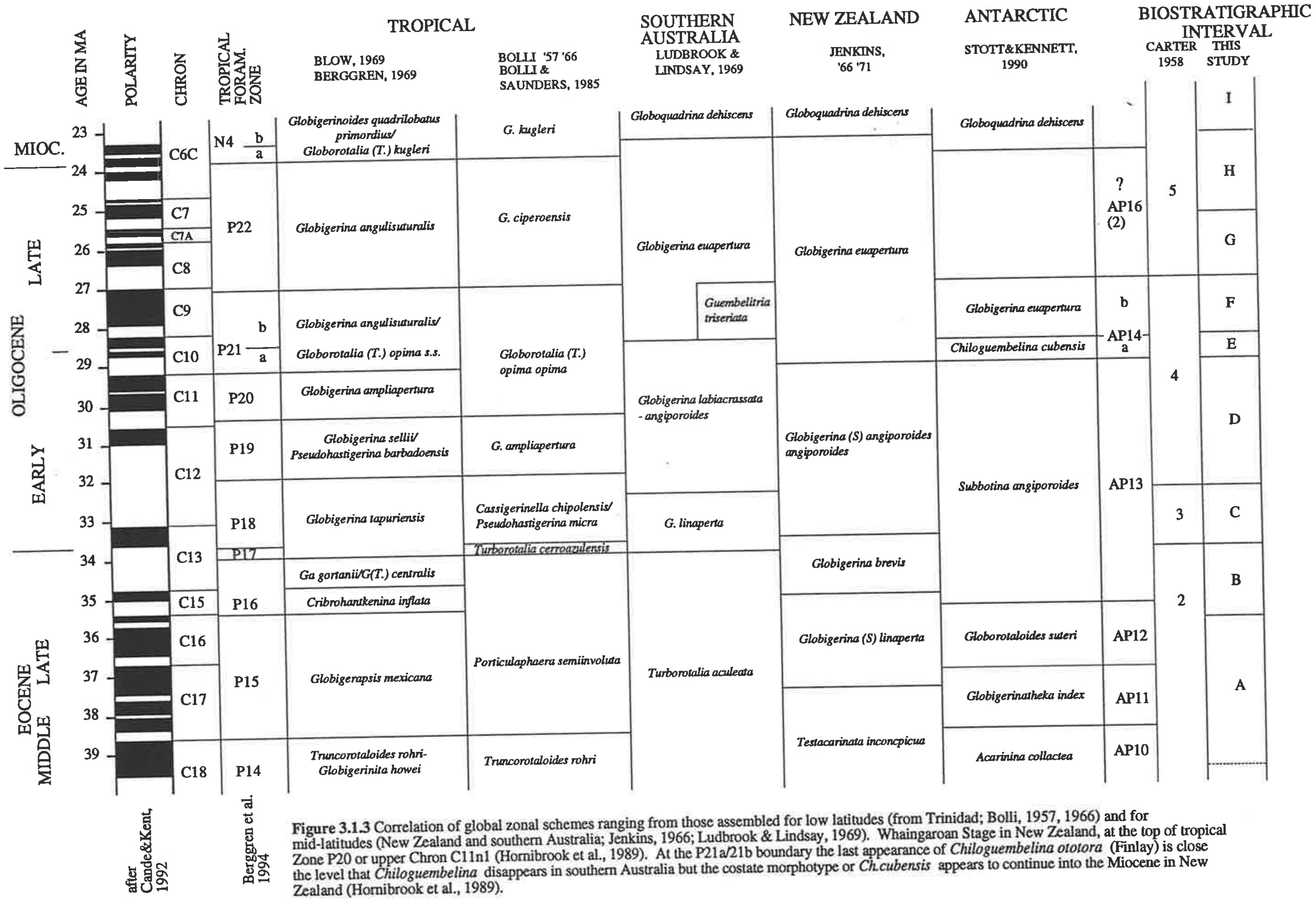


Figure 3.1.3 Correlation of global zonal schemes ranging from those assembled for low latitudes (from Trinidad; Bolli, 1957, 1966) and for mid-latitudes (New Zealand and southern Australia; Jenkins, 1966; Ludbrook & Lindsay, 1969). Whaingaroan Stage in New Zealand, at the top of tropical Zone P20 or upper Chron C11n1 (Hornibrook et al., 1989). At the P21a/21b boundary the last appearance of *Chiloguembelina ototora* (Finlay) is close the level that *Chiloguembelina* disappears in southern Australia but the costate morphotype or *Ch.cubensis* appears to continue into the Miocene in New Zealand (Hornibrook et al., 1989).

characteristically grey-green to almost black silica-rich carbonates of the Blanche Point Formation to the yellow-red-brown calcarenites to sandy and cherty bryozoan-rich calcarenites of the Port Willunga Formation. This sequence can be traced in subsurface bores in the Willunga Embayment as far as McLaren Vale, some 13 kms inland (Cooper, 1979), and also subsurface in the Adelaide Plains (Lindsay, 1981). The break is interpreted to mark the beginning of the ventilation of the St Vincent Basin at the end of the Eocene consistent with the development of psychrosphere (McGowran & Beecroft, 1986; McGowran, 1989; McGowran et al., 1992) (see chapter 4 for a detailed discussion).

Biostratigraphic criteria for the demarcation of the boundary are complicated by discrepancies between tropical and temperate zonal schemes (Fig. 3.1.3). The significant tropical index species *Turborotalia cerroazulensis* (Cole) is rare in southern Australia where only a few badly preserved specimens have been observed coincident with the Tortachilla 'warm ingression' from subsurface Adelaide Plains (Lindsay, 1981) and from Browns Creek (McGowran, 1989). *Cribrohantkenina inflata* Howe is absent, so the last appearance of both these species, as criteria for delineating the boundary, is more reliably based upon other events. *Hantkenina* disappears well below other significant events in South Australia but the last appearance in the northern hemisphere is recorded in the top of Chron C13r in the Massignano section in Italy (Coccioni et al., 1987; Brinkhuis, 1992). Some planktonic foraminiferal events appear to fit well with the calcareous nannofossil events, particularly the global last appearance of the rosette-shaped *Discoaster barbadiensis* Tan and *D. saipanensis* Bramlette & Riedel at the base of NP21 in Chron C13r. *Globigerinatheka index* (Finlay) disappears close to this level and there seems to be no evidence of diachrony at high latitudes in this useful event (Berggren, 1992).

3.1.4 Reconciling global correlations: establishing relations with New Zealand and beyond

There are obvious taxonomic similarities with New Zealand faunas and thus correlations have been attempted at various times using planktonic foraminifera (Finlay, 1947; Carter, 1958; Hornibrook, 1961; Jenkins, 1971; Ludbrook, 1971; Hornibrook, 1989). Previous work has attempted to construct 'local' southern Australian zones using material from basins with differing environments of deposition and limited exposure of coastal sections. This is complicated by inconsistent biostratigraphic control from drill-core samples in subsurface sections. Ludbrook and Lindsay (1969) noted the slight discrepancies that existed in the ranges of important planktonic species from southern Australia and New Zealand but recognized the importance of building a regional scheme to further correlations with East Africa and Trinidad.

Figure 3.1.3 shows the correlation of some of the zonal schemes from low to high latitudes. In southern Australia, the lower boundary of the *G. (S) linaperta* zone is marked by the last appearance of *Tenuitella aculeata* (Jenkins) while the top was the equivalent of the Eocene-Oligocene boundary and correlated with the top of the tropical planktonic Zone P18 and the last appearance of *Subbotina linaperta* (Ludbrook & Lindsay, 1969). In this study the boundary is defined by the last appearance of *Globigerinatheka index* , an event common to both New Zealand and southern Australia, and very close to the upper boundary of Jenkins' *G.brevis* zone in New Zealand. As the *G. brevis* zone is not recognized in southern Australia there is some disparity with New Zealand in the early Oligocene. The base of the *G.euapertura* zone is marked by the last appearance of *Chiloguembelina cubensis* (Palmer) at the Zone P21a/b boundary, while in New Zealand it is marked by the last appearance of *G.(S) angiporoides* at the base of Zone P21. Ludrook and Lindsay recorded the *Guembelitria stavensis* Bandy (=*G.triseriata* (Terquem)) zone occurring between the final appearance of *Ch. cubensis* and the last appearance of *G. triseriata.* This zone is not recognized in New Zealand. Finally, the top of the *G.euapertura* zone is correlated to the first appearance of *Globoquadrina dehiscens* (Chapman, Parr & Collins).

In summary; the planktonic foraminiferal zones corresponding to the New Zealand Whaingaroan Stage, the *Globigerina brevis* zone and the *Globigerina angiporoides angiporoides* zone, overlap with the Duntroonian *Globigerina euapertura* zone (Jenkins, 1971). These are the equivalents of the South Australian Aldingan, Willungan and Janjukian Stages respectively (Figure 3.2). The LAD of *Globigerinatheka index* (Finlay) correlates with the base of Zone P17, close to the FAD of *G. euapertura* Jenkins and close to the top of Chron C13r at the Eocene-Oligocene boundary (Jenkins, 1971; Hornibrook et al., 1989). The last appearance of *S. linaperta* occurs at the Runangan-Whaingaroan boundary in Chron C13r but in South Australia at about the middle of Chron C12r. Apart from this discrepancy most of these datums fit well with those from South Australia and in the case of *G.index* with the deep sea record of Berggren et al. (1992). *Subbotina angiporoides* (Hornibrook) disappears at the Australian Willungan-Janjukian Stage boundary and appears to correspond to the top of Zone P20 at the bottom of Chron C11n2.

The Oligocene of New Zealand is described as a period of widespread transgression with deepening facies in the Te Kuiti Basin in the North Island and extensive limestone deposition in the Canterbury Basin (Hornibrook et al., 1989). Early Oligocene (Lower Whaingaroan) shallow water benthic foraminiferal faunas are dominated by *Notorotalia-Gyroidinoides* and smaller rotalid assemblages after the disappearance of warm water species that survived from the Eocene. Late Oligocene faunas include such distinctive benthic species as *Victoriella* and *Pararotalia* along with many lagenid and polymorphinid taxa. The plankton includes species common to the early late Oligocene in southern Australia such as *Tenuitelinita juvenilis* (Bolli), *Tenuitella munda* (Jenkins), *Globigerina euapertura* and *Guembelitria triseriata* (Terquem). *G.triseriata*, an important index species in southern Australia, has a continuous range from the early Eocene to the early Miocene. A similar range applies to the characteristic Janjukian benthic species *Victoriella conoidea* (Rutten); in New Zealand the range extends beyond the Oligocene-Miocene boundary into the Altonian (late early Miocene, N7) while in southern Australia it is not recorded above Zone N4. These differences suggest that local

INTERVAL	AGE CORRELATION AND DURATION	FORAMINIFERAL EVENTS	COMMON BENTHIC TAXA
I			*Karreria maoria* *Textularia vertebralis* *Textularia semicarinata* *Amphistegina lessoni* *Siphouvigerina proboscidea* *Triloculina* spp.
	base Chron C6Cn1 (N4a/b, 23.2Ma)	*Globoquadrina dehiscens* FAD	
H	2.2Ma		*Cassidulina laevigata* *Hanzawaia scopos* *Notorotalia* spp. *Victoriella conoidea* *Cibicidoides karreriformis* *Cibicides lobatulus* *Anomalinoides procolligera* *Quinqueloculina* spp. *Triloculina* spp.
	base Chron C7r (mid P22, 25.3Ma)	*Turborotalia kugleri* s.l. FAD	
G	1.7Ma		*Victoriella conoidea* *Cassidulina laevigata* *Notorotalia clathrata* *Dorothia* spp.
	base Chron C8r (base P22, 27Ma)	*Globigerina angulisuturalis* FAD *Guembelitria triseriata* LAD	
F	1.5Ma		*Gyroidinoides allani* *Globocassidulina subglobosa* *Cassidulina carapitana* *Sphaeroidina bulloides* *Parrellina crespinae* *Gaudryina crespinae* *Bolivinopsis cubensis* *Notorotalia howchini*
	base Chron C10n1 (P21a/b, 28.5Ma)	*Chiloguembelina cubensis* LAD *Cassigerinella winniana* LAD	
E	0.9Ma		*Siphouvigerina proboscidea* *Parrellina crespinae* *Kolesnikovella australis* (small globigerinids)
	base Chron C10 (P20/21, 29.4Ma)	*Subbotina angiporoides* LAD	
D	2.8Ma		*Globocassidulina subglobosa* *Cibicides perforatus* *Cibicides mediocris* *Trifarina bradyi* *Victoriella conoidea* *Bolivina* spp.
	lower part Chron C12r (upper P18, 32.2M)	*Cassigerinella chipolensis* FAD *Subbotina linaperta* LAD	
C	1.8Ma		*Hoeglundina elegans* *Cerobertina kakahoica* *Massilina torquayensis* *Karreria pseudoconvexa* *Lamarckina airensis* *Lamarckina glencoensis*
	upper part C13r (P17/P18, 34Ma)	*Globigerinatheka index* LAD *Praetenuitella insolita* LAD	
B	2.5Ma		*Trifarina* spp. *Uvigerina* spp. *Cibicides perforatus* *Quinqueloculina spp.* *Cibicides pseudolobatulus* *Globocassidulina subglobosa* *Linderina glaessneri* *Halkyardia bartrumi* *Maslinella chapmani*
	bottom Chron C16n1 (upper part of P15, 36.5Ma)	above *Hantkenina primitiva* LAD	
A	?3.3Ma		

Table 3.1 Summary chart of Intervals A to I correlated to the revised geochronology, foraminiferal events in southern Australia and significant benthic taxa characteristic for each Interval. Durations of each interval are calculated and estimated from Berggren et al. (1994). LAD = last appearance datum, FAD = first appearance datum.

palaeoenvironmental constraints were important in the distribution of these species in the middle Tertiary.

The correlation of low- and high- latitude zonal schemes suggest the base of *Turborotalia cerroazulensis* can be the matched to the last appearance of *Globigerinatheka index* in southern Australia. The top of the *G. labiacrassata-angiporoides* zone correlates with the Zone P21a/b boundary while the base of the *G. angulisuturalis* zone correlates with the top of the *G. triseriata* zone providing some correlation of low- and mid-latitude zonal schemes.

3.1.5 Local chronological intervals defined (Table 3.1)

The base of interval zone A is proposed to be the equivalent of the base of the Tortachilla Limestone in the late Eocene Blanche Point Formation in the St Vincent Basin, while the top is tied to the prominent facies change from the opal-CT-rich Gull Rock Member to the opal-A rich Perkana Member, estimated to be close to the bottom of Chron C16n1. Biostratigraphic control for this interval zone boundary is very poor but it appears above the last appearance of *Hankenina*. Figure 4.1 shows that this zone marks the onset of a 'warm ingression' and commences with the transgressive sequence tract of cycle TA4.1. Zone B is equivalent to the upper part of Carter's faunal unit 2 (Carter, 1958) and ranges up to the Eocene-Oligocene boundary at the top of Chron C13r. The top is marked by the last appearance of *G.index* and *P. insolita* (Jenkins).

The interval zone C/D boundary, recognized by the local first occurrence of *G. triseriata* and the local last appearance of *Subbotina linaperta* (Finlay) just below the Zone P18/19 boundary in the lower part of Chron C12r. The C/D boundary also corresponds to the first occurrence of the chert-carbonate association characteristic of the Oligocene southern Australian stratigraphic record occurring in the Ruwarung Member of the Port Willunga Formation on the eastern side of the St Vincent Basin and in the Gambier Limestone in the Otway Basin. The top of interval zone D corresponds to the top of Chron C11n and is marked by the the last appearance of *S. angiporoides*. This is close to the level of inflection point in the major increase in the $\delta^{18}O$ curve (Oi2) of Miller and Kent (1987) and Miller and others (1991) (Fig 3.1.1).

If the Zone P21a/b boundary is placed at the base of Chron C10n2 (Berggren & Miller, 1988), then according to the revised Oligocene timescale it is slightly older than 28.5 myrs. The biostratigraphic criterion is the last appearance of the biserial heterohelicid planktonic species*Chiloguembelina cubensis* and the sporadically occurring *Cassigerinella winniana* (Howe). The costate morphotype of *Chiloguembelina* can be consistently identified in each of the basins. Beckman (1957) commented on the presence of *Chiloguembelina* in both restricted facies, with very low plankton, and more open marine facies and suggested that the genus may be an important correlative tool. The last appearance of *Ch.cubensis* has been confirmed as a isochronous tropical and temperate datum by Jenkins (1966). This useful event marks the boundary between zones E and F. The last appearance of *Guembelitria* and the first appearance of the distinctive planktonic species*Globigerina angulisuturalis* Bolli heralds the onset of the 'thin' *G.angulisuturalis* zone. This is followed by the first appearance of *Paragloborotalia kugleri sensu lato* (Bolli) and marks the bases of zones G and H respectively. Spezzaferri (1991) argued that the first appearance of *P. kugleri sensu stricto* occurs at the Oligocene/Miocene boundary and that the ancestral form of *P. kugleri* first appears in Zone P22. In this study there has been no attempt to discriminate between forms in the transitional series and therefore the first appearance of *P. pseudokugleri* (Blow) is used as the middle Zone P22 datum. Interval zone I, equivalent to a partial range zone, is marked by the first appearance of *Globoquadrina dehiscens sensu stricto* at the Zone N4a/b boundary that closely follows the last appearance of *Globigerina euapertura* at the Oligocene-Miocene boundary.

According to these correlations the Eocene-Oligocene boundary is interpreted to correspond to the type 1 sequence boundary at the top of Chron C13r that accords with the zone B/C boundary. Following this event the transgressive sequence tract of 3rd order cycle TA4.4 should occur at the top of Zone P18 in Chron C12r (interval zone C) and a sequence

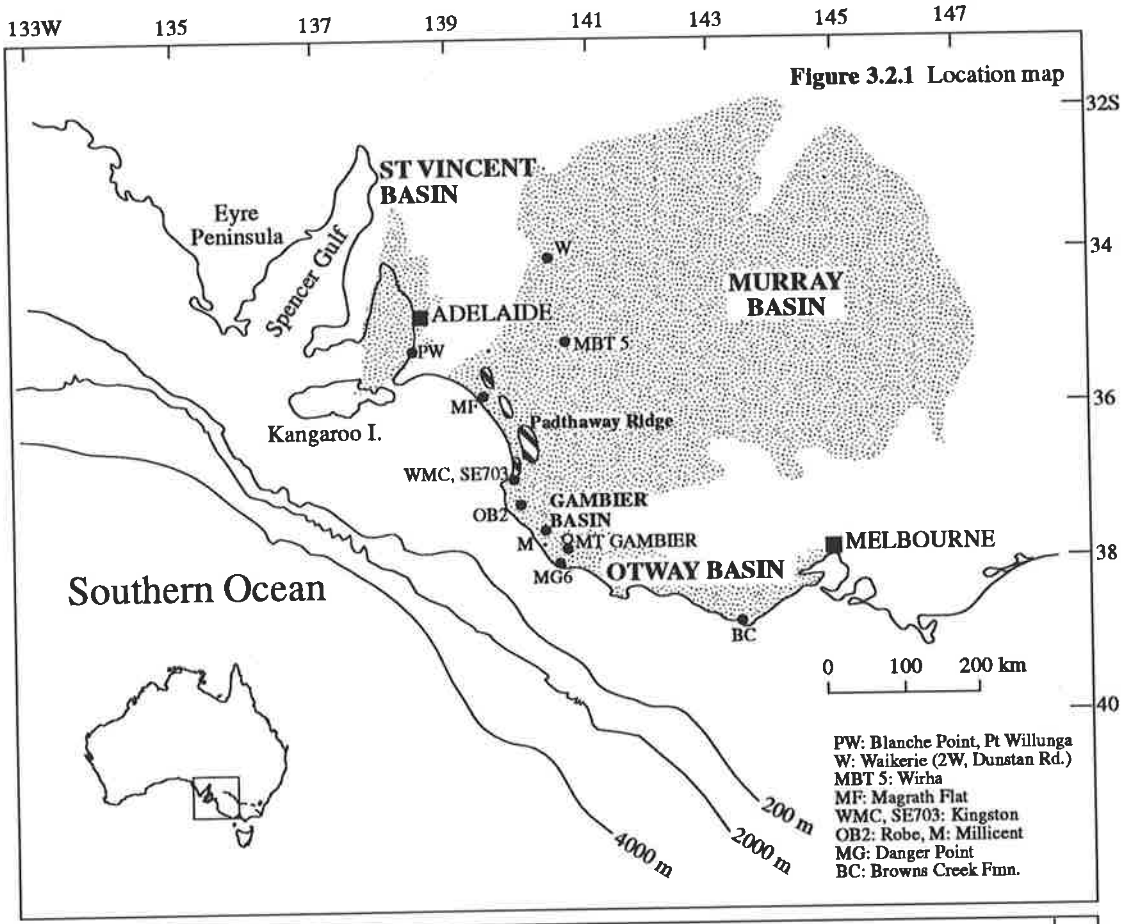


Figure 3.2.1 Location map

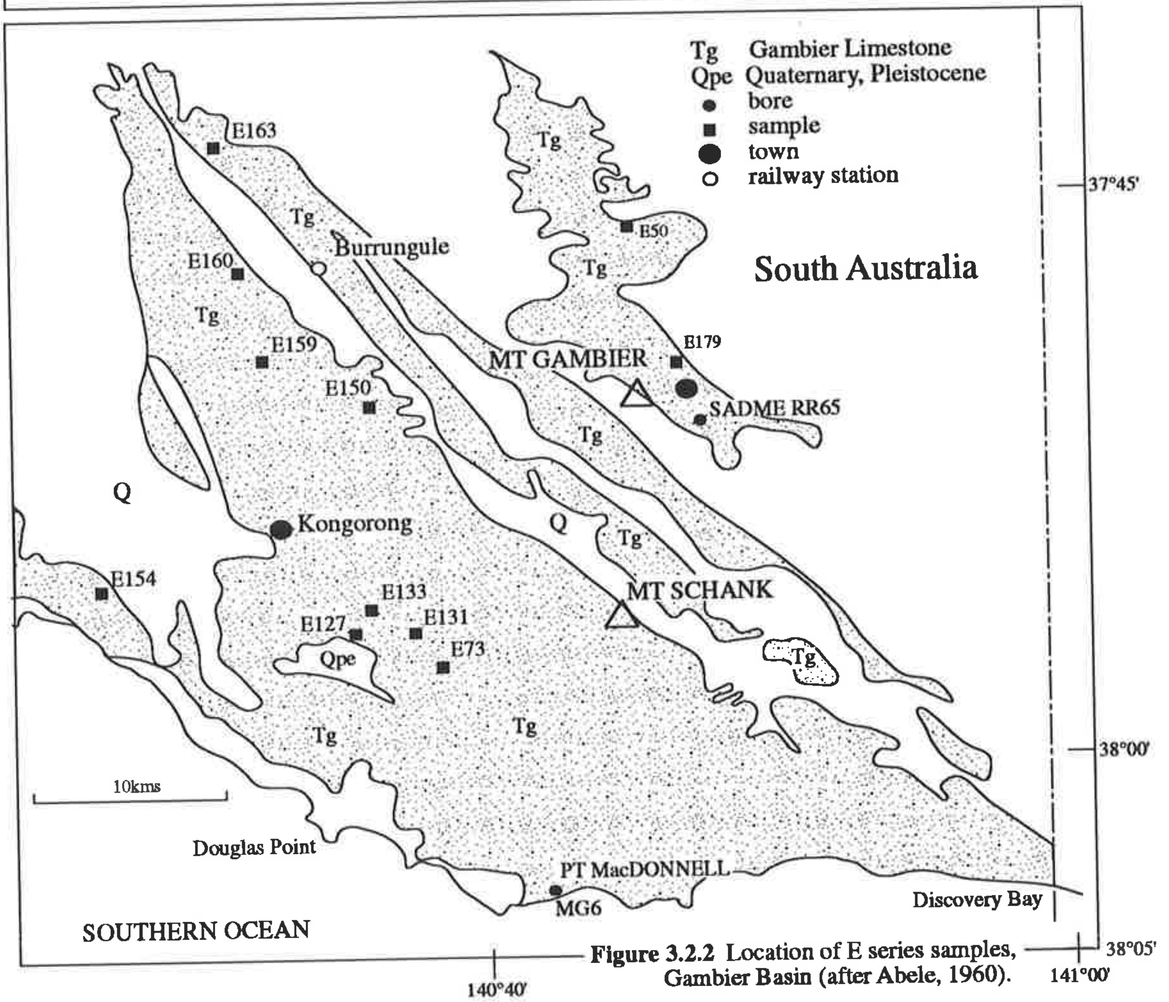


Figure 3.2.2 Location of E series samples, Gambier Basin (after Abele, 1960).

boundary (TA4.4/4.5 type 2 SB) is in the middle of zone D and planktonic foraminiferal Zone P19.

Sequence stratigraphic surfaces allocated by Haq and others (1987) to the late Oligocene have been: the MFS of TB1.1 at the late/early Oligocene boundary (Chron C10n1), a sequence boundary between TB1.1 and 1.2 at the top of Chron C9 at the base of P22 (this should occur very close to the interval zone F/G boundary), the MFS of TB1.2 at the top of Chron C8r in the lower part of interval zone G, the TB1.2/1.3 SB near the middle of interval zone G, the MFS of TB1.3 at the base of interval zone H at the base of Chron C7, and the type 1 SB near the middle of interval zone H at Chron C6Cn3.

PART 2 - LOCATIONS AND STRATIGRAPHY

3.2.1 Overview

The St Vincent Basin began to form in the middle Eocene following the reactivation of Paleozoic faults during the separation of Australia and Antarctica (Falvey & Taylor, 1976; Cooper, 1985). The Willunga Embayment began to accumulate Tertiary sediments at this time with the deposition of the non-marine and marginal deltaic facies of the North Maslin sands on top of Permian rocks. There is a relatively continuous Tertiary record accessible from outcrop until the middle Oligocene where there is an angular unconformity between the Ruwarung Member of the Port Willunga Formation and the overlying late Pliocene Hallett Cove Sandstone, after this Oligo-Miocene sediments are represented in sub-surface bores in the Willunga Embayment and the Adelaide Plains Sub-basin (Lindsay, 1981, 1985).

The Murray Basin is a saucer shaped, intra-cratonic shallow marine sedimentary basin that extends from western Victoria and New South Wales to southeastern South Australia. Lower Cretaceous sediments of the Otway Group are overlain by a series of Paleocene and Eocene sands and carbonaceous deposits that represent succession of shallow marine incursions since the late Paleocene/early Eocene. The latest Eocene deposits are glauconitic, shelly, and are dominated by grey pyritic calcarenites and sands; this represents Buccleuch Formation and their equivalents. The most prolonged of these invasions, that resulted in shallow water marine deposition, began in the Oligocene and continued into the Miocene (Brown et al., 1968; Lindsay, 1973; Brown & Radke, 1989). The Ettrick Formation (='Ettrick Marl') of Oligocene age overlies these sediments and consist of glauconitic, fossiliferous marls and clays overlain by bryozoal limestones and calcarenites representing the Oligo-Miocene Duddo Limestone. The Ettrick Formation is easily recognized from electric logs showing lesser resistivity than overlying Duddo Limestone (Lawrence, 1975) and is an important permeability barrier in the Murray Basin aquifer system (Brown & Radke, 1989). The thickest sequence of the marine component of Oligo-Miocene Murray Group is on the eastern side of the basin, while the western equivalents are represented by the marginal marine Winnambool Formation and the Geera Clay (Brown & Radke, 1989). Palynological studies have suggested that towards the end of the Oligocene and into the Miocene, floras changed from *Nothofagus* dominated assemblages, characteristic of year-round rainfall conditions, to assemblages dominated by Myrtacea and Casuarinacea more typical of seasonal climatic conditions (Macphail & Truswell, 1989; Martin, 1989), these observations are consistent with a global shift to a drier and more seasonal climate. The more equable late Oligocene conditions seemed to have persisted in New Zealand as *Nothofagus brassi* forests covered most of New Zealand until the late Miocene (Mildenhall & Pocknall, 1984).

A hiatus is recorded in the early to late Oligocene but this is much more prominent in the western or South Australian part of the Basin. The Murray Basin is separated from the Otway Basin in the south by the physiographic barrier of the Cambrian to Ordovician granites of the Padthaway Ridge. There is a contrast in palaeoenvironments: the Otway Basin, that was more open to oceanic conditions; and the relatively restricted environments of the St Vincent and Murray Basins. The Otway Basin contains Permian deposits at the base, that are overlain by Lower Cretaceous interbedded mudstones and sandstones of the Otway Group, followed by Upper Cretaceous sandstones and glauconitic siltstones of the Sherbrook Group. These are overlain by a reasonably continuous Tertiary sequence of foraminifera and bryozoa-rich limestones. The Otway Basin is relatively undeformed and there are few exposures, as a consequence most of knowledge of the sequence is derived from sub-surface bores.

As a part of a Murray Basin hydrogeological survey commenced in the 1980's Mines and Energy South Australian (MESA) undertook an extensive rotary drilling programme. Material from this survey (from locations in shown in Fig. 3.2.1) was obtained from MESA's storage facilities in Adelaide. These samples are supplemented with previously investigated material (for biostratigraphic studies) from observation bores drilled in the last three decades.

3.2.2 STRATIGRAPHY IN THE ST VINCENT BASIN

The stratigraphic succession in the St Vincent Basin is largely a function of the localised structural and tectonic controls. Silica-rich and calcareous clays to calcarenites, calcilutites and bryozoal limestones outcrop at Maslin and Aldinga Bay, 32 km south of Adelaide, these are the middle to late Eocene Blanche Point Formation to the late Oligocene type section of the Port Willunga Formation within the Willunga Embayment of the St. Vincent Basin. The package of sediments thickens basinwards and towards the Willunga Fault in the south (Cooper, 1979). The section forms basinward facing cliffs and are the most complete in the St Vincent Basin though Oligo-Miocene coastal exposures do outcrop on the western side on the Yorke Peninsula (Stuart, 1970).

In the Willunga Embayment the coastal exposures include middle Eocene fluvial deposits of the North Maslin Sands at the base to the late Eocene silica and organic-rich Blanche Point Formation (Fig. 3.1.2). The silica-rich Blanche Point Formation are probably part of a global late Eocene 'silica window' that includes the Oamaru Diatomite in the South Island of New Zealand and the Yumaque diatomite from the East Pisco Basin of Peru documenting a particular configuration of environmental and physiographic parameters (Marty et al., 1988; Marty et al., 1989; McGowran, 1989b). Lindsay (1967) summarized the biostratigraphy from the Chinaman Gully Formation to the middle Oligocene. The Port Willunga Formation is subdivided into the lowermost Aldinga Member of the Australian Aldingan Stage and the characteristic chert-bearing Ruwarung Member (Cooper, 1977), at the top, that partly encompasses of the late Oligocene Janjukian Stage. This interval includes the lower of the chert-carbonate associations in the early Oligocene (Fig. 4.1).

3.2.3 Previous correlations with 3rd order sea level cycles

In figure 4.1 the Tortachilla transgression is correlated with TA4.1 3rd order cycle and a type 2 SB separates the Tortachilla Formation and the Tuketja Members of the Blanche Point Formation. The hard opal-CT bands of the Gull Rock Member are the result of transgressive sequence tract of 3rd order cycle TA4.2, while the opal-A dominated Perkana Member correlates with a highstand sequence tract. Another type 2 SB marks the boundary between the Perkana Member and the next transgressive sequence tract of the Tuit Member. In these late Eocene units there is a conspicuous correspondence between the occurrence of the hard opal-CT horizons and the proposed positions of transgressive phases in the third order cycles.

The Chinaman Gully Formation has been identified as the type 1 sequence boundary corresponding to boundary of 3rd order cycles TA4.3/4.4 on the Exxon global cycle scheme (McGowran et al., 1992). The overlying Aldinga Member is the equivalent of the Lacepede Formation in the Otway Basin and corresponds to transgressive sequence tract for TA4.4, a prominent and ubiquitous event that occurs across all basins. There is a striking contrast with the underlying Blanche Point Formation. The lowermost unit of the Aldinga Member consists of cross-bedded sands that are intensively burrowed at the top, the opal-A-CT alternation is absent, sediments are red-brown bryozoal calcarenites and calcilutites, interbedded with occasional clay-silt and carbonate-nodule horizons. The top of the Aldinga Member is a lithological boundary most obviously characterised by the appearance of chert-nodule horizons in the Ruwarung Member and can be correlated with the lower member of the Gambier Limestone in the Otway Basin. These nodule-rich horizons alternate with the nodular/arborescent bryozoa horizons dominated by the Cheilostome bryozoan *Cellopora* that are today characteristic of deep-water and low energy environments (Bone & James, 1993). It is proposed that the chert-nodule horizons correspond to increased carbonate to clay ratios and that bryozoal chert-free horizons represent increased clay content during relatively quiet depositional cycles. The Port Willunga Formation represents the ventilation of a previously more stagnant Embayment that is probably an allocyclic signal of the developing psychrosphere (McGowran et al., 1992).

Lindsay (1981), from borehole studies, recognized the occurrence of the Aldinga Member beneath the Adelaide City area and described a 'typical' Aldinga Member planktonic foraminiferal assemblage that included *Cassigerinella chipolensis* (Cushman & Ponton) in the presence of *C. winniana* , *Subbotina linaperta* , *Praetenuitella insolita* (Jenkins) and *T. aculeata* (Jenkins), with the latter species being mostly restricted to the lower sandy facies. A sequence of events are recognised close to the base of the Janjukian Stage consisting of the lower range of the distinctive benthic species *Victoriella conoidea* (Rutten), followed by the last appearance of *Ch. cubensis*, closely followed by the last appearance of the triserial planktonic *Guembelitria triseriata* (Terquem). Ludbrook and Lindsay (1969) found the succession of the heterohelicid datums with rare globigerinids an important tool to help correlate sequences in the Murray, St Vincent Basins and more open marine sequences in the Otway Basin. The succession could be identified in both the St Vincent Basin in South Australia and the Torquay Basin in Western Victoria (Lindsay, 1981). These events are succeeded by the last appearance datum of the benthic species *Bolivinopsis cubensis* (Cushman & Bermudez) (McGowran, 1971; Lindsay, 1981).

Guembelitria triseriata has been suggested to be a cold-water indicator that made its last appearance early in the late Oligocene at the top Chron C9 in Zone P21b, correlating with the beginning of the warming trend towards the end of the Oligocene (McGowran & Beecroft, 1985). It is thus an important index species in southern Australia and its pattern of distribution in the Oligocene may go some way to distinguishing a significant step in separation of Antarctica and Australia and the development of the circum-Antarctic current (Jenkins, 1978; McGowran & Beecroft, 1985). *Subbotina angiporoides* disappears close to the top of the Ruwarung Member and is interpreted to be equivalent to the last 'solid' appearance in the Otway Basin in the middle of the Lower Member in the Gambier Limestone. This correlates with the top of Zone P20 at the bottom of Chron C10 that is designated the interval zone D/E boundary.

Lindsay (1981) suggested that the '30 million year event' (the Exxon TA4/TB1 supercycle boundary) is reflected in the change from the chert-rich Ruwarung Member to the sandy, coarse-grained quartz-rich 'upper Janjukian unit'. He could not recognize the 'expected' major regional unconformity. This event is recorded by Holdgate and Sluiter (1991) in the Gippsland Basin and they suggest that this is followed by five transgressive events in the late Oligocene, contrary to the four predicted by Haq and others (1987) in the Cenozoic Global Cycle curve. They go on to suggest that the Gippsland Basin may be more sensitive to sea level rise due to low continental topography. Accordingly, with minor caveats, they conclude a reasonable correspondence between Gippsland Basin cycles and Exxon 3rd order cycles for the late Oligocene.

3.2.3 STRATIGRAPHY IN THE MURRAY BASIN

SADME MBT 5, Wirha

Bore MBT 5 is located at Wirha around 170 km east of Adelaide in South Australia on the western margin of the Murray Basin. The bore, drilled by Mines and Energy South Australia in early 1990 as a part of a hydrogeological survey, intersected sandy non-marine facies with plant macrofossils at around 190m. After a non-marine sandy unit there appears to be a hiatus as the marine deposits show a sequence of foraminiferal events suggesting the section spans the late-early Oligocene to end of late Oligocene. Foraminifera were present from close to 190m at Wirha but assemblages became depauperate at the top of the cored section. *Ch. cubensis* makes its last appearance close to the base of the section near 189 m about a metre above the last appearance of *C. winniana*. The last appearance of *G. triseriata* is recorded at 182m and this is the interval zone F/G boundary. Bryozoa and shell fragments are a common feature and a sandy, glauconite/faecal pellet-rich horizon occurs around 177m. *G. euapertura* ranges almost to the so the section is considered to range at least as far as interval zone H with no biostratigraphic evidence for the zone G/H boundary.

Lindsay and Barnett (1989) reported woody material from the base of the Monash 1 well, is equivalent to the sandy-shelly carbonaceous unit close to 160m depth at Waikerie (Lindsay & Bonnett, 1971), and is interpreted as the the Moorlands Lignite Member (=Moorlands Coal Measures). Samples from shallower depths show facies changed to glauconite-rich and faecal-pellet-rich bryozoal calcarenites with abundant shelly faunas that appear to be marginal marine. The event is well represented in this part of the basin as the 'middle-regressive unit' of the Buccleuch Formation (Lindsay, 1981), where Zone P18 and part of Zone P19 are unrecorded. From the township bore at Coonalpyn Ludbrook (1957, 1961) recorded the last rare occurrence of *G. index* close to 312 ft (95m) and the last appearance of *S. linaperta* above this at 257ft (77m), so the earliest Oligocene is represented by a hiatus somewhere between these events in 'Buccleuch A' above a glauconitic 'marly' limestone and some 66ft (20m) above carbonaceous clays. More late Eocene deposits appear to be preserved at Coonalpyn than the above locations.

SADME Waikerie, Dunstan Road(p/n 26508)

Drilled in 1990 the bore intersected early to late Oligocene Ettrick Formation between 184 to 120 metres. The stratigraphy consists of calcareous muds and sands changing to dark grey calcilutites and calcarenites at around 142m. The Oligocene succession is confirmed by: the last appearance of *S. angiporoides* (Hornibrook) at the base, the last appearance of *Guembelitria triseriata* at 150m, and (although *Chiloguembelina* is absent) the last appearance of the benthic species *B. cubensis* above these events at 142m. *Victoriella conoidea* makes its last appearance at the 130 metre level after a short interval. The top of the bore may have intersected Miocene Mannum Formation but the boundary is difficult to identify with sparse planktonic faunas though there is a rare occurrence of *Globoquadrina dehiscens*

(Chapman, Parr & Collins) at the 132m level. This may be due to some downhole contamination and reworking at the top of the section. The lithologies penetrated consist of sands at the base grading up to fossiliferous and glauconitic calcareous sands and clays with occasional chert, particularly in the lower part of the section, to fossiliferous calcarenites at the top. Evidence from all biostratigraphic and stratigraphic data suggests that this section ranges from Zone P20 to the top of Zone P22 or interval zone D to possibly zone I.

SADME Waikerie, Bore WAK 1-'2W'

In 1965 SADME drilled an observation bore to a depth of around 235m, some 3.5 kms south-southwest of the town of Waikerie. Published biostratigraphic work by Lindsay and Bonnett (1971) suggested that the interval between 155 and 86m intersected Oligocene Ettrick Formation and the early Miocene lower Mannum Formation. Their early study was of the biostratigraphic succession using a composite of three bores (2W, 27W and 28W) drilled within 2 kms of each other. 2W was seen as particularly useful as it was extensively tube-cored during drilling, so biostratigraphic control was substantially improved.

The interval of interest intersected, at the base, lithologies of 'typical' Ettrick Formation ranging from glauconitic and limonitic calcarenites with fine-grained sand but around 142m grey chert appeared in the core (Lindsay & Bonnett, 1971). An indication of the presence in the Murray Basin of the chert-nodule marker horizons characteristic of Ruwarung Formation of the St Vincent Basin and the Gambier Limestone in the Otway Basin. It is proposed that the interval investigated ranges from the base of interval zone F into zone I or from Tropical Planktonic Zone P21a to the top of Zone N4. Because the succession samples a location close to the inner basin margin it is considered to be sensitive to fluctuations in sea level and condensed compared to coeval sections in the Otway Basin (Lindsay, 1973).

SADME bore Magrath Flat 1 (p/n 23074)

Located in the southwestern part of the Murray Basin in South Australia the bore was drilled in 1990 by the South Australian Department of Mines and Energy. Drilling intersected Permian calcareous, clay and silt close the base grading up to sandy marls and glauconitic calcarenites with a gradual increase in sand and silt from around the 100 to 90 metres interval. Following this there is a transition to grey sandy marls with bryozoal fragments. Collectively the units comprise the Permian Cape Jervis Formation and the late Eocene to early Oligocene Meningie Marl, that is the equivalent to the Buccleuch Formation in other parts of the basin, and these overly the sediments of the Renmark group. The location is important as it samples the sequence south of the Padthaway high and thus contrasts well with the northern bores. The foraminiferal succession indicates typical late Eocene assemblages (interval zone B) at the bottom of the investigated interval with the characteristic planktonics *Globigerinatheka index*, *Praetenuitella insolita* and *Pseudohastigerina micra* (Cole).

G. index makes its last appearance at around 96 metres and this event is followed by the first appearance of *Guembelitria* at the 87 metre level. The Eocene-Oligocene boundary is located between these two events. Above this event the stratigraphy consists of a dark marly limestone to 84m, close to the last appearance of *S. linaperta* and the first appearance of *G. triseriata*. The stratigraphy alters to an off-white limestone with occasional bryozoal and black flint fragments (Beecroft et al., in press) and this marks the base of interval zone D, equivalent to the top of Aldinga Member in the Willunga Embayment and the Lacepede Formation in the Otway Basin. *G. triseriata* and *Ch cubensis* make final appearances around the 60m level and this appears to be within Zone P21 or zone E.

3.2.4 STRATIGRAPHY IN THE OTWAY BASIN

INTRODUCTION

The Gambier Basin of the Otway Basin in southeastern South Australia was a more open marine basin (Fig. 3.2.1), with all samples investigated showing much higher planktonic to benthic ratios. Ludbrook (1971) reported that the Lacepede Formation is typically developed on the Padthaway Ridge and is present in all wells on the western side of the Otway Basin. It is of early Oligocene age and is overlain by Oligocene to Miocene Gambier Limestone. Taylor (1971) reviewed the depositional history of Cainozoic facies in the Otway Basin in

Victoria from subsurface data, and mapped the geographical extent of lower and upper Oligocene sediments. He suggested that there was a diachronous transgression that extended over most of the Otway Basin and for the first time in the Tertiary extended to around the northern margin of the Otway Ranges High. The maximum transgression occurred in the earliest Miocene and Oligocene and lower Miocene equivalents could be detected in the Bass Basin. The 'thin' local range zone of *Globigerina angulisuturalis* identified by Lindsay and Bonnett (1971) in the Murray Basin, suggesting more open marine influence, correlates with this maximum transgression. These observations in turn correspond to one of the seven warming/transgressive episodes in the Adelaide City area recognized in the Port Willunga Formation (Lindsay, 1981) and the increasing open marine influence exerted in the Otway Basin at this time (McGowran, 1979).

Glenie and others (1968) attempted to fit estimated patterns of sea level fluctuation with the palaeotemperature estimates from southern Victorian Tertiary molluscs. The major transgressive phase appeared to coincide with a general warming trend except for a 'minor' regression in the middle Oligocene. The rate of sedimentation suggested for the Gambier Limestone was 2.3 cms per kyr (James & Bone, 1989), which is within the range predicted by Nelson (1978) of ≤ 5 cms/kyr and close to the 1-2 cms/kyr of the Oligo-Miocene carbonates of New Zealand (Nelson, 1978). This contrasts with the much lower rate of sedimentation (0.8 cms/kyr) suggested by James and Bone (1991) for the equivalent to these rocks in Western Australia, the late early Oligocene to early Miocene Abrakurrie Limestone in the Eucla Basin. There is sedimentological evidence for periods of non-deposition, particularly the lower unit (=late Oligocene), that corresponds to a gradually rising long term sea level cycle punctuated by oscillating short term cycles.

SADME Observation Bore 2 (ROS 10), Robe

Observation Bore 2 (ROS 10) near Robe (Lat. 37°11'S and Long. 140°03'E) was drilled in 1970 by the South Australian Department of Mines and Energy. Samples were obtained from 1.5 to 2m intervals and four open tube cores were taken. The samples contain evidence of a wide variety of bryozoan depth-related assemblages that are dominated by delicate branching cyclostomes. The variations suggest palaeodepths through the Oligocene of shelf to deep-shelf edge and estimates of around 10 to 200m (James et al., 1992). The section spans the late Eocene to the latest Oligocene, though firm establishment of bases was hampered by the relative lack of core material obtained at the time of drilling so that sludges comprised most of the material. The Eocene-Oligocene boundary is located close to the 131m level (core material), matching McGowran's (1971) original placement, and corresponds to the last appearance of *G. index* and the calcareous nannofossil *Discoaster saipanensis* Bramlette & Reidell (Shafik, 1983), these events are immediately followed by an unconformity.

The top of the Lacepede Formation is marked by a lithological change from glauconite- and limonite-rich marls to bryozoa-rich limestones with chert-nodule horizons. This facies change is close to the last appearance of *Subbotina linaperta* and the triserial planktonic *Guembelitria triseriata* makes an appearance very close to the distinctive benthic species *Victoriella conoidea* (Rutten). Aragonitic species, such as *Cerobertina kakahoica* Finlay and *Hoeglundina elegans* (d'Orbigny) disappear and the assemblages became dominated by *Cibicides* spp., *Globocassidulina* and small globigerinids.

The planktonic foraminiferal succession correlates well with the generalized succession recorded for the Oligocene (Fig. 3.1.1), with the last appearance of *S. angiporoides* followed by the last appearance of *Ch. cubensis* and above this at around the 57m level the last appearance of *Guembelitria triseriata.*

SANR WMC 507, Kingston

McGowran, Moss and Beecroft (1992) compiled presence/absence and abundance profiles for a section drilled through the Eocene-Oligocene boundary at Kingston in the southeast. The section spans the earliest Oligocene to the latest early Oligocene. Waghorn (1985) recorded the first appearances of the calcareous nannofossil species *Helicospheara recta* Haq and *Sphenolithus ciperoensis* Bramlette & Wilcoxin, while he reported the absence of*Chiasmolithus oamaruensis* (Deflandre) that disappears at high latitude towards the top of Chron C13 (Wei & Wise, 1990). Approximately 1 or 2m above this *Guembelitria triseriata* makes a first appearance close to the last appearance of *Subbotina linaperta*, and this marks the top of Zone P18 near the top of the Lacepede Formation in the Otway Basin.

location	**n Samples (depth in metres) ranges, stages**
Waikerie 2W (SADME) - WAK1 (6829-00442)	23 (155.4-85.3m) P21- top N4 Janjukian
Waikerie - Dunstan Rd (SADME P/N 26508)	13 (182-120m) P21-top P22/?N4 Aldingan-Janjukian (Willungan-Janjukian)
Wirha, MBT 5	42 (192.3-165.4m) P20-P22 Aldingan - Janjukian
Magrath Flat (SADME P/N 23074)	10 (102-45m) P18-top P21a Janjukian (Willungan) - Janjukian
Maslin Bay - Blanche Point Formation †	39 (33m) P15-bottom P17 (Chron C13r) Aldingan
Aldinga Bay - Port Willunga Formation (McGowran & Beecroft, 1986; Moss, 1989)	44 (55m) bottom P18-P21, PW and R series, Aldingan to Janjukian
Browns Creek Formation - Aire District †	P15-P17 (Chron 13r) Aldingan
Robe OB2 (SADME) - ROS10 (6923-01566)	47 (135.6-9.1m) P17-top P22 Aldingan - Janjukian
Mt Gambier RR65, RR66 (SADME)	(235.2-192.5, 127.5-110.5m) P17-P21, P22-top N4, Aldingan - Longfordian
Danger Point MG6 (SADME) - CAR10 (7021-01099)	(126-20m sampled in this study) P21-top N4 ?N5, Janjukian - Longfordian
Abele's E series	12 samples, Janjukian
Kingston, WMC507	25 (37.5-22.8m) P17-P21a/b Aldingan - Janjukian
Millicent E&WS † (McGowran, 1968 unpublished data)	(182.9-68.6m) ?P18-N4, Willungan - Longfordian

.**Table 3.2.2** Summary of the geographical and temporal distribution of samples based upon biostratigraphic criteria. Section locations, number of samples, stratigraphic thickness in metres, estimated duration in P zones and local stages. †: Not included in cluster analysis.

E&WS bore 3, Millicent (Early Oligocene to Miocene)See Appendix D

At Millicent in the southeast an Electricity and Water Supply bore intersected cream coloured limestones typical of the Gambier Limestone containing assemblages characteristic of interval zone C, including benthic species *Karreria pseudoconvexa* (Parr) at the base, through limestones with frequent to abundant chert containing the large distinctive Janjukian species *Victoriella conoidea* (Rutten) to a characteristic assemblage for interval zone I (Table 3.1) with chert absent. The stratigraphy and the succession corroborate many of the observations from other localities.

There is a transition from the Willungan Stage with the top of interval zone D to the Janjukian stage. McGowran (unpublished data) documented an interval of around 30 metres of 'cream limestone' with chert absent sandwiched between an 'upper cherty unit' of greater than 40m and a 'lower cherty unit' of around 21 metres. At Robe the middle unit (=middle member) is 26.5m and the lower member marginally thicker at 36m but the lateral persistence of these units is conspicuous throughout the Otway Basin. The base of the lower member, at 134m, is close to the first consistent appearance of *Victoriella conoidea* and marks the beginning of the Janjukian Stage.

Stratigraphy of SADME bore RR65, Mt Gambier

As part of the developing hydrogeological survey, in 1989 MESA (SADME) drilled bore RR65 adjacent to the lakes at Mt Gambier. The drilling intersected late Eocene arenites and fossiliferous calcarenites at the base, with *G.index* present, above this a thick sequence of calcarenites grade into calcarenites with chert (unpublished SADME report). Early Oligocene fossiliferous bryozoal calcarenites and calcilutites continue to around 192m, after which extensive dolomitization interlayered with calcareous sand and clays make sampling for foraminiferal studies difficult, and so biostratigraphic control is lost until close to the 127m level in the late Oligocene. These correlative dolomitized calcarenite and calcilutite horizons can be traced in the Otway Basin and is suggested to be present at a similar level in the subsurface Willunga Embayment (WLG 38; Cooper, 1979) and as far as west as the Heyword in Victoria (Reed, 1965). This important interval appears to correspond with the onset of the type 1 (TA4.5/TB1.1)SB. The upper part of the section has *Chiloguembelina cubesis* and *Guembelitria triseriata* absent at the base but a few metres above this *G.angulisuturalis* and *T.pseudokugleri / kugleri* are encountered, although the diagnostic benthic species *Victoriella conoidea* is absent, characteristic interval zone D species are present including *Karreria moaria* (Finlay) and *Textularia vertebralis* (Cushman). Up section the sequence of bryozoal limestones with common chert grades into Miocene fossiliferous calcarenites and calcilutites with *Gq. dehiscens* present. The bore is capped by sub-recent basalt and volcanic tephra.

Otway Basin E series samples,

Appendix D (Fig. 3.2.2 for locations)

Abele (1961) collected 180 samples from from quarries (e.g. sample E50) and outcrops exposures in the Otway Basin are deposited at the Department of Geology and Geophysics at The University of Adelaide. A selection of 12 samples with *Victoriella conoidea* present, a characteristic Janjukian species, were examined and the absence or presence of benthic and planktonic species were recorded. These data were included in the cluster analysis to investigate similarities with assemblages from other interval zones and locations (chapter 5).

Browns Creek

The Browns Creek Formation outcrops at Browns Creek in the Aire District in the eastern part of the Otway Basin (Fig. 3.2.1). The stratigraphy consists of the dark grey carbonaceous sands of Johanna River Sands overlain by dark *Spiroculpus* -rich clays and silts, glauconitic, *Notostrea* -rich sands and above this bryozoal calcarenites and calcilutites, and sandy clay at the top that was considered by McGowran (1978) to be the Chinaman Gully equivalent in the Otway Basin. The biostratigraphy indicates that the base of the Tortachilla Limestone equivalent occurs close to the top of the Johanna River Formation and the lithological transition to the sandy clays at the top of the Browns Creek Formation marks the Eocene-Oligocene boundary. In summary, the section spans the equivalent of the Tortachilla

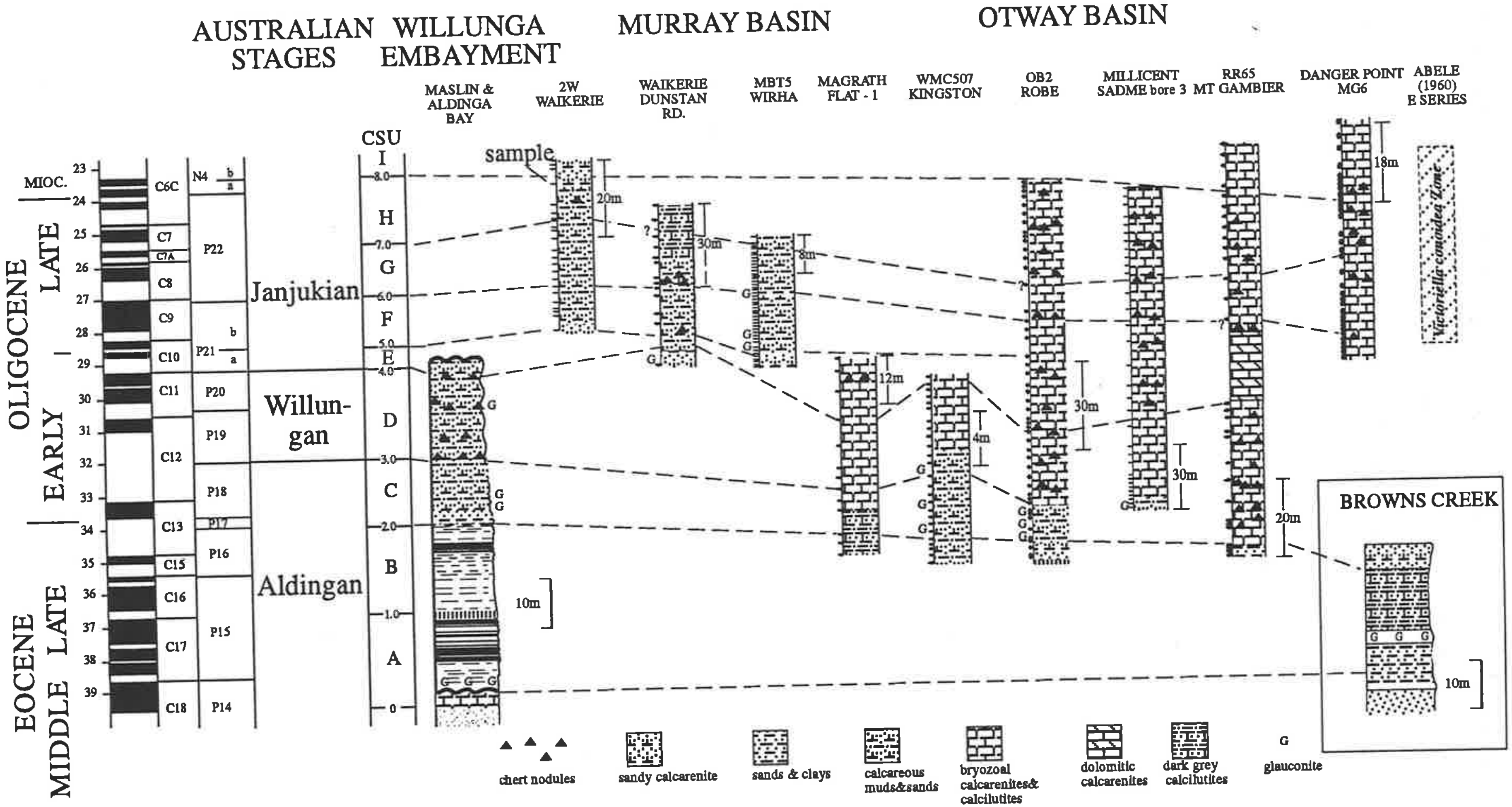


Figure 3.3 Chronostratigraphy versus stratigraphy for sections from the St Vincent, Murray and Otway Basins. Samples from Abele (1960) E series are selected from the *Victoriella conoidea* Zone in the Janjukian Stage. CSU = Composite Stratigraphic Units, to which all foraminiferal events are calibrated, see Chapter 5 for discussion.

Limestone to the Chinaman Gully Formation of the St Vincent Basin (Shafik, 1983; McGowran, 1987) and it is therefore considered that the section includes interval zones A and B.

3.3 CALIBRATING THE LOCAL STRATIGRAPHY

Figure 3.3 shows the correlations of each individual section with the chronostratigraphic timescale. The Oligocene is spanned by 9 sections and by the E series samples of Abele (1960) in the Janjukian of the Otway Basin. The late Eocene is encompassed by the the Blanche Point Formation in the restricted St Vincent Basin and the Browns Creek Formation in the more open marine Otway Basin. The critical aspect of the correlations in this study are the synchronization of biological events, lithological changes and comparing them to sequence stratigraphy. Three stages characterise the late Eocene to the beginning of the Miocene in southern Australia. The Aldingan Stage, redefined by Ludbrook & Lindsay (1966), stretches from the middle Eocene to the early Oligocene (mid P15 to P18), the Willungan (near top of P18 to P21a) as proposed by Lindsay (1985) corresponds to the New Zealand Whaingaroan Stage and this is followed by the mainly late Oligocene (P21a to the top of N4) Janjukian stage. Biostratigraphic criteria suggests the top of the Aldinga Member in the at Aldinga Bay and the Lacepede Formation in the Otway Basin coincides with the last appearance of *S.linaperta* in southern Australia and close to the local first appearance of *G.triseriata*, but these events are clearly preceded by the last appearance of *G.index* in the upper part of Chron C13r (Berggren, 1992), therefore the former datums are suggested to coincide with the top of Zone P18 in the middle of Chron C12r.

The Janjukian Stage is referred to the upper Oligocene and lower Miocene by Singleton (1941) and later by Glaessner (1951). It has been divided by Carter (1958) into faunal units 4 and 5 incorporated within the *Victoriella conoidea* Zone. Taylor (1971) reviewed the depositional history of Cainozoic facies in the Otway Basin in Victoria from subsurface data and mapped the geographical extent of lower and upper Oligocene sediments. Evidence began to indicate that the Janjukian Stage corresponded to the major transgression in the late

Oligocene and the early Miocene that could be correlated to the global late Oligocene transgressive phase. Carter (1958) proposed that the latest Eocene and earliest Oligocene was absent in the Port Campbell Embayment and Martin (1991) suggested that dinoflagellate evidence points to only a minor marine influence in the western part of the Murray Basin from the late Eocene to the Oligocene but was at its greatest in the early Miocene. The durations and the boundaries of the local Stages appear to fall within the 2nd order sea level timescales.

3.4 Interregional correlation

Correlation of Oligocene southern Australian sedimentary sequences with regional stratigraphic patterns are constructed from a composite from the three sedimentary basins. The northwest Murray Basin has early Oligocene absent and there is a hiatus in the Heytesbury Group, at the end of the early Oligocene. This follows the equivalent of the Aldinga transgression in the eastern Otway Basin (Glenie et al., 1968). The record of the Oligocene in the Murray Basin has to be constructed from composite of stratigraphic sequences but the Otway Basin has relatively complete sequences (Fig.3.3). The St Vincent Basin has a well preserved record in the outcrop and subsurface sections. In neritic facies, stratigraphic breaks can be correlated on a broadly regional extent. The Oligocene record in New Zealand is complicated by a complex of disconformities in the North Otago stratigraphic succession and part of the *'G'. angiporoides* zone and the overlying *G. euapertura* zone is absent (Hornibrook et al., 1989) but the *Globigerina linaperta* zone is correlated to the southern Australian *T. aculeata* zone and is approximately equivalent to interval zones A and B in the late Eocene while the *G.euapertura* zone is interregionally correlated and represents zones F to I. Quilty (1977) reports an hiatus over much of western Australia between the late Eocene to late early Oligocene and the 'Marshall Paraconformity' is suggested to record the late-early Oligocene type 1 sequence boundary in the New Zealand region (Carter et al., 1981). This is interpreted to be coeval with similar erosional unconformities in other deep-sea sections (Carter & Landis 1972, Schröder-Adams, 1991). This apparently regional event that is followed by a prominent Oligo-Miocene transgression that can be traced over a considerable regional scale that includes Africa (Brun et al., 1984), the Gulf Coast and the middle Atlantic coastal plain of North America (Olsson et al., 1980; Miller et al., 1993), and can also recognized in the deep sea (Carter & Landis, 1972; Keller, 1983). In New Zealand, the deposition of Oligo-Miocene limestones equivalent to Gambier Limestone, and perhaps Ettrick Formation, is recorded throughout the Canterbury Basin and eastward along the Chatham Rise (Hornibrook et al., 1989). The transgression, commencing in the late Oligocene, culminated in a maximum in the early Miocene in the Otway Basin (Taylor, 1971) and is recorded as a major sea level high (in Zone N4) in the

Latrobe Valley Depression in the Gippsland Basin of eastern Victoria (Holdgate & Sluiter, 1991).

3.5 Silica and dolomite occurrence and their significance

Silica rich units are common to the late Eocene and Oligocene. Table 3.3 catalogues the extent of silica occurrence in some southern Australian basins. Silica occurs as bands of opal-CT in the Gull Rock Member of the Blanche Point Formation in the late Eocene and as chert-nodule horizons in the Ruwarung Member and the Gambier Limestone of the Oligocene. Chert-nodule occurrence has been used as a distinctive marker for recognition of the 'Janjukian equivalents' in southern Australia (Lindsay & Bonnett, 1973; Lindsay & Williams, 1977; Lindsay, 1981), and though valuable correlative tools, to date there has been no comprehensive geochemical study of these enigmatic chert-carbonate associations. There is a distinctive break in chert-bearing sediments in the Gambier Limestone and this ties in with expected sea level fluctuation for the Oligocene in the Otway Basin (Fig. 4.1). The implications of widespread silica deposition (in the form of chert) across the southern margin during the Oligocene as been discussed by other at various times (Heath, 1974; Brewster, 1980; Lindsay, 1981). Baldauf (1992) reported that the middle Eocene, latest Eocene to earliest Oligocene and latest Oligocene to Miocene corresponded to an expansion of biosiliceous sediments in southern high latitudes that most likely represented the floral response to the development of the Antarctic cryosphere. Turnover in diatoms reached its minimum in the middle of the Oligocene with only 10% of the total assemblage and first appearances absent. There is a salient coincidence with these events and the sequential occurrence of chert-carbonate associations on the southern Australian margin, even though no siliceous tests have been reported from these horizons. The explanation of the precise mechanism of chert-carbonate alternation is seemingly complex and involves variations in the productivity of both carbonate and calcareous organisms (Decker, 1991). But the three-part coincidence of the wide distribution of the associations, excursions of the oxygen isotope curve to lower values, and transgressive events suggest allocyclic rather than autocyclic causes.

The correlatable dolomite rich horizon that interrupts the stratigraphic succession in the Otway Basin and can be traced, at a similar level, from a sub-surface bore in the St Vincent Basin to the Otway and Gippsland basins, and is a marker for the late/early Oligocene. Sarg (1988) proposed a mechanism for similar episodes of extensive dolomitization (mixing or hypersaline), suggesting there was a basinward migration of meteoric waters during a late highstand preceding a type 1 sequence boundary.

EPOCH	ST VINCENT	MURRAY	OTWAY
LATE OLIGOCENE-MIOCENE	Occasional chert nodules in sub-surface sections, Pt Willunga Formation (Lindsay, 1981)	Occasional chert nodules in the Ettrick Formation (eg. Waikerie WAK-1, '2W')	Abundant chert-nodules in the Gambier Limestone zone of intense dolomitization and chert absent (e.g. RR65)
early LATE OLIGOCENE	Abundant sandy dolomite (e.g. 195-144m in WLG38, early late Oligocene)		Winnowed bryozoal limestones with chert absent (e.g. OB2)
EARLY OLIGOCENE	Interbedded chert-nodule horizons in the Port Willunga Member; in outcrops on the western side of St Vincent Basin on the Yorke Peninsula, e.g. Rogue Formation (Stuart, 1970; pers. comm. B. Shubber)	Non-deposition or erosion	Abundant interbedded chert-nodule horizons (e.g. OB2, RR65)
LATE EOCENE	Opal-A and opal-CT in the Blanche Point Formation		

Table 3.3 Geographical and temporal distribution of silica- and dolomite-rich lithologies in the studied region.

CHAPTER 4

ECOSTRATIGRAPHY AND SEQUENCE STRATIGRAPHY

4.1 What is ecostratigraphy?

Marine organisms are constrained by controls such as: salinity, the availability of light and oxygen, water turbidity, temperature, changes in nutrient supply and competition. Ecostratigraphy attempts to treat multiples of species simultaneously such that a change in 'community structure' becomes an ecostratigraphic event and the biofacies changes are the focus of investigation. Boucot (1983) considered biofacies as community groups or associations of taxa persisting through intervals of species-level community evolution interrupted by episodes of 'quantum evolution'. They are correlatable benthic associations (including abundances) or recurrent assemblages that survive over some period of time only to be replaced by another association (Waterhouse, 1976; DiMichele, 1994). Martinsson (1973) called this approach ecosystem stratigraphy or a 'synecological-sedimentological' synthesis. And according to Kauffman et al. (1991) ecostratigraphic events may be rapid, short-term variations in assemblages that may occur over wide geographic areas due to environmental shifts that favour the proliferation and survival of species. Simple abundance and diversity changes have been used to recognise sequence boundaries (Armentrout et al., 1990) but a more detailed investigation of patterns of change in benthic associations is expected to identify more precisely specific and varying environmental conditions involved in sequence stratigraphy (Kauffman & Sageman, 1992).

4.2 Methods

Raw abundance data are the counts of taxa from 271 late Eocene to Miocene samples from 10 locations. Where necessary, samples were prepared by disaggregating material in boiling water and detergent (counts were then obtained from the resulting dried material). A minimum of 300 specimens of all genera were counted from each fraction. Percentage abundances and planktonic:benthic and (infaunal plus cyclindrical):epifaunal ratios were calculated for genera according to the criteria described in Table 4.1. Woronow (1991) has warned that percentage abundances may be misleading as they are components of a closed system and may lead to false correlations when analyzed statistically. All taxa are considered and percentages are directly compared to a ratio of counted specimens (I:E). They are not subjected to secondary statistical analysis. All percentage abundances and the raw abundance data are presented in appendix C.

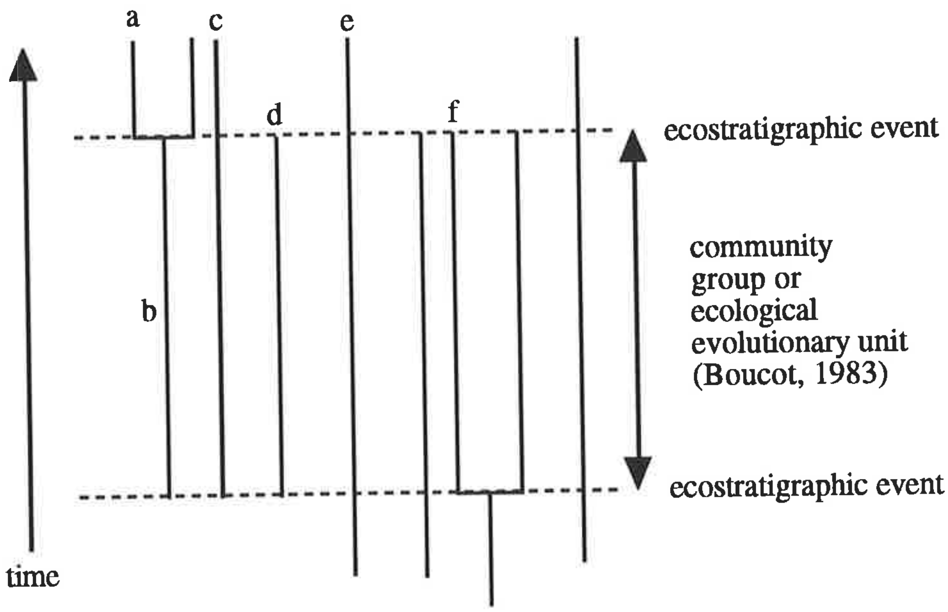


Figure 4 A schematic diagram of the bounding of an association by ecostratigraphic events. Contemporary taxa form a 'community group' with concurrent time ranges. Taxa b, d and f have ranges restricted to the community group while taxon c and e are transient members; their ranges are not restricted to the defined interval. Ecostratigraphic events are defined by anomalously higher numbers of simultaneous first and last appearances. Taxon a, the descendent of b is a product of the radiation following an ecostratigraphic event. Associations of members of the community group may be indicative of the prevailing environmental conditions. Adapted from Boucot (1986).

Samples were floated using the heavy liquids tetra-bromo-ethane or alternatively sodium polytungstate and the recovered float was dried. These were then sieved into fine (<75μ), medium (75μ<x<150μ), and coarse (>150μ) fractions. Specimens were picked from each fraction and simple presence and absence matrices or range charts for each section were compiled (appendix D). In some cases counts of important individual species were under-taken. Representative specimens were photographed using a Siemens ETEC Autoscan and a Philips 505 scanning electron microscope.

4.3 Morphotype and microhabitat: the infaunal/epifaunal ratio

The use of the relative abundance of taxa based upon morphotype criteria, as an environmental indicator, has numerous advantages. There is general agreement on the specific controls that determine test morphology and wall structure that are independent of species level taxonomy, and therefore negate inevitable differences that occur between workers (Severin, 1983). Taxa have been separated into ecological groups based upon the criteria of test morphology and microstructure of Corliss and Chen (1988) , Thomas (1990) and Murray (1991a) (Table 4.1). Linke and Lutze (1993) have warned that there is evidence that some of the demarcations are somewhat arbitrary and that vagile taxa may be more opportunistic and flexible in their behaviour than previously understood, particularly in their occupation of diverse habitats. Some authors simply disagree with the general employment of morphological criteria (Sen Gupta & Machain-Castillo, 1993). That said, it is clear that the abundance changes of morphological groups show patterns that match clear lithological changes. Distinct patterns can also be associated with changes in depth (Corliss and Chen, 1988; Armentrout, 1992). It seems reasonable to argue that biofacies changes are responses to shifts in the benthic environment. More work is necessary and ongoing, for example, one stratagem investigates variations in $\delta^{13}C$ in infaunal tests that enables an alternative method of identification of habitat for extinct taxa (Murray, 1991b). A multi-faceted approach must ultimately provide more convincing interpretations.

Infaunal species appear to adapt to high-organic carbon and low-oxygen conditions by increasing surface pore density over the entire test and increasing surface area relative to volume (Corliss and Chen, 1988). These taxa tend to have tapered, cylindrical, spherical, planispiral and flattened ovoid morphologies (Corliss, 1985). Such taxa include *Cassidulina, Globocassidulina, Uvigerina, Trifarina, Fissurina* , uniserial lagenids and *Pullenia*. (Plates 5, 7, 8, 9, 10, 11(*Pullenia*)). Coccioni and Galeotti (1993) suggested that taxa that adopt an infaunal strategy often possess cylindrical and elongate tests because they can easily move towards the more oxygenated sediment-water interface. And Bernhard (1986) argued that small test size may be an important adaptation to low-oxygen levels in the sediment but she also warns that as high levels organic carbon cannot be isolated from low-oxygen either may be the control.

Epifaunal species, that occupy habitats ranging from above the sediment-water interface (e.g., epiphytic or epizoic; sessile or motile) to within the upper 1cm of substrate, generally have planoconvex, biconvex, milioline and trochospiral morphologies and are associated with relatively elevated oxygen levels and decreased organic flux to the sea floor (Corliss & Chen, 1988; Coccioni & Galeotti, 1993). These species tend to restrict the distribution of test pores to surfaces not exposed to the relatively oxygen-rich bottom waters (Corliss & Chen, 1988). Examples of epifaunal taxa categorised according to functional morphology include *Cibicides*, *Cibicidoides*, *Hanzawaia*, *Eponides*, *Gyroidinoides*, and milioline species (Plates 4, 6, 11-16). Some genera may have more ambiguous morphologies, so some characters are weighted. Corliss and Chen argued that *Lenticulina* is categorised as an epifaunal genus because of its biconvex shape and imperforate test surface although it has planispiral coiling. Clades have been grouped into component genera in Table 4.2. Most are illustrated in Plates 3-16. Planktonic to benthic ratios (P:B) have been used to estimate the depth of assemblages as the relative abundance of planktonic tests are suggested to be indicative pelagic influence (e.g. Grimsdale & Morkhoven, 1955; Murray, 1976; Gibson, 1989; Murray, 1991a). It is important to note that taphonomic processes may have had considerable influence of the preservation of planktonic relative to benthic tests (Haynes, 1981). Although the values are more useful in the more open marine Otway Basin, that have consistently higher numbers of planktonic foraminifera, values for the restricted St Vincent and Murray Basins (too low to be a reliable bathymetric indicator) are mainly included for interbasin comparison.

EPIFAUNA	**INFAUNA + CYLINDRICAL**
rounded trochospiral genera	**rounded planispiral**
Gyroidinoides	*Astrononion*
planispiral	unkeeled *Elphidium*
keeled *Elphidium*	*Melonis*
planoconvex trochospiral	*Nonion*
Alabamina	*Pullenia*
Anomalina	**flattened ovoid**
Anomalinoides	*Cassidulina*
Cancris	*Fissurina*
Cerobertina	*Parafissurina*
Cibicides	**spherical or globular**
Cibicidoides	*Globocassidulina*
Discorbis	**tapered and cylindrical**
Gavelinella	*Amphicoryna*
Hanzawaia	*Bolivinella*
Patellina	*Brizalina*
Pararotalia	*Bulimina*
Valvinulineria	*Dentalina*
discoidal	*Nodosaria*
Planorbulina	*Trifarina*
Spirillina	*Uvigerina*
biconvex trochospiral and planispiral	**uniserial lagenids**
Eponides	**biconvex trochospiral**
Lenticulina	*Ammonia*
all miliolids	*Hoeglundina*
agglutinated	
Gaudryina	
Textularia	

Table 4.1 - Taxa grouped ecologically on morphotype criteria (Corliss & Chen, 1988; Thomas, 1990; Murray, 1992). Note: Corliss & Chen (1988) argue that *Elphidium* spp. are infaunal while Murray (1991a) propose that keeled forms are epifaunal and unkeeled are infaunal. See comments in appendix A.

Elphidiidae
Discorotalia
unkeeled *Elphidium*
Notorotalia
Parrellina
Porosorotalia

Uvigerinidae
Angulogerina
Kolesnikovella
Trifarina
Uvigerina

Bolivinidae & Buliminidae
Bolivina
Bolivinopsis
Latibolivina

uniserial lagenids
Cushmanina
Favulina
Fissurina
Lagena
Oolina
Palliolatella
Parafissurina

Cassidulina
Cassidulina
Globocassidulina

Nodosariidae
Amphicoryna
Astacolus
Chrysalogonium
Dentalina
Frondicularia
Lingulina
Marginulina
Marginulinopsis
Nodosaria
Planularia
Plectofrondicularia
Saracenaria
Vaginulina
Vaginulinopsis

agglutinated
Gaudryina
Siphotextularia
Textularia

Discorbidae
Discorbis
Trochulina

Cibicididae
Cibicides
Cibicidoides
Dyocibicides

miliolids
Biloculina
Massilina
Quinqueloculina
Triloculina

Table 4.2 - Important genera that have been used to compile biofacies profiles grouped according to clades.

Measures used in biofacies profiles are:

1. Planktonic to benthic ratios. P:B can be used to estimate marine influence. Rapid increases in the percentage of planktonic foraminifera result from increasing depths in outer shelf environments but salinity and turbidity effects may become important in the inner shelf when there are restrictions on oceanic influence (Gibson, 1989).
2. Percentage abundances of taxa.
3. (Infauna plus cylindrical) to epifaunal ratios (I:E). This is a ratio of the counts of individual specimens of the morphotype groupings discussed above.
4. Appearances and disappearances of taxa obtained from range charts (appendix D) resulting from: i) Rapid sample-by-sample reversible events of comings and goings (temporary migrations), and ii) Irreversible evolutionary change marked by 'final' first and last appearances.

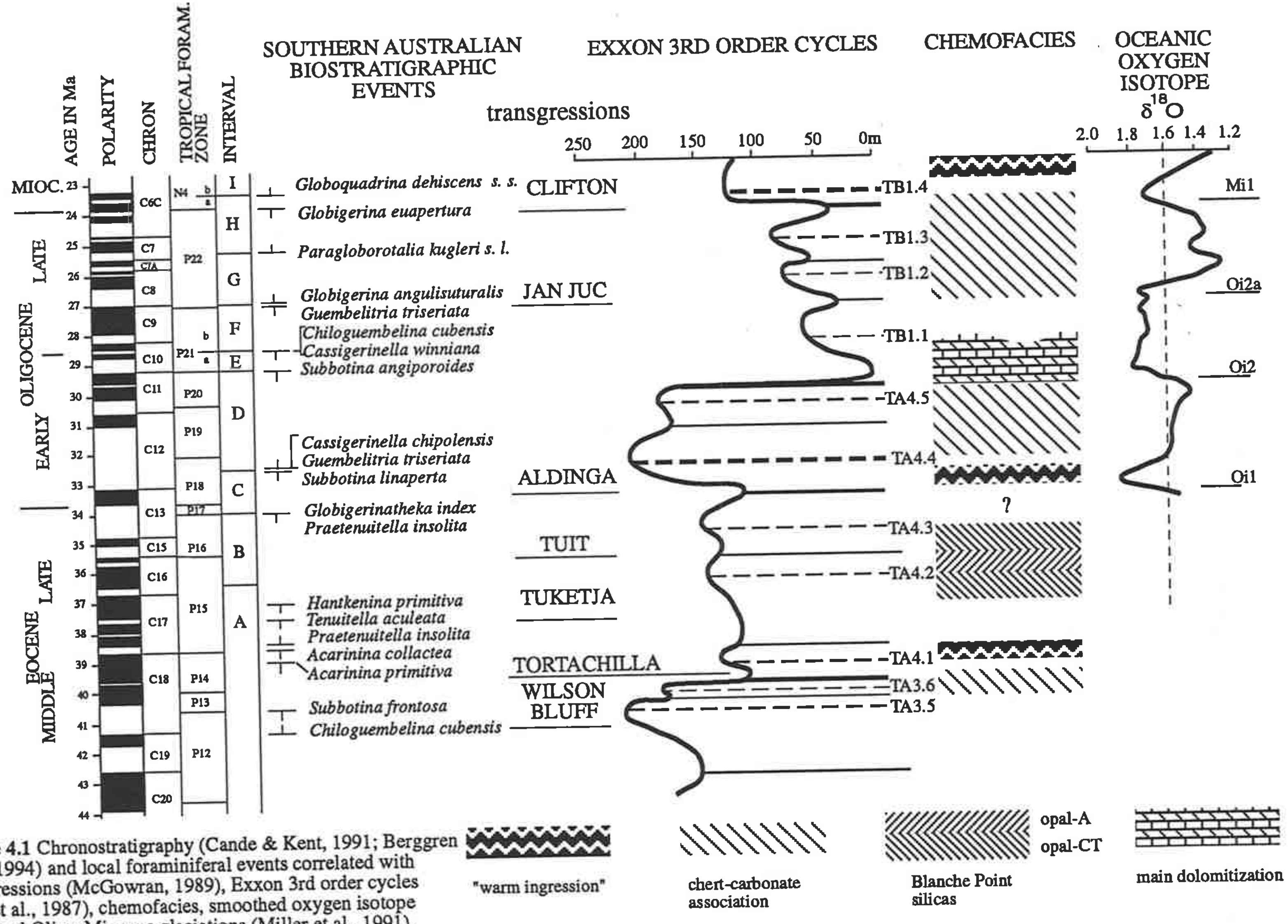


Figure 4.1 Chronostratigraphy (Cande & Kent, 1991; Berggren et al., 1994) and local foraminiferal events correlated with transgressions (McGowran, 1989), Exxon 3rd order cycles (Haq et al., 1987), chemofacies, smoothed oxygen isotope curve and Oligo-Miocene glaciations (Miller et al., 1991).

Figure 4.1 shows the geochronological timescale and magnetic polarity changes correlated to planktonic foraminiferal zones and local planktonic foraminiferal events, constructed intervals (from A to I based upon these events), recorded transgressive events, Exxon third order sequence stratigraphic cycles, chemofacies changes on the southern Australian margin and a smoothed composite oxygen isotope curve compiled from data from North and South Atlantic sites with Oligocene and Miocene glaciations (Oi, Mi) identified by Miller et al. (1991). McGowran (1989) summarized the series of local marine transgressions that can be recognized from the late-middle Eocene to the early Oligocene: the Wilson Bluff transgression in Chron C18r, the Tortachilla in the upper part of Chron C18 (Zone P14), the Tuketja in Chron C17n (upper part of Zone P15) and the Aldinga transgression in Chron C13 (Zone P18). All transgressions correlate with extratropical excursions of larger foraminifera and palynological zonations. The Jan Juc transgression follows the late-early Oligocene regression and is named after the Jan Juc Formation with the type section of glauconitic and fossiliferous calcarenites outcropping at Bird Rock near Torquay in the Otway Basin. These deposits are interpreted to correspond to the TB1 supercycle. The interval concludes with the Clifton transgression in the earliest Miocene in Chron C6C corresponding to the first of the four major Miocene upwelling events recorded in southeastern Australia (Li & McGowran, 1994). Added to this framework are chemofacies changes identified from a composite of the St Vincent and Otway Basin stratigraphic successions (McGowran & Beecroft, 1986; McGowran, 1987; McGowran et al., 1992). Chert-carbonate associations typically appear as rhythmic chert-nodule horizons interbedded with clay-, silt- and bryozoan-rich carbonates, they occur in three prominent packets: at the Wilson Bluff highstand; and in the late-early and late Oligocene. The second and third may be correlated to swings to negative values in the oxygen isotope curve.

The following section refers to Figures 4.2 to 4.11 in enclosure at the back of this thesis.

4.4 Biofacies patterns and third order sequences in the late Eocene

Biofacies correlations with reversible events show abundance profiles of key planktonic taxa from the late Eocene Tortachilla Limestone and the Blanche Point Formation (Fig. 4.2). The patterns are matched to those from the coeval Browns Creek Formation some 600 kms to the southeast in the Otway Basin. The Tortachilla/Tuketja unconformity, the TA4.1/4.2 sequence boundary, is followed by the glauconitic clays of the Tuketja Member in the St Vincent Basin and the *Turritella* clays in the Otway Basin. There is a parallel succession of (a) an increase *Pseudohastigerina* followed by (b) in *Globigerinatheka* and (c) rise in *Chiloguembelina* numbers preceding the appearance of (d)*Sphaeroidina* followed by (f) a peak in Robertinacea and finally another peak in *Chiloguembelina* (f). This correlation shows that the top of *G. index* (i) at Blanche Point precedes (ii) at Browns Creek. Level (p) is a correlatable horizon, identified from biofacies patterns in figures 4.2 and 4.3, that probably represents a parasequence cycle in the TST of TA4.2. This homotaxial succession invites ecostratigraphic correlation.

4.5 Chemofacies and biofacies changes within the Blanche Point Formation and Browns Creek

Blanche Point has essentially a four-part stratigraphic succession: the intensely burrowed, honey-combed and highly-fossiliferous Tortachilla Limestone unconformably overlain by the glauconitic Tuketja clays; the banded grey to black *Spirocolpus*-dominated opal-CT-rich Gull Rock; the opal-A-rich sponge spicule-dominated Perkana; and a return to grey to black opal-CT-rich deposits in the Tuit Member. Changes in biofacies patterns closely follow changes in the lithostratigraphy. The change from the glauconite-rich, silica-free Tuketja to the Gull Rock deposits also match a change in macrofossils from epifaunal bivalve-dominated to infaunal gastropod-dominated molluscan assemblages (Buonaiuto, 1979). This matches (p) at Browns Creek (Fig. 4.4) as the I:E ratio plunged sharply close to the 9m level *Cibicides* and *Cibicidoides* reached their peak at about the level of a thick-soft calcareous layer. Uvigerinidae numbers rose as the harder silica-rich layers became more frequent. Nodosariidae and *Lagena* profiles show relatively little activity, while elphidids are absent and bolivinids are in much higher numbers. So there are considerable parallels but also there are conspicuous differences. Miliolids, for example, became an important component of assemblages at around (p) and just before a rapid rise in the P:B ratio, the fall in cibicidids and a sharp rise in uvigerinids.

McGowran and Beecroft (1986) have highlighted the comparatively high numbers of Uvigerinidae in the units bearing opal-CT while observing that the opal-A horizons are dominated by Bolivinidae (Fig. 4.3). Explanations of these patterns are complex. Mullins et al. (1985) have argued that the oxygen tension in interstitial fluids present in the substrate could have specific controls on the abundances of *Uvigerina* and *Bolivina* spp., with *Bolivina* spp. alternatively more abundant in sediments with lower concentrations of oxygen in the oxygen minimum zone (OMZ). Employing this reasoning, it appears the Perkana Member was deposited in a uniformly oxygen-stressed deeper-water environment, where *Bolivina* spp. and plankton numbers reached their maxima, while the opal-CT-rich Gull Rock and Tuit Members record rapid swings in oxygen concentrations. The alternating aerobic-dysaerobic parasequence cycles of the Gull Rock TST may have also controlled the cycling of the hard siliceous levels, as redox reactions at the 'anoxic-oxic' boundary are suggested to be a key process in flint formation at the time of silica deposition (Hesse, 1990; Savrda et al., 1991). These patterns, of the episodic deoxygenation events that accompany parasequence flooding in the TST typical of the Gull Rock and Tuit Members, draw a sharp contrast to the uniform character of the Perkana Member (Uvigerinidae low/planktonics, Bolivinidae and textularids high). Interestingly, Tada (1991) argued that the post-depositional transformation of opal-A to opal-CT is catalysed by high carbonate content and is retarded by the presence of clay, that affords little opportunity for silica nucleation. This model provides a explanation for the carbonate- and opal-CT-rich transgressive sequence tract of the Gull Rock and Tuit Members and the clay- and opal-A-rich highstand sequence tract of Perkana Member. The sequence boundary separating 3rd order cycles TA4.2 and TA4.3 appears to correlate with the base of the Tuit Member. The TST of 3rd order cycle TA4.3 is recorded in the Tuit Member, with organic-rich facies repeating patterns similar to those observed for the Gull Rock Member. A marked escalation in infaunal numbers, summarized by a rapid increase in the I:E ratio, is truncated by the essentially non-marine facies of the Chinaman Gully Formation, the TA4.3/4.4 type 1 sequence boundary. The highstand sequence tract of cycle TA 4.3 appears to be absent.

Parallel ecostratigraphic profiles in these St Vincent and Otway Basin sections suggest that taxa have responded to a common process. Figure 4.4 for Browns Creek shows the transgressive sequence tract of TA4.2 corresponds to erratic alternations in infaunal and epifaunal clades that appear to record parasequence cycles. A sequence boundary (TA4.2/4.3) is interpreted to correlate with the base of the Tuit Member at Blanche Point, and the TST of TA4.3 is marked by the return to the banded, opal-CT, *Spiroculpus* facies. At the top of the section correlation with Maslin Bay is obscure, but it is tempting to interpret the sharp fall in Uvigerinidae preceding the pair of sharp jumps in *Cassidulina* and Bolivinidae numbers, separated by a rise in miliolids in interval zone B, as roughly coeval with the sequence boundary at the base of the Tuit.

It has been argued that silica accumulation in the Blanche Point Formation has been the result of the semi-isolation of the basin from the Southern Ocean. This resulted in sluggish circulation patterns and stratification of the water column. While silica appears to have been flushed from the open-neritic Browns Creek section (McGowran & Beecroft, 1986). But this appears to be part of a geographically widespread episode of restricted ventilation in the Southern Ocean from the middle to early-late Eocene. Thomas (1990) reports high percentages of infaunal taxa at these times at high latitudes in the Maud Rise area and local neritic facies appear to show similar biofacies similarities. There are rapid changes in abundances of taxa resembling the occupation or desertion of infaunal and epifaunal habitats: at the top of the Tortachilla Limestone (TA4.1/4.2), a prominent emergent hardground; the TA4.2/4.3 SB between the Perkana and Tuit Members; and the type 1 SB at the top of the Blanche Point Formation in the St Vincent Basin (Fig. 4.6).

4.6 The Eocene-Oligocene transition in the St Vincent Basin : evidence of environmental change from ecostratigraphic profiles

There are striking lithological and biofacies changes at the level of the Chinaman Gully Formation. Biostratigraphic data for the recognition of the Eocene-Oligocene boundary (see section 3.1.2 and Fig. 3.1.1) corresponds well with this major lithological change at the Chinamn Gully Formation or the type 1 SB. McGowran, Moss and Beecroft (1992) have shown that this event had a parallel impact on foraminiferal faunas in both the restricted environment of the St Vincent Basin and the open-neritic Otway Basin.

Abundance profiles in the St Vincent Basin (Fig. 4.5) are interpreted to show:

i). Planktonic to benthic ratios are generally much higher in the late Eocene with the peak of 0.3 at 21.1m in the lower part of the Perkana Member of the Blanche Point Formation and this is interpreted to be the HST of 3rd order cycle TA4.2, following the MFS at the Gull Rock-Perkana boundary.

ii). Uvigerinidae numbers consistently alternate with *Cibicides* and *Cibicidoides* in the Blanche Point Formation as the faunas appear to be responding to changing oxygen and nutrient supply controlled by 4 to 6 order parasequence cycles. Uvigerinidae numbers collapsed after the Chinaman Gully regression with the ventilation of the St Vincent Basin in the early Oligocene corresponding to the TA4.3/4.4 type 1 sequence boundary. This significant biofacies event is correlated between the relatively restricted St Vincent and the more open-neritic Otway Basin. Though the impact was dramatic in the St Vincent Basin as shown by the spectacular fall in the I:E ratio.

4.7 Biofacies patterns and third order sequences in the early Oligocene

Bolivina, Bulimina, Cassidulina, Globocassidulina, Sphaeroidina, Fissurina and uniserial Lagenids fall spectacularly in the Pt Willunga Formation. With the reduction of *Cassidulina* numbers after the Aldinga transgression and an increase in *Cibicides* and elphidids, the onset a chert-carbonate association marks the HST of 3rd order cycle TA4.4 in the

Ruwarung Member. The change also marks the C/D interval zone boundary. There is a marked contrast between the biofacies in the HST of the oxygen stressed Blanche Point, with high numbers of infaunal taxa, and the well ventilated Ruwarung Member (low numbers).

The Ruwarung Member shows three-part cyclic alternations of shell-beds followed by burrowed horizons and chert-nodule horizons overlain by abundant bryozoa-bearing strata. The rhythms appear to record parasequences (possibly Milankovitch cycles) that coincide with the highstand in TA4.4 and the excursion in the oxygen isotope curve.

4.7.1 Evidence for 3rd order cycles in WMC 507 Kingston

Biofacies patterns are presented for Western Mining Corporation bore 507 in Figure 4.6. It can be seen from a comparison between the Port Willunga Formation (Fig. 5) with WMC 507 (Fig. 4.6) that infaunal taxa appeared to do much better across the Chinaman Gully regssion in the Otway Basin. A maximum flooding surface is closely followed by a sequence boundary in the middle of the WMC section. *Cibicides-Cibicidoides* numbers decreased and *Bolivina*, Uvigerinidae abundances increased closely followed by a sharp decline in the P:B ratio and a rise in *Cibicides-Cibicidoides* immediately followed by a rise in *Cassidulina* numbers. The biofacies patterns appear to correlate with the MFS of TA4.4 followed by the TA4.4/4.5 SB. A peak in bolivinids is followed closely by a rapid fall and then a rise in *Cassidulina* can be matched in OB2 (Fig. 4.10) and Magrath Flat (Fig. 4.7). The sharp rise to around 0.4 in the P:B as well as highs in infaunal clades and lows in *Cibicides* is interpreted to mark the MFS of TA4.5. Other correlations include: i) The Elphidiidae abundance profile shows a sudden burst to around 10% of the total benthos at about the level of the Aldinga-Ruwarung boundary equivalent in the St Vincent Basin (zone C/D boundary). This event appears to be delayed at Robe where, as seen in SADME bore OB2 (Fig. 4.10), Elphidiidae do not reach large numbers until well into zone E, or close to the base of Zone P21a. If these events are coeval then sedimentation rates are reduced in the HST of TA4.4 or a hiatus at the TA4.4/4.5 SB in WMC 507, and ii) Miliolids disappear well below the base of the Elphidiidae highs at around 30m and appear to coincide with the last gasp of the robertinids in both WMC 507 and OB2 in the Otway Basin.

4.7.2 Sequences in Magrath Flat 1

Figure 4.7 shows profiles for SADME bore Magrath Flat 1 in the south west of the Murray Basin. Planktonic to benthic ratios and the relative abundance of 11 prominent taxa are arranged against I:E ratios, and the number of benthic species coming or going per sample. A maximum fooding surfaçe at the bottom of the section is marked by a peak in P:B and I:E ratios that is followed by a sharp rise in epifauna signalling a sequence boundary. These events correspond to the MFs of TA4.4 and the TA4.4/4.5 SB. At around 64m the P:B ratio and Uvigerinidae numbers are elevated as Elphidiidae and discorbid species became an important component of assemblages. This is interpreted to be near a maximum flooding surface (of TA4.4). As discorbids rise sharply the top of the section is truncated by an unconformity with Pleistocene deposits. This is interpreted to mark the TA4/TB1 SB.

Conclusions from the above discussion are that Magrath Flat 1 records: i) The highstand sequence tract of TA4.3 to around 94m, ii) A sequence boundary (TA4.3/4.4) between 94-92m at the base of interval zone C, iii) A SB (TA4.4/4.5) is recorded at the base of interval zone D at around 81m, iv) The maximum flooding surface of TA4.5 at around 64m near the top of interval zone D, and vi).The highstand systems tract of TA4.5 to around 50m.

4.8 Ecostratigraphy and 3rd order sequences in the late Oligocene

4.8.1 Biofacies and 3rd order sequences in MBT 5 at Wirha

Abundance profiles obtained for SADME Bore MBT 5 at Wirha are presented in figure 4.8. It is immediately clear that planktonic to benthic ratios are consistently very low, with values at around 0 to 0.2. A maximum flooding surface close to 184m is signalled by synchronous abundance peaks in all infaunal taxa, agglutinated species and miliolids. Bolivinidae remained relatively stable in the highstand as *Cassidulina* numbers fell sharply. A sequence boundary (TB1.1/1.2) corresponds to rapid decrease in all infaunal at 179m. The rise in the

the diverity curve, the disappearance of agglutinated taxa and a relative increase in the *Cibicides-Cibicidoides*, after the disappearance of the miliolids marks the beginning of the TST (of 3rd order cycle TB1.2; Jan Juc). There is a lithological change from glauconite-rich marls with abundant shell and bryozoa fragments to red-brown sands with bryozoa fragments and poorly preserved foraminifera. The Jan Juc transgression shows a gradual build-up in infaunal and Elphidiidae numbers. There is a tentative identification of the TB1.2 MFS with a small peak in infauna near to 174m that is closely followed by a rapid loss of species suggesting the TB1.2/1.3 SB.

4.8.2 Biofacies and 3rd order sequences at Waikerie

Figure 4.9 shows assembled biofacies profiles from the Dunstan Rd. section at Waikerie. Biostratigraphic control is poor in this marginal marine sequence but sequence stratigraphy is estimated from general trends. Rapid abundance changes occur in the middle of the section with a cluster of biostratigraphic events. Last *G. triseriata*, first *G. euapertura* and last *Ch. cubensis* follow in rapid succession with a peak in *Cibicides-Cibicidoides* and *Anomalina* followed by a rapid increase in infauna. The events are condensed but patterns can be correlated to bores 2W (Fig. 4.9a) and MBT 5 at Wirha (Fig. 4.8). A maximum flooding surface (of TB1.1) followed by the TB1.1/1.2 sequence boundary and a the onset of the Jan Juc transgression.

Comparisons with profiles of bore '2W' (Fig.9b) show some overlap and support for the above observations. The sequence of biostratigraphic events are the last appearance of such key species as *Ch. cubensis* followed by last *G. triseriata* . The correlation of the latter event in both sets of profiles suggests that level 1 in figure 4.9a could correspond to the an interpreted sequence boundary close to 130m. This fits with the TB1.1/1.2 SB. The zig-zag pattern in the incoming-outgoing curve at 149.3m appears to mark the MFS of TB1.1. Miliolids declined rapidly and there is an increase in infaunal numbers excepting *Cassidulina* spp., planktonic to benthic ratios provide little evidence of relative changes in oceanic influence. Here, as at Dunstan Rd., 3rd order cycle TB1.3 appears to be condensed. A maximum flooding surface (possibly TB1.3) is interpreted to be near 110m . Uvigerinidae are rare but increases in *Cassidulina* and *Bolivina* result in a peak in the I:E ratio and there was a prominent influx of around 20 species. This event was immediately followed by a collapse in infauna, a gain in miliolids and a rapid loss of around 50 species; this is interpreted to be the TB1.3/1.4 SB. The uppermost samples in 2W are accompanied by high abundances of *Cibicides*, *Bolivina*, Elphidiidae and *Cassidulina* and a slightly increased planktonic to benthic ratio (though this remains very low). This is interpreted to record the 'warm ingression' (Fig.4.1) in cycle TB1.4 in the early Miocene. This is supported by the recorded the top of the 'lower *Amphistegina* peak' at around 109m from core together with a very thin *P. kugleri* zone (Lindsay and Bonnett, 1973).

To summarize: i) A maximum flooding surface (TB1.1) is interpreted to be close to the 150m level, in interval zone F, ii) A sequence boundary (TB1.1/1.2) is interpreted to occur at around 130m in the lower part of zone G, iii) Cycle TB1.2 appears to be relatively condensed within zone G, iv) a sequence boundary is recorded at around 108m at the base of zone H, and v) 3rd order cycle TB1.3 appears to be condensed and the TB1.3/1.4 SB is obscure but the onset of the Clifton warm ingression in the earliest Miocene appears to correspond to rapid abundance changes and temporary migrations of species at around the 110m level.

4.8.3 Biofacies and sequences in SADME Bore ROS 10 'OB2', Robe

The OB2 section at Robe are shown in figure 4.9 provides the most complete survey of Oligocene sequence stratigraphic succession. The recorded sequence begins with the TST of TA4.4 (Aldinga transgression) following the equivalent of the Chinaman Gully regression. Bolivinidae rose sharply to reach a peak in the HST and then numbers fall rapidly at the TA4.4/4.5 SB, as do *Cassidulina*. During this interval *Cibicides* spp., Nodosariidae and *Cassidulina* spp. dominated the benthic assemblages. Species tended to rapidly migrate in and out of assemblages, probably responding to the abrupt changes in environment associated with retrograding parasequence cycles, this pattern appears to be repeated in the next TST of cycle TA4.5. The HST of TA4.4 heralded the onset of chert-carbonate association in the Otway Basin. Agglutinated numbers reached around 8% of the fauna in concert with highs in Bolivinidae, Uvigerinidae and planktonic to benthic at the top of zone D and this is interpreted to be close to the level of the MFS of TA4.5. The big fall in all infaunal taxa and highest peak in *Cibicides-Cibicidoides* numbers at the zone D/E boundary marks the major supercycle TA4/TB1 type 1 SB. The onset of TB1.1 corresponded to the introduction of increasing numbers of Elphidiidae (dominated by *Parrellina* spp.) that contributed to a consistently high and stable I:E, these changes suggest a significant change in benthic environments at the beginning of 2nd order cycle TB1.

The lithostratigraphy abruptly changed to a winnowed bryozoal-carbonate with the disappearance of the chert-carbonate association. The MFS of TB1.1 is suggested to be signalled by a minor peak in the P:B ratio, elevated numbers of infauna, a fall in epifauna and a peak in diversity. The TB1.1/1.2 sequence boundary at the base of interval zone F is marked by elevated *Cibicides-Cibicidoides* numbers and a sharp loss of species at around the 65m level. The low P:B ratio and relatively low abundance of Bolivinidae seem to suggest a low relative sea level in the middle of the section. As *Cassidulina* became the dominant infaunal genus. With increasing relative sea level *Cassidulina* became less important as Bolivinidae, Elphidiidae, Nodosariidae and uniserial lagenids became more abundant.

The MFS of next 3rd order cycle (TB1.2) and the beginning of the Jan Juc transgressive phase is interpreted as a sharp peak in Elphidiidae corresponding to a small increase in *Bolivina* and *Bulimina* spp. and agglutinated species. This is closely followed by a sequence boundary registered by an increase in *Cibicidoides* and *Cibicides* spp. and a high number of outgoing species per sample (at around 55m). Near the level of the last appearance of *G. triseriata* and the first appearance datum of *Globigerina angulisuturalis* there is repeated alternation of cibicidids, *Cassidulina* and Elphidiidae that in turn result in a rapidly increasing I:E ratio. The late Oligocene records the highest I:E values at around 45 to 30 metres, and planktonic to benthic ratios reach close to 50% plankton in interval zone H in the late Oligocene There is maximum open-marine influence for the Oligocene synchronous with third order cycle TB1.4 and marks the onset of the warm ingression and the Clifton transgression. This interval correlates with the so-called 'thin' local range of *G. angulisuturalis* in both the Murray and Otway Basins.

Sequence stratigraphic surfaces and tracts in OB2 match the 3rd order cycle chart for the Oligocene (with a few misfits in the late Oligocene).

Biofacies patterns are interpreted to show sequence stratigraphic events:

i) At the base the section records the Aldinga transgressive phase, a MFS (TA4.4) and a sequence boundary between 110 and 115m (TA4.4/TA4.5),

ii) A major sequence boundary (TA4.5/TB1.1) is interpreted to be close to the 95m level near the top of zone D and is marked by a rapid fall in all infaunal clades and a rapid rise in *Cibicides-Cibicidoides*. This event possibly corresponds to a decline in the deep-sea heterohelicid *Chiloguembelina*, an event that has been recorded in North and South Atlantic sections (Boersma and Premoli Silva, 1989),

iii) The first 3rd order cycle (TB1.1) in the late Oligocene ushered in high numbers of Elphidiidae, particularly of *Parrellina* spp. and *Notorotalia* spp., suggesting a fundamental change in environmental conditions,

iv) Patterns at the beginning of the Jan Juc transgression show the TB1.1/1.2 SB is followed by the MFS of TB1.2 and TB1.3/1.4 SB close to the top of zone F that is closely followed by the second Oligocene chert-carbonate association. This may correspond to a warming trend, if this is the meaning of the excursion in the oxygen isotope curve (Fig. 4.1) to lower values,

v) The beginning of the Clifton transgression (TA1.4) follows the sharp fall in the *Cassidulina*, an increase *Cibicides* and *Cibicidoides*, an increase in the number outgoing species per sample, all clustering around the 25m level in the middle of interval zone H. This event is immediately followed by the peak in the P:B curve and increased infaunal numbers.

4.8.4 Biofacies and sequences in RR65, Mt Gambier

Profiles shown for SADME core RR65 from Mt Gambier (Fig. 4.11) show the dominant infaunal and epifaunal clades arranged adjacent to the P:B and I:E ratio curves. Many of the samples from the lower part of the section are depauperate and specimens are badly preserved so consequently the sequence stratigraphy is obscure. The TA4.3/4.4 is marked by the rapid fall in infaunal numbers and the P:B at the base of the section. This records the last appearance of high numbers of *Globigerinatheka index*. The lithostratigraphy changes from brown to black glauconitic, limonite-rich arenite to fossiliferous calcarenite. Though foraminiferal test preservation is poor and the planktonic component of the assemblage is dominated by *G. index* and *Subbotina* spp. A sequence boundary is interpreted to be around the middle of zone D (TA4.4/TA4.5) and is marked by a low in infaunal numbers as discorbid abundance began to increase. At the top of the lower part of the section lithologies show intensive dolomitization and lithification so sampling was abandoned with the continuing presence of *G.triseriata* and *Ch. cubensis*. This change marks the impact TA4/TB1 type 1 sequence boundary in this part of the Otway Basin.

The increase in *Cibicides —Cibicidoides*, *Siphonina* numbers and the drop in all infaunal taxa near 124m is interpreted to be a record of the TB1.2/1.3 SB at the top of interval zone G. There appears to be a good fit of the MFS of 3rd order cycle TB1.3 with the peak in the P:B ratio at around 119 metres showing an increase to around 1.5 and a parallel, but somewhat smoother, increase in the I:E. These patterns again match a trough in the *Cibicides* and *Cibicidoides* spp. abundance curve and a marginal increase in *Cassidulina* numbers, *Bolivina*, and particularly *Uvigerina* abundances. Following the parallel plunge in the P:B and I:E ratios immediately above this level comes an influx of *Siphonina australis* Cushman to account for around 10% of the benthos. This matches a slight increase in *Cibicides -Cibicidoides* numbers. These sequence of events mark the TB1.3/1.4 type 1 SB and the onset of 3rd order cycle TB1.4. The last appearance of *Globigerina euapertura* followed is followed by a very high P:B and the rapidly increasing I:E ratio marks the beginning of interval zone I. These patterns record the warm ingression and the Clifton Transgression in the early Miocene.

Interpretations of sequence tracts and surfaces in RR65 can be summarized as:

i) A sequence boundary (TA4.4/4.5) is interpreted to be between the 220 to 210m (lower part of interval zone D) in SADME bore RR65 at Mt Gambier,

ii) The poor faunas in the lower part of the section mean that estimates of sequence stratigraphy are poorly constrained but it is suggested that the trough in the I:E resulted from the TA4.4/4.5 sequence boundary,

iii) The late-early Oligocene (TA4/TB1) type 1 sequence boundary, at the top of zone D, is marked by intensive dolomitization. Dolomitization can be correlated at similar biostratigraphic levels in sub-surface sections in the St Vincent Basin and in the Gippsland Basin,

iv) The upper part of the section begins with the Jan Juc transgression followed closely by the TB1.2/1.3 sequence boundary at around the 124m level. This matchies a high in cibicidids and agglutinated abundances and a low in infaunal clades,

v). The maximum flooding surface of TB1.3 occurs around 119m and is closely followed by a sequence boundary (TB1.3/1.4) in zone H,

vi). The next 3rd order cycle (TB1.4), corresponding to the Clifton transgression, is marked by increasing I:E values as the P:B ratio became extremely high towards the top of the section.

4.9 Comparisons between biofacies patterns in the late Eocene and the Oligocene

Biofacies patterns record 3rd order sea level changes in the more restricted St Vincent and Murray Basins as well as the more open-neritic Otway Basin. There is a prominent contrast between biofacies fluctuations in the late Eocene and those in the early Oligocene. Infaunal numbers are much higher in the Blanche Point and the Browns Creek Formation, notably Uvigerinidae (20-40% of the benthos) and *Cassidulina* spp. (20-50%) while abundances of equivalent taxa in the early Oligocene (Pt Willunga Formation, WMC507 and OB2) are generally lower, particularly in the St Vincent Basin. Epifaunal abundances, chiefly

Cibicicides-Cibicidoides, appear to have dominated the early Oligocene. Unkeeled Elphidiidae became more common from the late-early Oligocene onwards and in the late Oligocene regularly constituted around 10% of the benthos. This may reflect increased nutrient supplies to neritic environments as a result of upwelling corresponding to the Jan Juc transgression in the late Oligocene.

Sequence stratigraphic surfaces and tracts in the late Eocene can be convincingly matched between the Blanche Point Formation and the more open-neritic Browns Creek Formation in the Otway Basin. In the Oligocene attempts to correlate sequence stratigraphic surfaces between basins of are less successful. Sequence boundaries are more confidently identified and appear to have the most significant impact on biofacies, while maximum flooding surfaces may be obscured by individual parasequence cycles.

In the Oligocene the transgressive systems tract of 3rd Order cycle TA4.4, the Aldinga transgression, can be identified in the Otway Basin and the St Vincent Basin but appart from being recorded at Magrath Flat, south of the Padthaway Ridge, it is not recorded in the Murray Basin. The facies change from the silica- and organic-rich late Eocene to the well ventilated siliciclastic-dominated Oligocene appear to reflect marked changes oceanic circulation patterns in the early Oligocene. The top of the Lacepede Formation (interval zone C/D) corresponds to the the loss of milioline and aragonitic species from the Otway Basin and the appearance of a chert-carbonate association in both the Otway and St Vincent Basins. The late-early Oligocene sequence boundary, correlated with the supercycle TA4/TB1 boundary, is marked by a hiatus in the Murray Basin, an unconformity in the St Vincent Basin and significant lithological changes, to winnowed limestones and the disappearance of the chert-carbonate association in OB2 and dolomitization in RR65, in the Otway Basin. Biofacies profiles in OB2 show a collapse in abundances of all infaunal taxa and the P:B ratio and a sharp rise in agglutinated followed a *Cibicides-Cibicidoides*.

The onset of Supercycle TB1 and the Jan Juc transgression corresponds to a restoration of increased abundances in all infaunal taxa in the Murray and Otway Basin. In OB2 the I:E ratio climbs with the introduction of Elphidiidae that become a component of assemblages in all sections. Third order cycles appear to have much more significant impact in the Murray Basin marginal marine sections but can be recognized in all sections and, based upon interval zone correlations, appear to approximate the Exxon TB1.1 to TB1.4 3rd order cycles. The Clifton transgression and warm ingression is recorded in the Otway Basin. This event is obscure in the Murray Basin but appears to be recorded at Waikerie with increasing abundances of infauna and the presence of the distinctive warm-water species *Amphistegina* at the top of section 2W.

CHAPTER 5: FAUNAL CHANGE

5.1 Introduction

Patterns of species overturn at the Eocene-Oligocene boundary are described from compilations of first and last appearances and diversity changes in the St Vincent and Otway Basins. These patterns are then compared to records of turnover at the late-early Oligocene regression from section OB2 in the Otway Basin. Then a study of all species ranges documents significant episodes of species turnover in the Oligocene. Patterns of faunal change are established from composites of species ranges using graphic correlation. The results of graphic correlations are presented as ranges ordered by first and last appearances in each basin, frequency histograms of the numbers of incoming and outgoing benthic species against interval zones, and species survivorship curves. These data are analysed in the context of the ecostratigraphic changes discussed in Chapter 4 to identify episodes of faunal change that accompany changes in lithostratigraphy, 3rd order sequence stratigraphic cycles and excursions in the stable isotope curve. The multivariate technique of cluster analysis and ordination have been used to further analyse patterns of similarity between all assemblages (samples) in the Oligocene to identify significant changes in assemblage composition through the studied successions.

5.1 The St Vincent and Otway Basins: parallel response to the Chinaman Gully regression

A detailed investigation of species turnover (non-reversible events) in the stratigraphic successions reveal contrasts and similarities. A detailed comparison highlights the differences in stratigraphy in the late Eocene: the St Vincent Basin contains richly fossiliferous prominently banded silica-rich sequences and shows clear chemofacies changes with prominent opal-A/ opal-CT alternations; chemofacies changes are absent in the sandy, clay-rich and glauconitic calcarenites of the Otway Basin. The foraminiferal succession does not show such a contrast — patterns of faunal change and abundance profiles generally correlate between basins at significant chronostratigraphic levels.

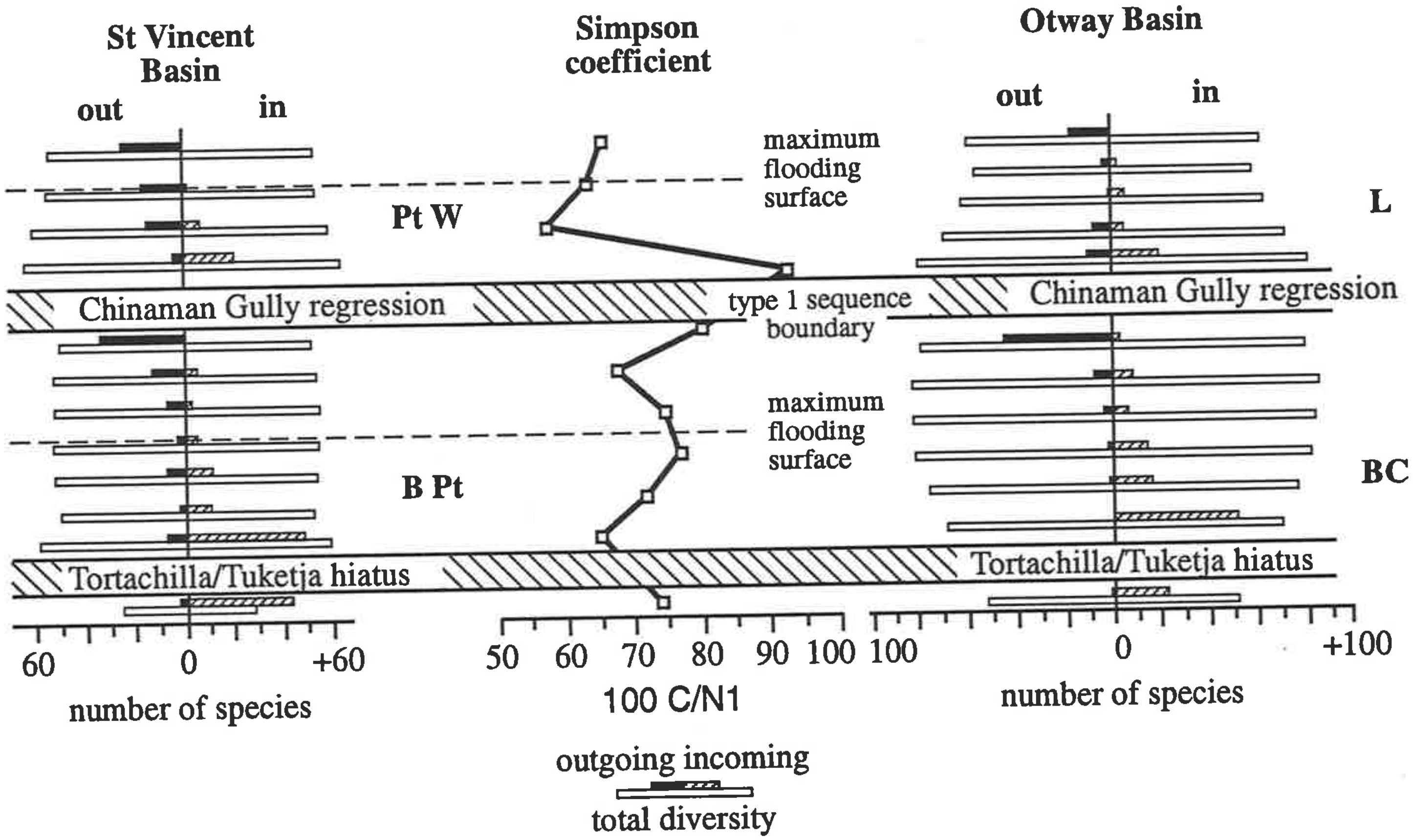


Figure 5.1 Benthic species overturn from the late Eocene to the early Oligocene in the St Vincent and Otway Basins, in 3 and 5m intervals. The Simpson similarity coefficient measures the number of species in common divided by the smallest diversity in the assemblages compared. Formation names: Pt W= Pt Willunga, L= Lacepede, BC= Browns Creek, and B Pt= Blanche Point (from McGowran, Moss and Beecroft, 1992)

The Tortachilla-Tuketja hiatus at the end of the middle Eocene shows a significant gain of species at Maslin Bay and Browns Creek (Fig.5.1). The Simpson similarity index starts off relatively low and rises in the late part of the Zone P15, perhaps reflecting a gain in cosmopolitan benthic species towards the Gull Rock-Perkana boundary. The number of first and last appearances reached their lowest at the level of the maximum flooding surface of 3rd order cycle TA4.2. Following this, there is a rapid loss at both locations. The Simpson index shows that assemblages began to become more dissimilar. Significant species turnover appears to correspond to sequence boundaries. Initially there is a gain of species with the Tuketja transgression with very few disappearances then the type 1 sequence boundary, corresponding to the Chinaman Gully Formation, records the most significant loss of species for the late Eocene, of around 40 to 50 species from each section. Following the Chinaman Gully regression, there is an across-the-board gain of species and a rapid rise in the Simpson coefficient.

5.3 Faunal turnover: end-Eocene contrasted with the mid-Oligocene

A comparison between patterns of turnover at the Chinaman Gully regression and the 'mid'-Oligocene regression recorded from SADME bore OB2 at Robe in the Otway Basin show a striking contrast (Fig. 5.2). The prominent episode of turnover at the Chinaman Gully regression is not repeated at the 'mid' Oligocene regression in at least this one study in the Otway Basin even though a significant sequence boundary (TA4/TB1) is prominently recorded in biofacies and lithological changes (Chapter 4, section 4.8). This seems a surprising response of taxa to such a prominent sea level fall. Benthic species in this part of the Otway Basin appear to be much more robust in the face of this second Oligocene glaciation. Faunas may have become preconditioned in the intervening time of intensified oceanic mixing with increased ventilation and perhaps nutrient supply to these neritic environments.

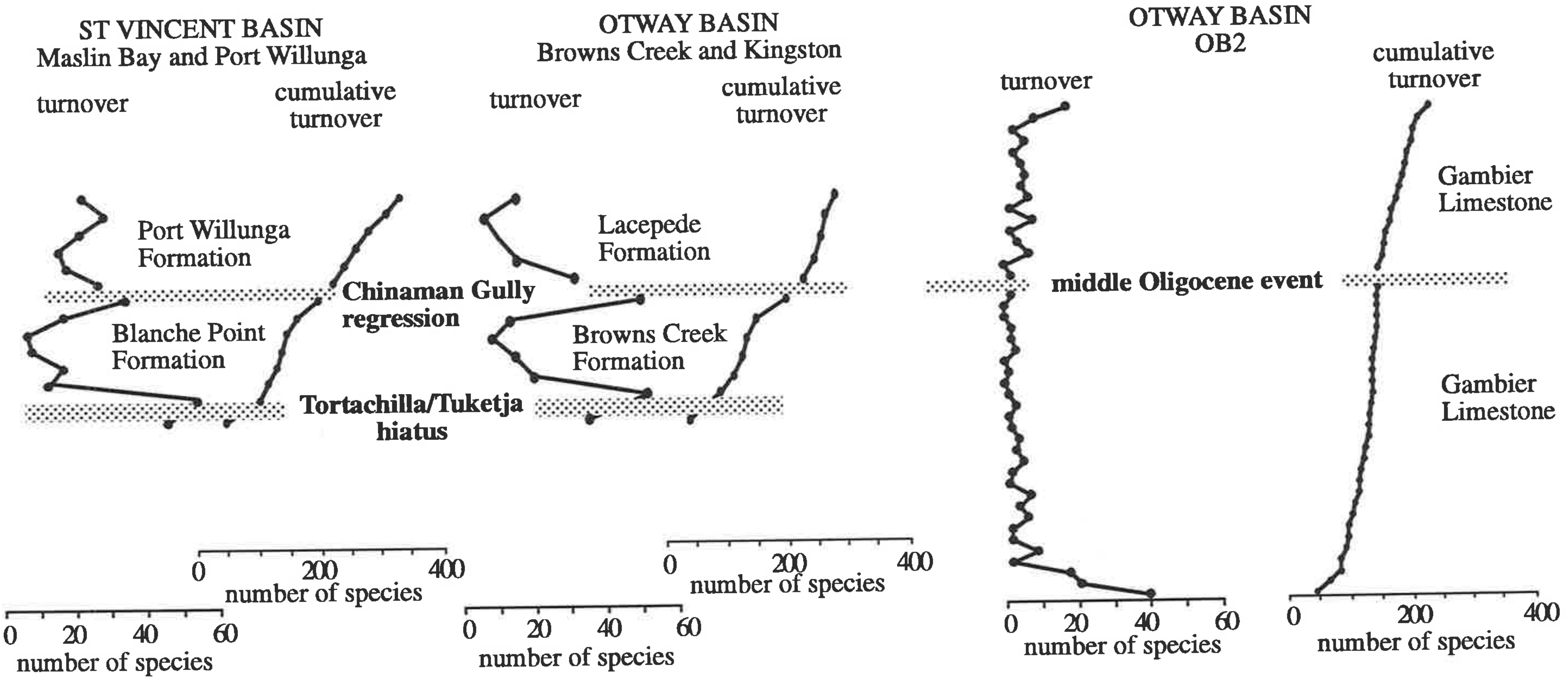


Figure 5.2 A comparison between benthic species turnover at the late Eocene-early Oligocene and the 'middle' Oligocene of SADME bore OB2 in the Otway Basin. Turnover is the sum of first and last appearnces and cumalative is a running sum of the total. The vertical scale is in 3 and 5 m intervals.

5.4 Faunal analysis of the Oligocene

5.4.1 Graphic correlation - Introduction

Shaw (1964) described a method of comparing sections by arranging them perpendicularly and plotting events, such as first and last occurrences of species. The method, as a tool in biostratigraphy and sequence stratigraphy, has been refined by numerous workers (Miller, 1977; Edwards, 1984; Gradstein and Agterberg, 1985; Edwards, 1989; Macleod, 1991; Martin et al., 1993). First occurrences (bases) are marked as solid circles and last occurrences (tops) are open circles. The worker using as much evidence as possible (e.g. biostratigraphic events, marker horizons etc.) fits a line that hypothetically represents the Line Of Correlation (LOC) (Edwards, 1984). It can be seen that the maximum number of first occurrence datums (FAD) lie on or below the line and the maximum number of last occurrence datums (LAD) are on or above the line. Observations of the slope of the line at any point on the LOC results in the approximation of the relative rates of sedimentation at any point during the total elapsed time encompassed by the stratigraphic sections. Theoretically, the use of this method should help to identify hiatuses and changes in the rate of sedimentation. More relevant to this study, it is also possible to adjust species ranges to fit a new series of maximised ranges on the Composite Reference Section (CRS) in a series of steps (Fig. 5.3a): tops and bases are plotted as depths in compared sections, points may plot to the left and right respectively of the hypothesized LOC; by tracing down or up the ordinate to the LOC and along the abscissa onto the CRS for each added section in turn the range can be adjusted to find the new 'maximized' range for each individual species (Shaw, 1964; Miller, 1977; Edwards, 1984).

5.4.2 Construction of composite sections

Raw data are first and last appearances of taxa against depth in individual sections (range charts, appendix E). The sections are correlated to the chronostratigraphic framework using biostratigraphic events, so that they can then be scaled to Composite Standard Units (CSU) (see chronostratigraphy versus stratigraphy Fig. 3.3). The scale in CSU's is arbitrarily constructed from 0 to 9 with increments of 1 marking the interval zone boundaries. The Tortachilla Limestone at Maslin Bay is allocated 0 and the youngest sample in the study from MG6 at Danger Point is 9. Observations of bases and tops can then be correlated to specific levels such that, for example, the last appearance of *Ch. cubensis* marks interval zone E/F boundary and has a CSU value of 5 and *S. angiporoides* LAD has a CSU of 4. Datums that occur within this interval can be calibrated between these values. In this way, episodes of turnover will be recorded for each interval regardless of apparently varying sedimentation rates and apparent diachrony between sections. CSU values are presented in appendix F.

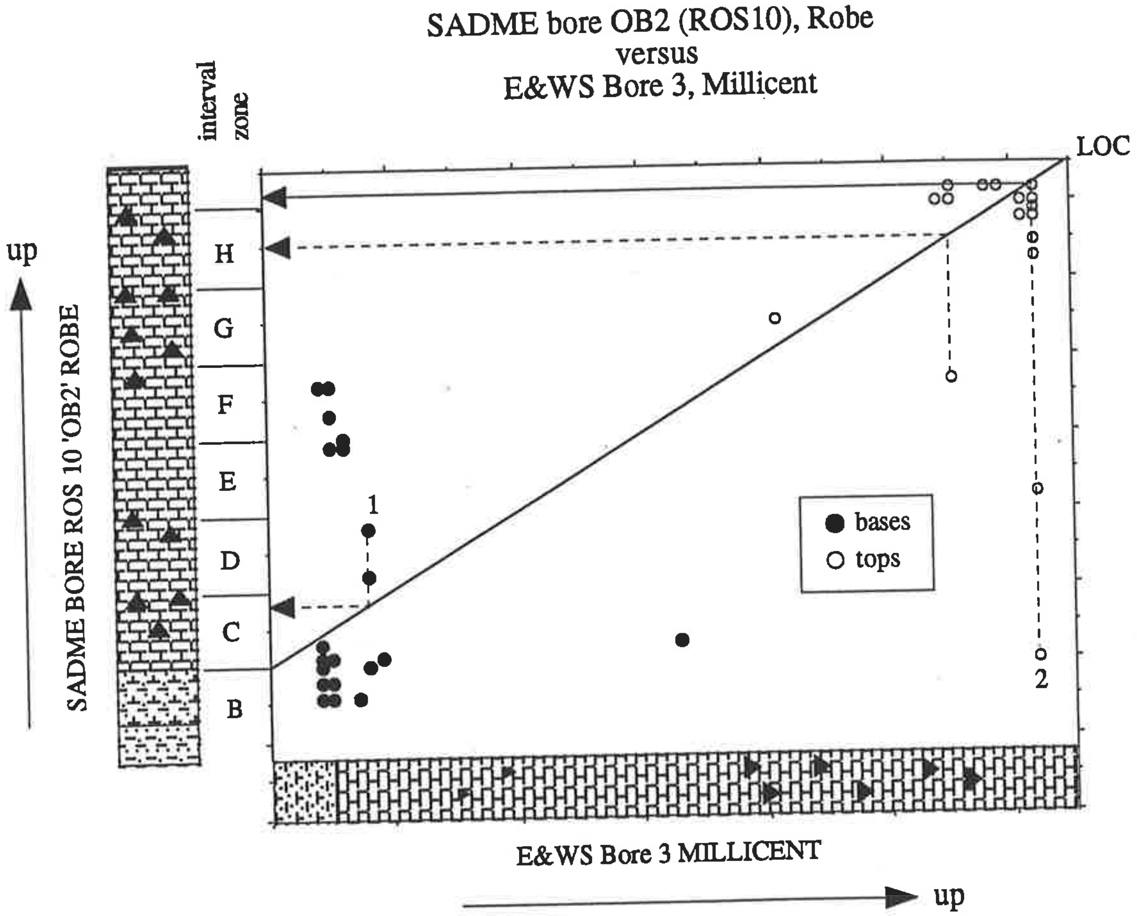


Figure 5.3a Example of graphic correlation of two sections to derive maximum species ranges in the Otway Basin. SADME Bore OB2 (Robe) correlated with E&WS Bore 3 (Millicent). OB2 is considered the most complete section and therefore becomes the Standard Reference Section (SRS). The base of species 1 is traced to the LOC such that its base in OB2, at the top of interval zone D, is extended downwards to the top of zone C. The top of species 2 in OB2 is in the upper part of interval zone B with the addition of range data from Millicent its top is extended to zone I. The process can be repeated for all additional species.

The ranges of species in each section can then be directly compared, and if necessary adjusted to a maximum 'regional' range using graphic correlation. A composite was initially

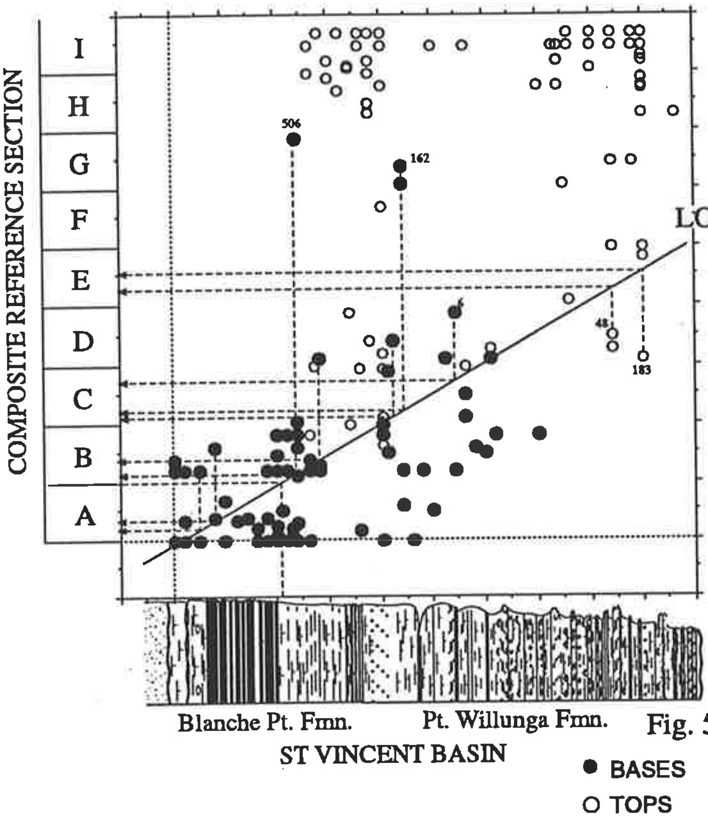


Fig. 5.3b

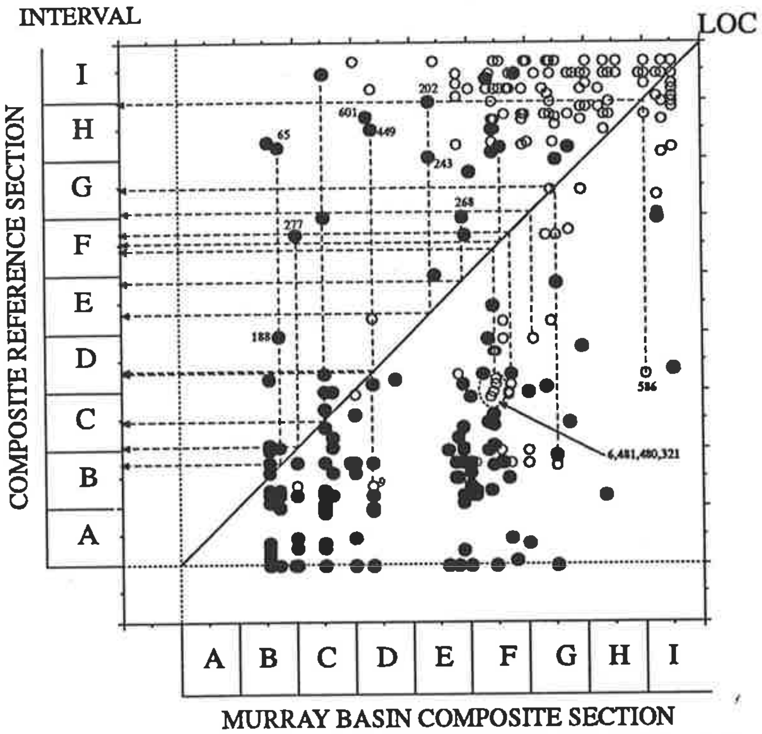


Fig. 5.3c

Figure 5.3b Graphic correlation of the Composite Reference Section (from all data from the Otway Basin) with the St Vincent Basin. The line of correlation (LOC) is fitted according to the position of well de fined and confidently placed biostratigraphic and lithostratigraphic datums, for example the first appearance of the chert-carbonate association in the Otway Basin. Species bases and tops are readjusted and ranges consequently extended, see text for explanation. Examples illustrated are bases extended (numbers in parenthesis are taxon codes): (6)*Bulimina bortonica* Finlay, (49) *Textularia gladizea*, (74) *Cibicides praecipuus* Copeland, (162) *Cibicides molestus* Hornibrook, (209) *Angulogerina carinata* tops ex tended: (25) *Cibicides thiara* (Stache), (48) *Pararotalia mackayi* (Karrer), (183) *Calcarina calcar* (Brady). **Fig. 5.3c** shows the resulting Composite Reference Section graphically correlated with the composite from the Murray Basin. Taxon codes (T.C.) are given in in species list in appendix B.

constructed for the Otway Basin, for example figure 5.3a shows SADME bore 3 from Millicent plotted against Bore OB2 from Robe, as the latter is considered to be the most complete and therefore is regarded the standard reference section (see Edwards, 1984 for a discussion of the SRS). Ranges of the species that have bases falling to the left of the LOC or tops to the right have their ranges extended. This operation has been repeated for each additional section in the Otway Basin and the whole process was repeated for the Murray Basin. The composite from the Otway basin was then graphically correlated with the Blanche Point and Pt Willunga Formations in the St Vincent Basin (Fig. 5.3b) and the resulting composite was correlated with the Murray Basin composite (Fig. 5.3c). From these the ranges of taxa are then be assembled against intervals zones (Figs. 5.4a-c).

5.4.3 Ranges ordered by first and last appearance

The succession of intervals zones are scaled against CSU values such that, for example, zone E/F (Zone P21a/b) boundary is marked by a CSU value of 5 and the a value of 8 marks the base of tropical planktonic Zone N4b. Species first and last appearances are thus calibrated to these values. Species ranges have then been ordered by first and last appearances for each individual section and composite for each basin. Durations of interval zones are calculated from the chronostratigraphic chart (Fig.3.1.1) and are given in Table. 3.1.

5.4.4 Benthic species ranges in the Blanche Point and Port Willunga Formations (Figures 5.4 to 5.6; enclosure)

Figure 5.4 shows that in the Willunga Embayment first and last appearances rapidly increase in interval zone B, but there was also a concomitant loss of species towards the zone B/C boundary. There was continuous gain of species through zone C but very few losses up until the middle of zone D, with only 3 species disappearing. In the later part of zone D the rate sharply increases with about 6 species lost per million years. There is apparently a high rate of species loss at the top of zone E but this records the loss of available section.

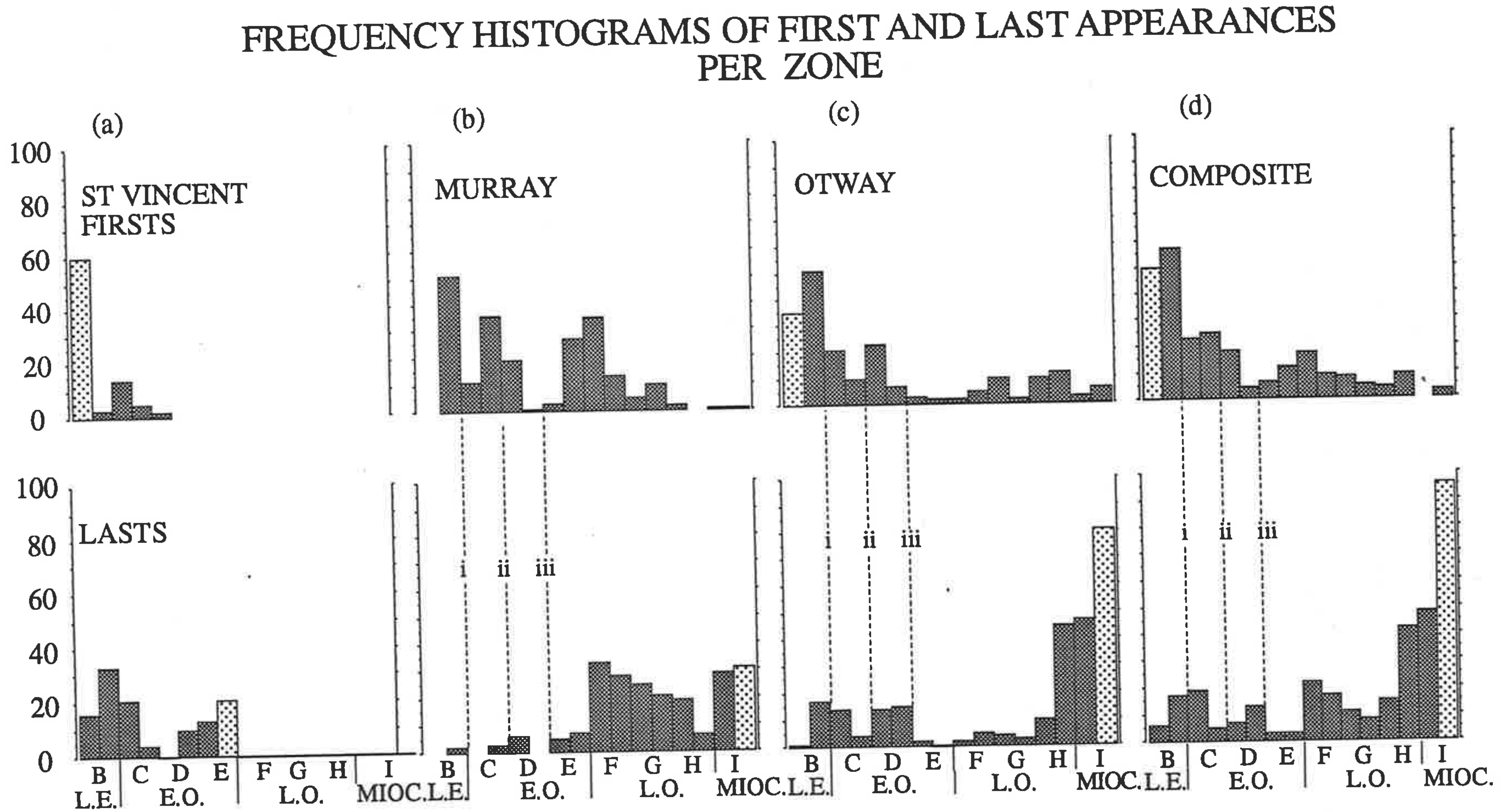


Figure 5.7a-d Histograms of 'final' first and last appearances. Labels i-iii. refer to sequence stratigraphic surfaces and are repeated in Figure 5.8 of benthic species survivorship, i. type 1 SB, ii. MFS and iii. type 1 SB. Less densely stippled pattern is to highlight the loss of available section.

5.4.5 Benthic species ranges in the Murray Basin

The pattern of first and last appearances from the Murray Basin are presented as a composite of all sections. First appearances (Fig. 5.5) show a burst in interval zone C, with a rate of 22 species appearing per million years (sp/myr). This slows down considerably to around 6 in zone D and then increases rapidly close to the E/F boundary to 42 sp/myr. The remaining Oligocene continues to show high rates of disappearance of 22 and 17 sp/myr in zones F and G respectively but the high rates may also include pseudoextinctions due to the truncation of studied sections. MBT-5 and Waikerie 2W show a burst of first appearances that contribute to the peak in zone F in the frequency histogram for the Murray Basin (section 5.5).

5.4.6 Benthic species ranges in the Otway Basin (Fig. 5.6)

Interval zone B in the Otway Basin probably shows anomalously high rates of first appearances due to the combination of artifact, from the beginning of the record, and true first appearances. In interval zone C (earliest Oligocene), the rate of first appearances is 12 sp/myr and 11 following the Aldingan/Willungan Stage boundary. In interval zone E the rate fall to 9 with the onset of the late early Oligocene regression in the Otway Basin. In the late Oligocene species accumulate at a rate of 12.5 in interval zone F to around 27 species per million years in zone G. Last appearances show a higher rate at the C/D interval zone boundary (8.6 sp/myr) that parallels first appearances, declining to a low at the latest early Oligocene. Last appearances stay relatively constant across the interval zone F/G boundary. Interval zone H show a very high rate of disappearances before zone I that records the truncation of available sections.

5.5 Frequency histograms of first and last appearances

With composite ranges established for each basin, non-reversible first and last appearance events can be shown as frequency histograms. This should highlight pronounced episodes of turnover. Figure 5.7a presents the pattern in the Willunga Embayment of the St Vincent Basin. Here there is a marked gain and a loss of species at the Eocene-Oligocene boundary and a lull in activity in the beginning followed by an increase in last appearances in the second half of interval zone D, the equivalent to the lower part of the Ruwarung Member in the Port Willunga Formation.

Murray Basin histograms show an increase in first appearances in the early Oligocene, collapsing in the later part of interval zone D and the early part of interval zone E corresponding to is a slight increase in last appearances. The late early Oligocene, as expected, appears to be a time of drama in the Murray Basin. There is a major turnover of species with close to 30 species appearing in the later part of interval zone E and over 30 in early interval zone F. Outgoing reached a peak in interval zone F and the decline in outgoing is almost monotonic towards the end of the Oligocene. There is a slight increase in the number of incoming species in the upper part of interval zone G.

Patterns for the Otway Basin suggest a sharp increase in appearances close to the Eocene-Oligocene boundary that generally decreases towards the early-late Oligocene boundary. This trend is interrupted in early interval zone D with a burst of around 25 incoming species. The peak is accompanied by an increase of close to 30 species disappearing in interval zone D. Interval zone E shows very little turnover, there are few first or last appearances and from zones F to H there is a gradual gain of species but again few last appearances. The Oligocene-Miocene boundary records an increase in first appearances from less than 10 species in the early part of interval zone H and around 12 species in the later part.

Figure 5.7d shows the composite of all benthic species first and last appearances from all basins. Three prominent episodes of turnover can be identified:

i. The Eocene-Oligocene boundary corresponds to a large gain of species in the later part of interval zone B and C of around 100 species.

ii. There is an increased rate of disappearances in the later part of interval zone D compared to the earlier part.

iii. In the second half of zone E and early zone F there is a major gain of species, most new species are recruited in the Otway Basin sections, and a prominent peak in outgoing reflecting disappearances from the Murray Basin. Composite data show a steady addition of species throughout the late Oligocene but many of the new species appearing in the Murray Basin (Interval F) are already extant in the Otway Basin and therefore negate this apparent burst. Disappearances are still prominent in the late Oligocene, in the composite of last appearances, and most of these appear to have been lost from the more restricted Murray Basin.

5.6 Species survivorship

Species survivorship curves have been constructed from range data that track groups of simultaneously taxa originating through successive intervals during the late Eocene and Oligocene. The groups of species originating at selected levels are described as cohorts and percentages are those surviving. If the resistance of species to environmental perturbation is contingent upon the time of origination in the the Murray and Otway Basins then it may be expected that some may be more resistant than others.

Figure 5.8a (enclosure) shows a series of cohorts originating in particular zones in the Murray Basin. Cohorts B1-D are derived principally from samples obtained from Magrath Flat and Waikerie due to the late Eocene to early Oligocene hiatus through much of the Murray Basin. Cohort B1, steady through through the early Oligocene, was substantially perturbed in zone F as the survivorship curve plunged from 90% to around 75%. There was then a slower decline for the rest of the Oligocene until the top of the recorded sections truncate real ranges. A similar pattern is displayed by cohort B2. Cohort C, originating at the base of Interval C, shows an almost monotonic decline throughout the Oligocene with no conspicuous episodes of perturbation. Cohort F fell rapidly from the middle Oligocene but recovered briefly in Intervals F and G where the rate of attrition substantially declined.

Survivorship curves for the Otway Basin reveal substantially different patterns (Fig.5.8b). The middle to late Oligocene is strikingly devoid of drama. Cohorts A and B substantially effected at the interval B/C boundary, where around 25% of the species are lost from cohort A and 10% from B. Cohort A does not show a comparable loss (around 15%) at the base of zone D, about the level of the middle Oligocene regression. Cohort B registers a rapid fall with around 20% of the species lost. Cohorts C and D display rapid loss of species immediately following origination consistent with the impact of the sequence boundary of 3rd order cycle TA4.5. Cohort C losing close to 40% of its species up until the zone D/E boundary but the remaining species (60%) pass through the late Oligocene relatively unscathed. Cohort D originating at the base of zone D displays immediate, but less substantial loss, and the survivors are unperturbed through zones E to the top of G.

Summary:
Cohorts originating in the late Eocene are substantially affected by the Chinaman Gully regressive episode but there appears to be no similar response in zone D where the late-early Oligocene regression should show its impact. The survivors of these two episodes, that is both type 1 sequence boundaries (TA4.3/4.4 and TA4.5/TB1.1), appear to gradually decline through the late Oligocene.

5.7 CLUSTER ANALYSIS

5.7.1 Introduction

Cluster analysis was used to analyse similarities between assemblages from different stratigraphic levels and geographical locations. Patterns in the resulting dendrogram and ordination plots were then compared to ecostratigraphic patterns in the Oligocene (Chapter 4). Cluster analysis has been used on a very broad scale by Boltovskoy and Boltovskoy (1988) to detect similarities between assemblages and faunal breaks between locations immediately prior to and following the Eocene/Oligocene boundary in the deep-sea. It has also been used by Scott (1970) and Hayward and Buzas (1979) to interpret the distribution of fossil assemblages from the Miocene in the Waitemata Basin in northern New Zealand. And in a palaeoecological study, Lockley (1983) used the technique to detect similarities between Ordovician brachiopod assemblages in an attempt match facies preferences for related palaeocommunities. In conjunction with a robust measure of compositional dissimilarity, it is capable of handling large collections of multivariate data arranged as an object-by-attribute matrix (presence or absence of species in each sample) and allows simultaneous comparisons of samples.

A data matrix consisting of 259 species from 248 samples was analysed, by initially constructing a correlation matrix (a sample-by-sample correlation using an association algorithm) and then performing a cluster analysis to produce a final dendrogram of the results. The spreadsheet matrix (appendix) was analysed using *PATN* software developed by Belbin (1991).

The association measure selected was the Kulczynski association coefficient. Expressed as:

in an asymmetric form: $$Dij=\frac{1.0-(\min(Dik,Djk))}{\Sigma(Di)} \qquad 5.1$$

and $$Dji=\frac{1.0-\min(Dik,Djk)}{\Sigma Dj} \qquad 5.2$$

The algorithms (5.1&5.2), originally designed for presence and absence data, was used to compute a correlation matrix specifically concentrating on common occurrences rather than absences of species per sample. Dissimilarity between samples i and j (Dij) results from the function of the minimum values between Dik and Djk divided by (ΣDi) the sum of values in the *i* th row. Where Dik is the data value for the *i* th object (row) and k attribute (column) and is the sum of all values in the *i*th row. The asymmetric form ignores mutual absences that, if otherwise considered, would introduce unnecessary noise into the results. Positive data (mutual presences) are recognized as more valuable and absences may be due to other than palaeoecological controls, for example; a missed identification of a taxon or differential preservation of taxa. This metric, in various forms, has proved to be a robust and effective association measure (Cheetham & Hazel, 1969; Faith et al., 1987; Belbin, 1992).

Due to the data handling limitations of the software a matrix was selected that included the most 'information-rich' species, this included taxa with taxon codes 1-259 (appendix B2 lists the species with corresponding taxon code (t.c.)). The reduction of the database to an amenable size has removed increasingly rare species. Samples from the Millicent section were eliminated as many of the taxa had been identified to genera level only and some late Oligocene samples from OB2 were omitted because some were suspected to be contaminated by downhole contamination. The computed correlation matrix was subjected to a flexible-UPGMA (Unweighted Pair Group using ArithMetic-Averaging) clustering method with a β value of -0.1, thereby extending the multivariate space and increasing cluster definition (Belbin, 1975; Belbin & McDonald, 1993 for a complete discussion).

5.7.2 Interpretation of dendrogram (Fig. 5.9; enclosure)

The cluster analysis run using the asymmetric form of the Kulczynski coefficient (5.1) resulted in 4 major cluster groups that had been selected by *PATN* based upon a critical dissimilarity value of around 1 (appendix G1 lists samples according to groups). Most importantly, breaks in clusters forming groups indicate prominent changes in assemblage composition that may be coincident with rapid shifts in the physical environment. Inspection of the dendrogram has been interpreted to show the major clusters that have further subdivided into seven groups according to a dissimilarity value of around 0.92.

Group 1:

Reasons for the clustering of a few samples from the Otway and Murray Basins in group 1 are unclear as most are from different stratigraphic levels. They all show very low diversities (≤ 10 species) and therefore appear to cluster predominantly on the basis of a few common species. They constitute an outlier to the larger clusters forming the rest of the dendrogram.

Group 2:

Group 2 is largely composed of samples from the late Oligocene to Miocene from MG6 at Danger Point in the Otway Basin but also includes some of the younger samples from Waikerie and MBT 5 at Wirha in the Murray Basin, e.g. 2W131.1 and MB168. Some of the lower (early Oligocene) low diversity samples from RR65 at Mt Gambier cluster with late Oligocene MG6 samples, again apparently due to the presence of some shared key species. The group clusters at a dissimilarity value of around 1.0.

Group 3:

Samples from the Murray Basin dominate group 3. Most come from MBT 5 at Wirha but the upper part of bore 2W at Waikerie also form a major component of this group. Included within this cluster are early Oligocene samples from bore RR65 at Mt Gambier and a few of the E series samples from the Kongorong region in the Otway Basin (see fig. 3.6). There is a smaller cluster of samples from the latest Oligocene-Miocene at MG6 that show the highest dissimilarity for the group. Group 3 clusters at a dissimilarity value of around 1.0.

Group 4:

This very large group can be subdivided into four smaller clusters cut at a dissimilarity value of close to 0.924 with clusters beginning and ending at the lines dividing samples MB190.1 and OB92.6, E163 and RR115.5, MB185.2 and 2W109.1. The first cluster is composed mostly of samples from the late Oligocene from bore 2W and a few samples from the early Oligocene of MBT 5. Assemblages appear similar on the basis of a few common species and specifically species common to shallow marine environments associated with the very early stages of a TST (RR196.5, MB191.1, 190.1 all immediately follow a SB).

Cluster 4b is dominated by samples from the Ruwarung Member at Aldinga Bay, a few from the lower to upper part of OB2 and the upper part of 2W in the Murray Basin. These early Oligocene samples, apparently reflecting similar facies associations in quite disparate localities have dissimilarity value of less than 0.924.

Samples from group 4c come from the late-early to late Oligocene sequences in the Otway Basin (particularly OB2), a few of the later samples from Aldinga Bay in the St Vincent Basin, a wide scattering of E series samples and the late Oligocene of 2W at Waikerie. The group clusters at a dissimilarity value of very close to 0.924.

The final large group (4d) is dominated by early Oligocene samples from the Otway Basin with most of the early Oligocene sequence at Magrath Flat. Included within this group are many of the younger samples from Waikerie. The lower part of 4d shows a close similarities between samples in the early Oligocene in WMC at Kingston. Samples from group 4 especially 4d show lower dissimilarity values (are more similar) and are clearly quite different to those in the late Oligocene to Miocene (in groups 2 and 3). E-series samples

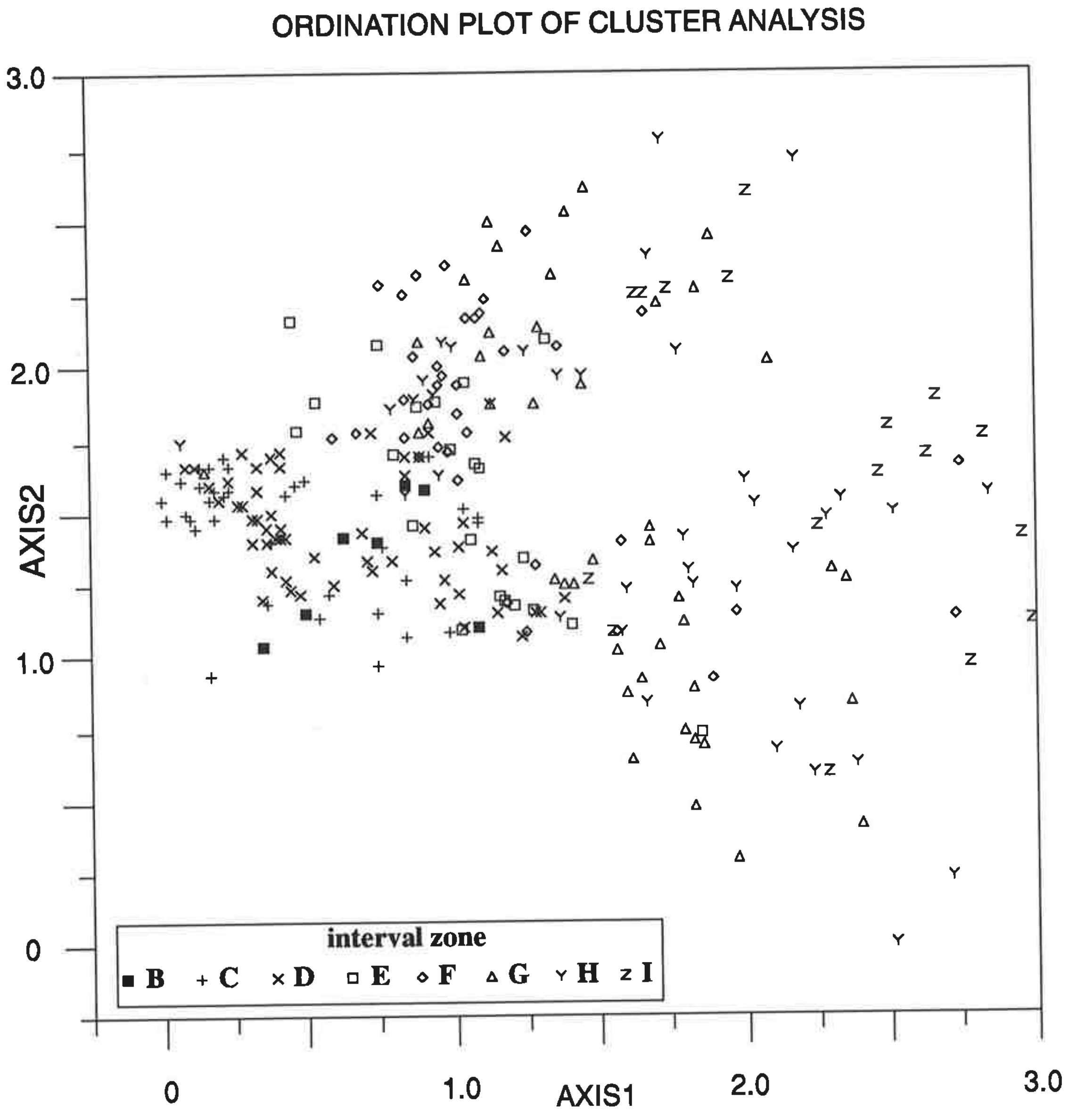


Figure 5.10 Plot in 2-dimensional space of eigenvectors extracted from the association matrix. Symbols show points from each interval zone. Distances between points is proportional to dissimilarity.

cluster within groups 4b,c and show similarities with mostly early and late-early Oligocene samples from St Vincent and Otway Basins, with a few outliers in groups 4a (E132) and 3 (E73, E150).

5.7.3 Ordination

The dendrogram appears to show a trend to increasing dissimilarity between samples increasing upwards in Fig. 5.9 (towards the late Oligocene to Miocene). To check this apparent pattern distances were subjected to analysis by ordination. Ordination, using Detrended Correspondence Analysis (DCA), a method commonly used in ecology to study ecological gradients (see Gauch Jr., 1982; Faith et al, 1987; Minchin, 1987) , was employed to help better define clusters interpreted from the dendrogram. Figure 5.10 shows the original two dimensional configuration of points (eigenvectors) with distances between sample pairs proportional to their compositional dissimilarity. Each sample is allocated a class based upon its stratigraphic interval and these are represented by symbols. Classes are circled according to a 90% density contour. Figure 5.11 shows that samples that fall within the time-range of interval zones B and C cluster quite closely while intervals D and E have a wider scattering of points. After interval zone E the 90% density ellipses expand indicating a much wider scattering of points in zones F, G, H and I showing increased dissimilarity in late Oligocene-Miocene samples. The change follows the TA4/TB1 sequence boundary. Increasing dissimilarity develops with the beginning of the Jan Juc transgression and becoming most pronounced in interval zone H.

Figures 5.12a, b. show that if points are circled (with a 90% density ellipse) according to location rather than age, there tends to be a tighter grouping of points at each location than for successive zones and groups do not overlap in any consistent way. This may indicate dissimilarity between separate locations. As may be expected sections that encompassed a greater time-range show a wider scattering of points, for example the clustering of points is much tighter in the early Oligocene section WMC 507 in the Otway Basin, the Pt Willunga Formation in the St Vincent Basin and late Oligocene MBT 5 at Wirha in the Murray Basin

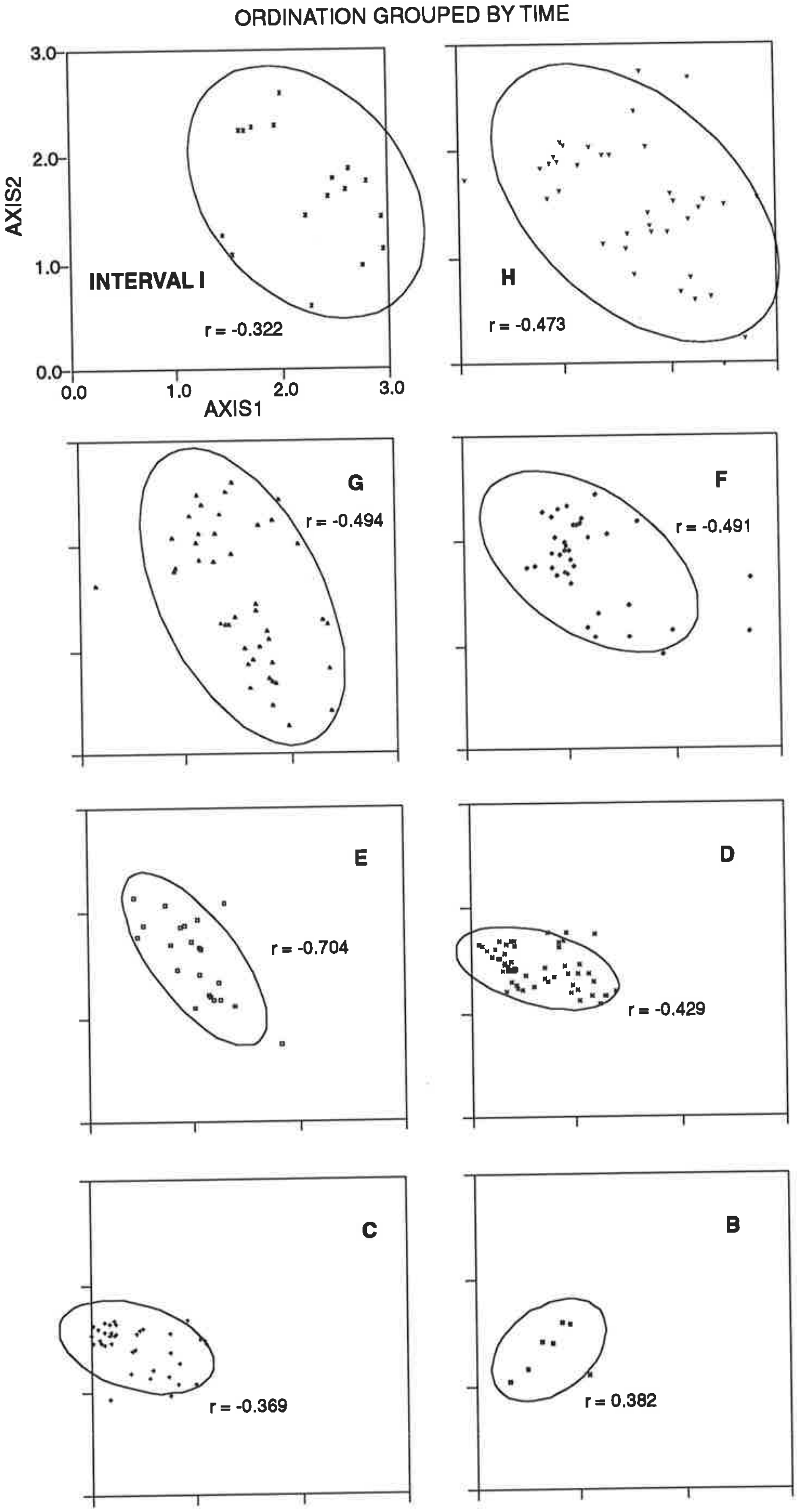


Figure 5.11 Ordination of cluster analysis data grouped according to interval zone. Distance between points (eigenvectors) is proportional to similarity. Grouped by a 90% density ellipse.

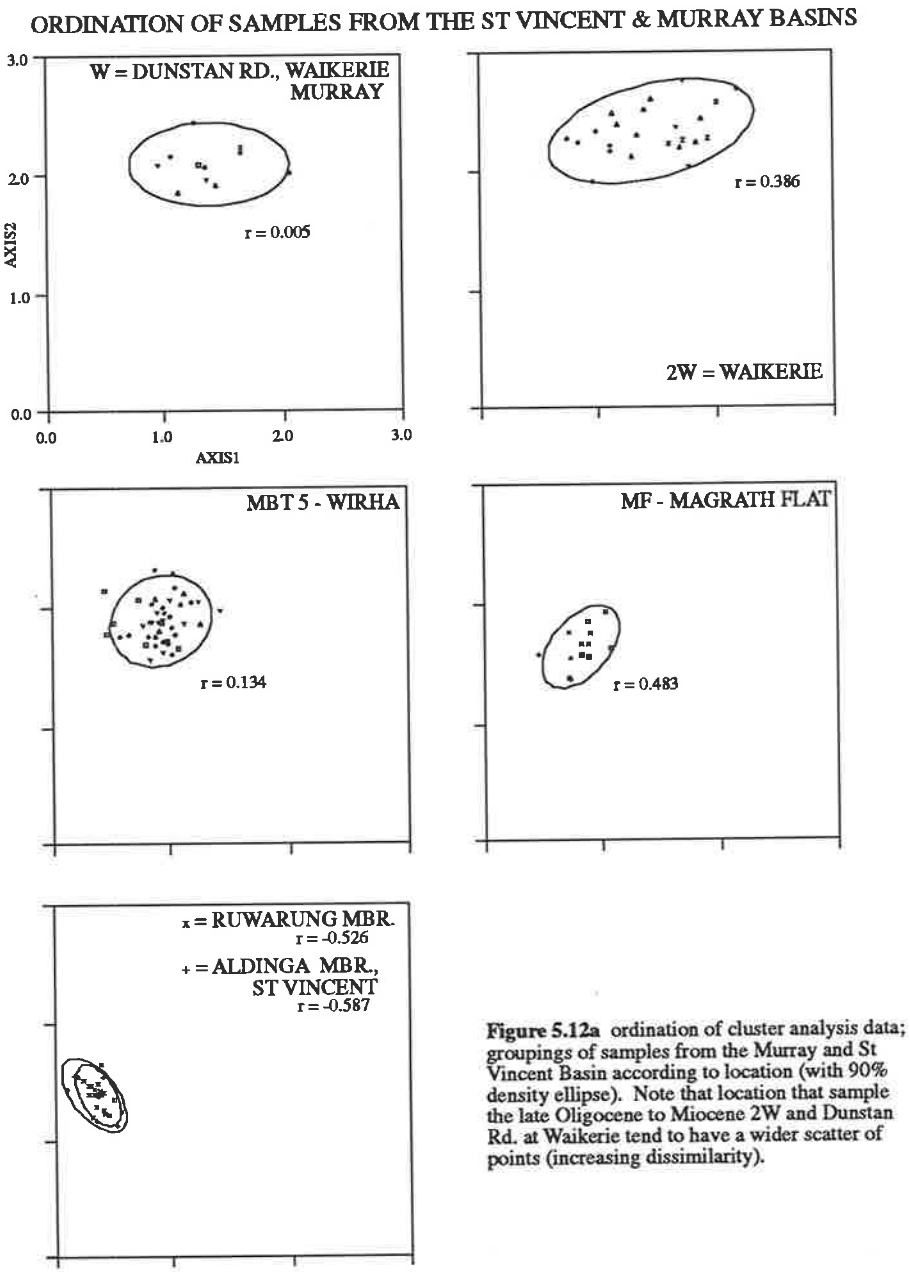


Figure 5.12a ordination of cluster analysis data; groupings of samples from the Murray and St Vincent Basin according to location (with 90% density ellipse). Note that location that sample the late Oligocene to Miocene 2W and Dunstan Rd. at Waikerie tend to have a wider scatter of points (increasing dissimilarity).

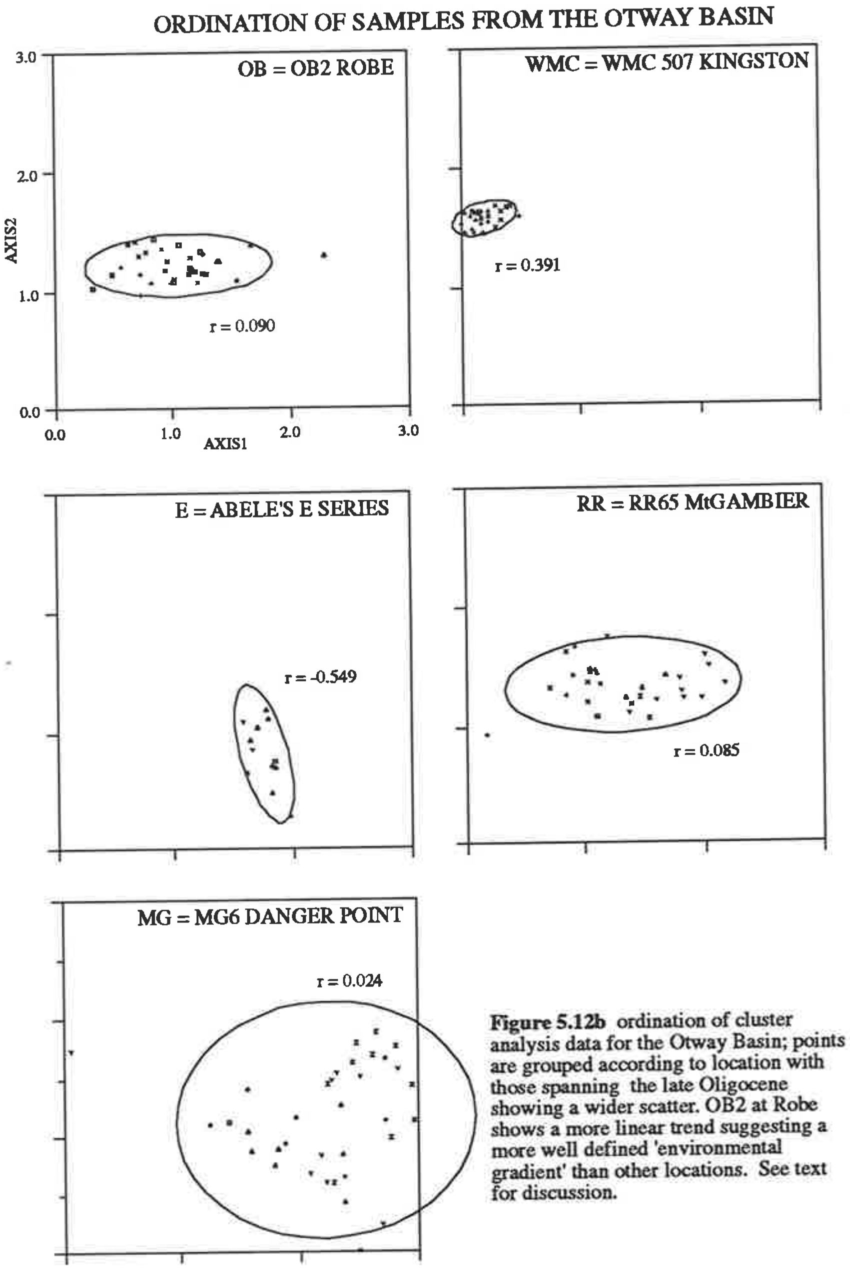


Figure 5.12b ordination of cluster analysis data for the Otway Basin; points are grouped according to location with those spanning the late Oligocene showing a wider scatter. OB2 at Robe shows a more linear trend suggesting a more well defined 'environmental gradient' than other locations. See text for discussion.

than in those for RR65 or MG6 in the Otway Basin. Plots that show a well defined linear trend, such as the pattern of points shown for OB2, suggest a 'gradient' or a spectrum of similarity where points at one end of the array are considerably dissimilar to the other end with transitory assemblages in between.

5.7.4 Summary

Cluster analysis show about seven more obvious clusters if the dendrogram is cut at around the 0.924 dissimilarity level. From the analysis of all Oligocene samples the dendrogram and ordination patterns show that assemblage compositions are much more alike in the early Oligocene. Samples show increasingly dissimilar assemblages towards the late Oligocene and Miocene. This change has a prominent step in interval zone E corresponding to the late-early Oligocene TA4/TB1 supercycle boundary as the late Oligocene assemblages (zones F to H) appear to become increasingly more dissimilar. Are these early Oligocene assemblages dominated by preconditioned cosmopolitan taxa? They were apparently more similar and appear to have been more resistant to the second Oligocene glaciation (Oi2) and the 'mid' Oligocene sea level fall (Fig. 5.2). There patterns in neritic environments parallel the 'homogeneous, low diversity-high abundance' faunas reported from the early Oligocene in deep-sea (Boersma et al., 1987).

CHAPTER 6

CONCLUSIONS

Ecostratigraphy and taxic overturn on the southern Australian Margin

Biofacies profiles from three disparate basins have identified 3rd order cycles of sea level change on the southern Australian margin from the late Eocene to Miocene. These sequences have been matched to Eocene to Miocene Exxon 3rd order cycles and the oxygen isotope curve and Oligocene glaciations. The most significant impact on biofacies and the temporary comings and goings of taxa are summarized as:

i) Biofacies profiles responding to 3rd order sequence stratigraphic cycles in the late Eocene show convincing correlations between the more 'restricted'-neritic facies of the Blanche Point Formation and the more 'open'-neritic Browns Creek Formation, some 600 kms to the southeast.

ii) Ecostratigraphic correlations suggest that foraminiferal faunas were more sensitive to 3rd order sea level fluctuations in the late Eocene than in the early Oligocene.

iii) The Chinaman Gully regression corresponds to a striking change from the infaunal-dominated biofacies and partly oxygen-stressed chemofacies of the late Eocene to the apparently well ventilated epifaunal-dominated early Oligocene. It is the most profound change in the late Eocene-Oligocene succession and correlates with a rapid swing in the oxygen isotope curve to higher values and the first of the Oligocene glaciations (Oi1) in Chron C13 (TA4.3/4.4).

iv) Epifauna dominate early Oligocene sequences in the St Vincent and Otway Basins and infaunal abundances increased steadily from the late Oligocene to Miocene in the Otway Basin. The switch followed the late-early Oligocene type 1 TA4/TB1 sequence boundary (glaciation Oi2) and corresponds to the beginning of the 2nd order TB1 supercycle.

v) The first Miocene glaciation (Mi1) correlates with a sequence boundary at the end of the Oligocene in the upper part of interval zone H. There is a rapid shift in biofacies with a decline in all infaunal abundances followed by much higher planktonic: benthic ratios signaling maximum oceanic influence and a return to high infaunal abundances in the Clifton transgression.

Significant episodes of taxic overturn can be correlated with ecostratigraphic patterns with:

i) A rapid gain of species after the Tortachilla-Tuketja hiatus matches the influx of infauna in the early part of the TA4.2 TST at the base of interval zone A (in the middle of Chron C18).

ii) The largest episode of faunal change is at end of the Eocene between interval zones B and C at the TA4.3/4.4 type 1 sequence boundary corresponding to glaciation Oi1 and late in Chron C13n. It corresponds to the major biofacies change St Vincent Basin.

iii) The end of the late-early Oligocene TA4/TB1 regression with glaciation Oi2 at the top of zone D (Chron C11).

iv) In the Otway Basin first appearances correspond to transgressive sequence tracts in interval zones C (TA4.4), D (TA4.5), G (TB1.2), H (TB1.3) and appear to be responding to interglacial cycles or warming episodes; if this is the meaning of the oxygen isotope curve in Figure 4.1.

Turnover at the third event is much more subdued in the Otway Basin when compared to taxic overturn at the Chinaman Gully regression in both the restricted St Vincent Basin and the oceanic Otway Basin. One explanation is that early Oligocene faunas in the Otway Basin were much more robust in the face of this second major environmental perturbation. It may be, as Corliss and Keigwin (1986), Berggren and Prothero (1992) and Prothero (1994b) have already argued, that warm-climate taxa had been eliminated at earlier events and had been replaced by cold-adapted taxa that were able to tolerate subsequent cooling events. It may be that the biota had been 'preconditioned' in an earlier warm and perhaps equable period and taxa had become vulnerable to environment perturbation. The evidence shows relatively higher similarity between assemblages in the early Oligocene (Figs. 5.1, 5.9) compared to the latest Eocene or the late Oligocene. The taxa that survived into the early Oligocene appear cosmopolitan. Cluster analysis suggest that taxic change across the TA4/TB1 supercycle boundary in the Oligocene appears to be more a response to change closer to the scale of 2nd order cycles (sea level change and warming) and most often at type 1 sequence boundaries. There appears to be restocking that accompanied the late Oligocene warming, resulting in decreasing similarity between assemblages, this may have increased the proportion of warm-water taxa that resulted in increased endemism.

Sequence boundaries are recognized by rapid shifts in reversible (ecostratigraphic) events involving changes in the I:E ratio and temporary comings and goings of taxa per sample. Maximum flooding surfaces are more obscure. This is most apparent in the early Oligocene in both the St Vincent and Otway Basins, where infaunal numbers are lower than the Eocene and the I:E profiles much 'flatter' perhaps responding to increased global ventilation..

By default rather than design local stage boundaries have corresponded to sequence stratigraphic events. This study details the correlation of the top of the Aldingan Stage to a maximum flooding surface within the warming trend following the first glaciation (Oi1) in the early Oligocene. The top of the Willungan Stage is marked by a type 1 sequence boundary that corresponding to the Oligocene glaciation Oi2. The Janjukian Stage reflects a major transgressive event and warming in the late Oligocene.

If high resolution correlations of ecostratigraphic patterns can be extended to a wider regional scale it will add weight to than any single study and help resolve signals of third order cycles that can be more confidently matched to the Exxon global cycle chart. It may be that the promise that sequence stratigraphy is the tool that will revolutionise chronostratigraphy is yet to be realised.

REFERENCES

Abele, C. 1961. The Gambier Limestone and its foraminiferal fauna. PhD thesis (unpubl.). University of Adelaide.

Albani, A.D. and Yassini, I. 1989. Taxonomy and distribution of shallow-water Lagenid foraminiferida from the south-eastern coast of Australia. *Australian Journal of Marine and Freshwater Res.*, 40:369-401.

Allmon, W. D. and Ross, R. M. 1990. Specifying causal factors in evolution: The paleontological contribution. In *Causes of Evolution*, R. M. Ross and W. D. Allmon eds. University of Chicago Press, Chicago. Pp.1-17.

Alvarez, L. W., Alvarez, W., Asaro, F., Michel, H. V., 1980. Extraterrestrial cause for the Cretaceous-Tertiary extinction. *Science*, 208:1095-1108.

Armentrout, J. M. 1992. Biostratigraphic signature of sequence boundaries, maximum flooding surfaces, condensed sections, and depositional systems. *5th North American Paleontological Convention*, Abstr. and Prog., p. 9.

Armentrout, J. M., Echols, R. J. and Lee, T. D. 1990. Patterns of foraminiferal abundance and diversity: Implications for sequence stratigraphic analysis. *Gulf Coast Section Society SEPM Foundation 11th Annual Res Conf*, Program & Abstracts: 53-58.

Arthur, M. A. and Garrison, R. E. 1986. Cyclicity in the Milankovitch band through time: an introduction. *Paleoceanography*, 1(4):369-372.

Asaro, F., Alvarez, L. W., Alvarez, W. and Michel, H. V. 1982. Geochemical anomalies near the Eocene/Oligocene and Permian/Triassic boundaries. *Geological Society of America, Spec.Pap.*, 190: 517.

Aubry, M.- P. 1992. Late Paleogene calcareous nannoplankton evolution: A tale of climatic deterioration. In *Eocene-Oligocene Climatic and Biotic evolution*, D. R. Prothero and W. A. Berggren eds. Princeton University Press, Princeton. 272-309 pp.

Baird, G. C. and Brett, C. E. 1991. Submarine erosion on the anoxic sea floor: stratinomic, palaeoenvironmental, and temporal significance of reworked pyritebone deposits. In *Modern and Ancient Continental Shelf Anoxia*, R. V. Tyson and T. H. Pearson eds. Geological Society Spec. Pub. No58, London. Pp.233-257.

Barbin, V. and Keller-Grünig, A. 1991. Benthic foraminiferal assemblages from the Brendola section (Priabonian stage stratotype area, northern Italy): Distribution, palaeoenvironment and palaeoecology. *Marine Micropaleontology,* 17: 237-254.

Barker, R. W. 1960. Taxonomic notes - on the species figured by H.B. Brady in his report on the foraminifera dredged by H.M.S. *Challenger* during the years 1873-1876. Society of Economic Paleontologists and Mineralogists, Tulsa. Spec. Pub. no.9.

Barron, J., Larsen, B. and Baldauf, J. G. 1991. Evidence for Late Eocene to Early Oligocene Antarctic glaciation and Observations on Late Neogene glacial history of Antarctica: Results from leg 119. In J. Barron, B. Larsen et. al eds. *Proc. ODP, Sci Results,* 119: College Station TX(Ocean Drilling Program), 869-891 pp.

Bartek, L. R., Vail, P. R., Anderson, J. B., Emmet, P. A. and Wu, S. 1991. Effect of Cenozoic ice sheet fluctuations in Antarctica on the stratigraphic signature of the Neogene. *Journal of Geophysical Research,* 96(B4): 6753-6778.

Bartek, L. R., Cirbus Sloan, L., Anderson, J. B. and Ross, M. I. 1992. Evidence from the Antarctic continental margin of Late Paleogene ice sheets: A manifestation of plate reorganization and synchronous changes in atmospheric circulation over the emerging Southern Ocean. In *Eocene-Oligocene Climatic and Biotic Evolution,* D. R. Prothero and W. A. Berggren eds. Princeton University Press, Princeton, pp. 131-159.

Baum, G. R. and Vail, P. R. 1988. Sequence stratigraphic concepts applied to Paleogene outcrops, Gulf and Atlantic basins. In *Sea-Level Changes-An Integrated Approach,* C. K. Wilgus, B. S. Hastings, C. G. S. C. Kendall, H. W. Posamentier, C. A. Ross and J. C. Van Wagoner eds. Society of Economic Paleontologists and Mineralogists, Spec.Pub.42, pp.309-327.

Beecroft, A. 1980. Foraminiferal Biofacies of the Tortachilla Limestone and Blanche Point Formation, Late Eocene, Willunga Sub-basin, S. Aust. Honours thesis (unpublished), University of Adelaide.

Beecroft, A., Alley, N. and Lablack, K. 1993. Biostratigraphy of the Buccleuch Formation, southwestern Murray Basin, South Australia. MS (in press).

Belbin, L. 1992. *PATN* Technical Reference Manual. *CSIRO Division of Wildlife & Ecology.* Canberra.

Belbin, L. and McDonald, C. 1993. Comparing three classification strategies for use in ecology. *Journal of Vegetation Science,* 4(3): 341-348.

Bennett, K. D. 1990. Milankovitch cycles and their effects on species in ecological and evolutionary time. *Paleobiology,* 16(1): 11-21.

Benson, R. H. 1975. The origin of the psychrosphere as recorded in deep-sea ostracode assemblages. *Lethaia,* 8: 69-83.

Benson, R. H., Chapman, R. E. and Deck, L. T. 1985. Evidence from the ostracodes of the major events in the South Atlantic and world-wide over the past 80 million years. In *South Atlantic Paleoceanography,* K. J. Hsü and H. Weissert eds. Cambridge University Press, New York. Pp.325-350.

Berggren, W. A. 1978. Marine micropaleontology: an introduction. In *Introduction to Marine Micropaleontology,* Haq, B. U. and Boersma, A., Elsevier, New York, Pp. 1-17.

Berggren, W. A. 1992. Paleogene planktonic foraminifer magnetobiostratigraphy of the southern Kerguelen Plateau (sites 747-749). In S. W. Wise, R. Schlich et al. eds. *Proc. ODP, Sci Results,* 120: College Station TX(Ocean Drilling Program), National Science Foundation, Pp.551-568.

Berggren, W. A. and Aubert, J. 1983. Paleogene benthonic foraminiferal biostratigraphy and bathymetry of the central Coast Ranges of California. *U.S. Geological Survey professional paper,* 1213: 4-21.

Berggren, W. A., Kent, D. V. and Flynn, J. J. 1985. Paleogene geochronology and chronostratigraphy. In *The Chronology of the Geological Record,* N. J. Snelling ed. Blackwell Scientific Pub, Oxford. Pp.141-186.

Berggren, W. A. and Miller, K. G. 1988. Paleogene tropical planktonic foraminiferal biostratigraphy and magnetostratigraphy. *Micropaleontology,* 34(4): 362-380.

Berggren, W. A., Kent, D. V., Obradovich, J. D. and Swisher, C. C. 1992. Toward a revised Paleogene geochronology. In *Eocene-Oligocene Climatic and Biotic Evolution,* D. R. Prothero and W. A. Berggren ed. Princeton University Press, Princeton, pp. 29-45.

Berggren, W. A. and Prothero, D. R. 1992. Eocene-Oligocene climatic and biotic evolution: an overview. In *Eocene-Oligocene climatic and biotic evolution,* D. R. Prothero and W. A. Berggren eds. Princeton University Press, Princeton. Pp.1-28.

Berggren, W. A., Kent, D. V., Swisher III, C. C. and Aubry, M.-P. 1994. A revised Cenozoic geochronology and chronostratigraphy. In *Geochronology, Time Scales and Global Stratigraphic Correlations: A Unified Temporal Framework for an Historical Geology,* W. A. Berggren, D. V. Kent and J. Hardenbol eds. Society of Economic Paleontologists and Mineralogists Spec Vol (in Press).

Berry, W. B. N. and Boucot, A. J. 1973. Glacio-eustatic control of Late Ordovician-Early Silurian platform sedimentation and faunal changes. *Geological Society of America Bull.*, 84:275-284.

Blow, W. H. 1969. Late Middle Eocene to Recent planktonic foraminiferal biostratigraphy. *Proceedings First International Conference on Planktonic Microfossils*, Geneva, 1: 199-422.

Boersma, A. 1985. Oligocene benthic foraminifers from North Atlantic sites: Benthic foraminifers as water mass indexes in the in the North and South Atlantic. *Initial Reports of the Deep Sea Drilling Project, Scientific Results*, 82:611-627.

Boersma, A., Premoli Silva, I. and Shackleton, N. J. 1987. Atlantic Eocene planktonic foraminiferal paleohydrographic indicators and stable isotope paleoceanography. *Paleoceanography*, 2(3): 287-331.

Boersma, A., Shackleton, N., Hall, M. and Given, Q. 1979. Carbon and oxygen isotope records at DSDP Site 384 (North Atlantic) and some Paleocene paleotemperature and some carbon isotope variations in the Atlantic Ocean. *Initial Reports of the Deep Sea Drilling Project*, 43: 695-717.

Bolli, H. M. 1957. The genera *Globigerina* and *Globorotalia* in the Paleocene-Lower Eocene Lizard Springs Formation of Trinidad. *B W I Bulletin of the US Natnl Mus*, 215: 61-81.

Bolli, H. M. 1966. Zonation of Cretaceous to Pliocene marine sediments based on planktonic foraminifera. *Boletino Informativo Associacion Venezolana de Geologia, Mineria y Petroleo*, 9: 3-32.

Bolli, H. M. and Saunders, J. B. 1985. Oligocene to Holocene low latitude planktonic forminifera. In *Plankton Stratigraphy*, H. M. Bolli, J. B. Saunders and K. D. Perch-Nielsen eds. Cambridge University Press, Cambridge. Pp.155-262.

Boltovskoy, E. and Boltovskoy, D. 1988. Cenozoic deep-sea benthic foraminifera: Faunal turnovers and paleobiogeographic differences. *Revue De Micropaléontologie*, 31(2): 67-84.

Boltovskoy, E. and Giussani De Kahn, G. 1990. Benthic unilocular calcareous foraminifers in Late Cenozoic deep sea deposits of the Pacific and Atlantic Oceans. *Revista Española De Micropaleontologia*, 22(3): 361-406.

Boltovskoy, E., Giussani, G. and Watanabe, S. 1980. Atlas of benthic shelf foraminifera of the southwest Atlantic. Dr W. Junk bv Pub : The Hague. 147 pp.

Bone, Y and James, N.P 1993. Bryozoans as carbonate sediment producers on the cool-water Lacepede Shelf, southern Australia. *Sedimentary Geology*, 86:247-271.

Boucot, A. J. 1983. Does evolution take place in an ecological vacuum? II. *Journal of Paleontology,* 57(1): 1-30.

Boucot, A.J. 1986. Ecostratigraphic criteria for evaluating the magnitude, character and duration of bioevents. In *Global Bio-events,* O. Walliser ed. Lecture Notes in Earth Sci., Vol.8, Springer-Verlag, pp.25-45.

Bretsky Jr, P.W. 1969. Evolution of Paleozoic benthic communities. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 6:45-49.

Brett, C.E. and Baird, G.C. 1992. Taphofacies and bioevents in marine sequences of the Appalachian Basin Middle Devonian. *5th North American Paleont Convention Abstr&Progr,* p.35.

Brewster, N. A. 1980. Cenozoic biogenic silica sedimentation in the Antarctic Ocean. *Geological Society of America Bull.,* 91(1): 337-347.

Brinkhuis, H. 1992. Late Paleogene dinoflagellate cycts with special reference to the Eocene/Oligocene boundary. In *Eocene-Oligocene Biotic and Climatic Evolution,* D. R. Prothero and W. A. Berggren eds. Priceton University Press, Princeton. Pp.327-340.

Brown, C. M. and Radke, B. M. 1989. Stratigraphy and sedimentology of mid-Tertiary permeability barriers in the subsurface of the Murray Basin, southeastern Australia. *BMR Journal of Australian Geology and Geophysics,* 11: 367-385.

Brown, D. A., Campbell, K. S. W. and Crook, K. A. W. 1968. The geological evolution of Australia and New Zealand. Pergamon Press : Oxford. 409 pp.

Brun, L., Chierici, M. A., Meijer, M. and Monteil, L. 1984. Répartition et paléoécologique des principales espèces de Bolivinitidae (foraminifères) du Tertiaire du Golfe De Guinée. *Benthos '83; 2nd. Int. Symp. Benthic Foraminifera (Pau, April 1983),* pp. 91-104.

Buzas, M. A. and Culver, S. J. 1984. Species duration and evolution: Benthic foraminifera on the Atlantic continental margin of North America. *Science,* 225: 829-830.

Buzas, M. A. and Culver, S. J. 1989. Biogeographic and evolutionary patterns of continental margin foraminifera. *Paleobiology,* 15(1): 11-19.

Cande, S. C. and Kent, D. V. 1992. A new geomagnetic polarity time scale for the Late Cretaceous and Cenozoic. *Journal of Geophysical Research,* 97(B10): 13,917-13,951.

Carter, A. N. 1958. Tertiary foraminifera from the Aire District, Victoria. *Geological Survey of Victoria , Bulletin* 55.

Carter, A. N. 1964. Tertiary foraminifera from Gippsland, Victoria and their stratigraphical significance. *Geological Survey of Victoria Memoir no.23,* : 154 and plates.

Carter, R. M. and Landis, C. A. 1972. Correlative Oligocene unconformities in southern Australasia. *Nature Phys. Sci.,* 237: 12-13.

Carter, R. M., Carter, L., Williams, J. J. and Landis, C. A. 1985. Modern and relict sedimentation on the South Otago Continental Shelf, New Zealand. *Mem. N.Z. Oceanogr. Inst.,* 93: 43.

Carter, R. M., Lindqvist, J. K. and Norris, R. J. 1981. Oligocene unconformities and nodular phosphate - Hardground horizons in western Southland and northern West Coast. *Journal of the Royal Society of New Zealand,* 12(1): 11-46.

Chapman, F., Parr, W. J. and Collins, A. C. 1934. Tertiary foraminifera of Australia — The Balcombian deposits of Port Phillip. Part 3. *Journal of the Linnean Soc. London (Zool.),* 38: 553-577.

Cheetham, A. H. and Hazel, J. E. 1969. Binary (presence-Absence) similarity coefficients. *Journal of Paleontology,* 43(5): 1130-1136.

Christophel, D. C. 1990. The impact of mid-Tertiary climatic changes on the development of the modern Australian floras. *Geological Society of America, abstracts with programs,* 22(7): A77.

Clark, F. E. and Patterson, R. T. 1993. An illustrated key to the identification of unilocular genera of calcareous foraminifera. *Journal of Paleontology,* 67(1): 20-28.

Coccioni, R. and Galeotti, S. 1993. Orbitally induced cycles in benthonic foraminiferal morphogroups and trophic structure distribution patterns from the Late Albian "Amadeus Segment" (Central Italy). *Journal of Micropalaeontology,* 12(2): 227-239.

Coccioni, R., Monaco, P., Monechi, S., Nocchi, M. and Parisi, G. 1988. Biostratigraphy of the Eocene-Oligocene boundary at Massignano (Ancona, Italy). In *The Eocene-Oligocene Boundary in the Marche-Umbria Basin (Italy),* I. Premoli Silva, R. Coccioni and A. Montanari eds. IUGS, Ancona. Pp.59-74.

Collinson, M. E. and Hooker, J. J. 1987. Vegetational and mammalian faunal changes in the early Tertiary of southern England. In *The origin of the Angiosperms and their biological consequences.* Friis, E. M., Chaloner, W. G. and Crane, P. R. eds., Cambridge Uni Press, pp. 259-304.

Cooper, B. J. 1977. New revised stratigraphic nomenclature in the Willunga Embayment. *Quarterly Notes of the geological Survey of South Australia,* 64: 2-5.

Cooper, B. J. 1979. Eocene to Miocene stratigraphy of the Willunga Embayment. *Department of Mines and Energy, Geological survey of South Australia, Report of Investigations,* V. 50, 101pp.

Corfield, R. M. and Shackleton, N. J. 1988. Productivity change as a control on planktonic foraminiferal evolution after the Cretaceous/Tertiary boundary. *Historical Biology,* 1: 323-343.

Corliss, B. H. 1979. Response of deep-sea benthonic foraminifera to the development of the psychrosphere near the Eocene-Oligocene boundary. *Nature,* 282:63-65.

Corliss, B. H. 1985. Microhabitats of benthic foraminifera within deep-sea sediments. *Nature,* 314:435-438.

Corliss, B. H., Aubry, M. P., Berggren, W. A., Fenner, J. M., Keigwin Jr., L. D. and Keller, G. 1984. The Eocene/Oligocene boundary event in the deep sea. *Science,* 226: 806-810.

Corliss, B. H. and Keigwin, L. D. 1986. Eocene-Oligocene paleoceanography. In *Mesozoic and Cenozoic Oceans,* Hsü, K ed., American Geophysical Union, geodynamics series, vol. 15, pp. 101-118.

Corliss, B. H. and Chen, C. 1988. Morphotype patterns of Norwegian Sea deep-sea benthic foraminifera and ecological implications. *Geology,* 16: 716-719.

Darwin, C. 1964. On the Origin of Species. Facsimilie of 1st ed. Harvard University Press: Cambridge, Mass.

Decker, K. 1991. Rhythmic bedding in siliceous sediments - an overview. In *Cycles and events in stratigraphy,* G. Einsele, W. Ricken and A. Seilacher eds. Springer-Verlag, Berlin. Pp. 464-479.

DiMichele, W. A. 1994. Ecological patterns in time and space. *Paleobiology,* 20(2):89-92.

Edwards, L. E. 1984. Insights on why the graphic correlation (Shaws method) works. *Journal of Geology,* 92: 583-597.

Edwards, L. E. 1989. Supplemented graphic correlation: A powerful tool for paleontologists and nonplaeontologists. *Palaios,* 4: 127-143.

Faith, D. P., Minchin, P. R. and Belbin, L. 1987. Compositional dissimilarity as a robust measure of ecological distance. *Vegetatio,* 69: 57-68.

Field, B. D., Browne, G. H., Hoskins, R. H. and Strong, C. P. 1988. Unconformities and seismic reflectors in the Cretaceous-Cenozoic of eastern South Island, New Zealand. *17th. BMR Research Symposium extended abstracts,* Record 1988/42: 24.

Finlay, H. J. 1947. The foraminiferal evidence for the Tertiary Trans-Tasman correlation. *Transactions of the Royal Society of New Zealand,* 76(3): 327-352.

Fordyce, R. E. 1977. The development of the Circum-Antarctic Current and the evolution of the Mysticeti (Mammalia: Cetacea). *Palaeogeography, Palaeoclimatology, Palaeoecology,* 21: 265-271.

Fordyce, R. E. 1980. Whale evolution and Oligocene southern ocean environments. *Palaeogeography Palaeoclimatology Palaeoecology,* 31: 319-336.

Fordyce, R. E. 1992. Cetacean evolution and Eocene/Oligocene environments. In *Eocene-Oligocene Climatic and Biotic Evolution,* D. R. Prothero and W. A. Berggren ed. Princeton University Press, Princeton, pp. 368-381.

Frakes, L. A., Probst, J.-L. and Ludwig, W. 1994. Latitudinal distribution of paleotemperature on land and sea from early Cretaceous to middle Miocene. *C. R. Acad. Sci.,* Paris, 318(2): 1209-1218.

Fürsich, F. T., Oschmann, W., Jaitly, A. K. and Singh, I. B. 1991. Faunal response to transgressive-regressive cycles: example from the Jurassic of western India. *Palaeogeography Palaeoclimatology Palaeoecology,* 85: 149-159.

Ganapathy, R. 1982. Evidence for a major meteorite impact on earth 34 million years ago: Implication for Eocene extinctions. *Science,* 216: 885-886.

Gaskell, B. A. 1991. Extinction patterns in Paleogene benthic foraminiferal faunas: Relationship to climate and sea level. *Palaios,* 6: 2-16.

Gauch Jr, H. G. 1982. Multivariate analysis in community ecology. Cambridge University Press: Cambridge. 298 pp.

Glass, B. P. and Crosbie, J. R. 1982. Age of the Eocene/Oligocene boundary based upon extrapolation from the North American microtektite layer. *American Association of Petroleum Geologists Bull.,* 66(4):471-476.

Glaessner, M. F. 1951. Three foraminiferal zones in the Tertiary of Australia. *Geological Magazine,* 88(4): 273-283.

Glenie, R. C., Scholfield, J. C. and Ward, W. T. 1968. Tertiary sea levels in Australia and New Zealand. *Palaeogeography Palaeoclimatology Palaeoecology,* 5: 141-163.

Gould, S. J. 1985. The paradox of the first tier: an agenda for paleobiology. *Paleobiology,* 11(1): 2-12.

Gradstein, F. M. and Agterberg, F. P. 1985. Quantitative correlation in exploration micropaleontology. In *Quantitative stratigraphy,* F. M. Gradstein, F. P. Agterberg, J. C. Brower and W. S. Schwarzacher eds. UNESCO & D. Reidel publ. co., Paris. Pp.309-357.

Greenlee, S. M. and Moore, T. C. 1988. Recognition and interpretation of depositional sequences and calculation of sea-level changes from stratigraphic data - offshore New Jersey and Alabama Tertiary. In *Sea-level Changes: An Integrated Approach,* C. K. Wilgus et al. eds. SEPM Spec Pub No42, Tulsa. Pp.329-353.

Grimsdale, T. and Morkhoven, F. 1955. The ratio between pelagic and benthonic foraminifera as a means of estimating depth of deposition of sedimentary rocks. *4th World Petrology Congress Proceedings,* Sect I/D(Rept 4): 473-491.

Hallam, A. 1978. How rare is phyletic gradualism and what is its evolutionary significance? Evidence from Jurassic bivalves. *Paleobiology,* 4: 16-25.

Hallam, A. 1987. Radiations and extinctions in relation to environmental change in the marine Lower Jurassic of northwestern Europe. *Paleobiology,* 13(2): 152-168.

Hallam, A. 1990. Mass extinction: Processes. In *Paleobiology - A synthesis,* D. E. G. Briggs and P. R. Crowther eds. Blackwell Sci. Pub., Oxford. Pp.160-164

Hallam, A. 1992. Phanerozoic Sea-level Changes. Columbia University Press : New York. 266 pp.

Hallock, P. 1987. Fluctuations in the trophic resource continuum: a factor in global diversity cycles? *Paleoceanography,* 2(5): 457-471.

Hallock, P. and Glenn, E. C. 1986. Larger foraminifera: A tool for paleoenvironmental analysis of Cenozoic carbonate depositional facies. *Palaios,* 1: 55-64.

Hallock, P., Premoli Silva, I. and Boersma, A. 1991. Similarities between planktonic and larger foraminiferal evolutionary trends through paleogene paleoceanographic changes. *Palaeogeography Palaeoclimatology Palaeoecology*, 83: 49-64.

Hambrey, M. J., Ehrmann, W. U. and Larsen, B. 1991. Cenozoic glacial record of the Prydz Bay continental shelf, East Antarctica. In J. Barron, B. Larsen et. al eds. *Proc. ODP, Sci Results,* 119: College Station TX(Ocean Drilling Program), pp. 77-132.

Haq, B. U. and Van Eysinga, F.W.B. 1987. Geological Timetable. Elsevier Science Pub.: Amsterdam.

Haq, B. U., Hardenbol, J. and Vail, P. R. 1988. Mesozoic and Cenozoic chronostratigraphy and cycles of sea-level change. In *Sea-level changes: an integrated approach,* C. K. Wilgus, B. S. Hastings, C. G. S. C. Kendall, H. W. Posamentier, C. A. Ross and J. C. Van Wagoner eds. SEPM Spec Pub 42, Tulsa. pp.72-108

Haynes, J. R. 1981. Foraminifera. Macmillan : London. 433 pp.

Hayward, B. W. and Buzas, M. A. 1979. Taxonomy and paleoecology of Early Miocene benthic foraminifera of northern New Zealand and the North Tasman Sea. *Smithsonian Contributions to Paleobiology,* 36: 154pp.

Heath, G. R. 1969. Carbonate sedimentation in the abyssal equatorial Pacific during the past 50 million years. *Geological Society of America Bulletin,* 80: 689-694.

Hesse, R. 1990. Origin of chert: Diagenesis of biogenic siliceous sediments. In *Diagenesis,* I. A. McIlreath and D. W. Morrow eds. Geoscience Canada Reprint series, Ottawa. Pp.253-275.

Hoffman, A. and Kitchell, J. A. 1984. Evolution in a pelagic planktic system: a paleobiologic test of models of multispecies evolution. *Paleobiology,* 10(1): 9-33.

Holdgate, G. R. and Sluiter, I. R. K. 1991. Oligocene-Miocene marine incursions in the Latrobe Valley depression, onshore Gippsland Basin: evidence, facies relationships and chronology. In *The Cainozoic in Australia: A re-appraisal of the evidence,* M. A. J. Williams, P. DeDeckker and A. J. Kershaw ed. Geological Society of Australia Spec. Publ .18, Sydney. Pp. 137-157.

Hornibrook, N. de B. 1992. New Zealand Cenozoic marine paleoclimates: A review based on the distribution of some shallow water and terrestrial biota. In *Pacific Neogene : Environment, Evolution, and Events,* R. Tsuchi and J. C. Ingle Jr. eds. University of Tokyo Press, Tokyo. Pp.83-106.

Hornibrook, N. de B. 1968. A handbook of New Zealand microfossils (foraminifera and ostracoda). *New Zealand geological Survey, Information ser.,* 62: 136pp.

Hornibrook, N. de B. 1971. A revision of the Oligocene and Miocene foraminifera of New Zealand described by Karrer and Stache in the reports of the 'Novara' Expedition (1864). *New Zealand Geological Survey palaeontological bulletin* 43:1-85.

Hornibrook, N. de B., Brazier, R. C. and Strong, C. P. 1989. Manual of New Zealand Permian to Pleistocene foraminiferal biostratigraphy. *New Zealand Geological Survey, Bull.56,* 175 pp.

Hornibrook, N. de B. 1958. New Zealand foraminifera: Key species in stratigraphy-no.6. *New Zealand Journal of Geology and Geophysics,* 1: 653-676.

Hornibrook, N. de B. 1961. Tertiary foraminifera from Oamaru district (N.Z.): Part 1-Systemics and Distribution. *New Zealand Department of Scientific and Industrial Research, Paleontological Bulletin* 34 (1), 192pp., 28 pls.

Hornibrook, N. de B. 1968. A handbook of New Zealand microfossils (foraminifera and ostracoda). *New Zealand geological Survey, Information ser.,* 62: 136pp.

Hornibrook, N. de B. 1968. Distribution of some warm water benthic foraminifera in the New Zealand Tertiary. *Tuatara,* 16: 11-15.

Hornibrook, N. de B. 1971. A revision of the Oligocene and Miocene foraminifera of New Zealand described by Karrer and Stache in the reports of the 'Novara' expedition (1864). *New Zealand Geological Survey, Palaeont. Bull.,* 43: 85pp.

Hornibrook, N. de B., Brazier, R. C. and Strong, C. P. 1989. Manual of New Zealand Permian to Pleistocene foraminiferal biostratigraphy. *New Zealand Geological Survey Bull.,* 56: 175 pp.

Hornibrook, N. de. B. 1967. New Zealand Tertiary microfossil zonation correlation and climate. In *Tertiary Correlations and Climatic Changes in the Pacific,* K. Hatai ed. Tertiary correlations and Climatic Changes in the Pacific, Tokyo. 29-39 pp.

Hornibrook, N. de B. 1961. Tertiary foraminifera from the Oamaru District (N.Z.). *N.Z. geol. Surv. paleont. Bull.* 34(1).

Hut, P., Alvarez, W., Elder, W., Hansen, T., Kauffman, E. G., Keller, G., Shoemaker, E.M and Weissman, P. R. 1987. Comet showers as a cause of mass extinctions. *Nature,* 329: 118-126.

Inoue, Y. 1989. Northwest Pacific foraminifera as paleoenvironmental indicators. *Science Reports of the Institute of Geoscience University of Tsukuba Sec B,* 10: 57-162.

Jablonski, D. 1980. Apparent versus real biotic effects of transgressions and regressions. *Paleobiology*, 6(4): 397-407.

Jablonski, D. 1985. Marine regressions and mass extinctions: a test using modern biota. In *Phanerozoic Diversity Patterns*, J. W. Valentine ed. Princeton University Press, Princeton. Pp. 335-354.

James, N. P. and Bone, Y. 1991. Origin of a cool-water, Oligo-Miocene deep shelf limestone, Eucla Platform, southern Australia. *Sedimentology*, 38: 323-341.

James, N. P. and Bone, Y. 1992. Synsedimentary cemented layers in Oligo-Miocene cool-water shelf limestones, Eucla Platform, southern Australia. *Journal of Sedimentary Petrology*, 62(5): 860-872.

James, N. P., Bone, Y., Von Der Borch, C. C. and Gostin, V. A. 1992. Modern carbonate and terrigenous clastic sediments on a cool water, high energy, mid-latitude shelf: Lacepede, southern Australia. *Sedimentology*, 39: 877-903.

Jenkins, D. G. 1965. Planktonic foraminiferal zones and new taxa from the Danian to Lower Miocene of New Zealand. *New Zealand Journal of Geology and Geophysics*, 8(6): 1088-1126.

Jenkins, D.G. 1971. New Zealand Cenozoic planktonic foraminifera. *N.Z. geol. Surv. Bull.* 42.

Jenkins, D. G. 1978. Guembelitria samwelli Jenkins, a new species from the Oligocene of southern Australia. *Journal of Foraminiferal Research*, 8(2):132-137.

Jenkins, D. G. 1993a. Cenozoic southern mid- and high-latitude biostratigraphy and chronostratigraphy based on planktonic foraminifera. *The Antarctic paleoenvironment: a perspective on global change, Antarctic Research series, AGU*, 60: 125-144.

Jenkins, D. G. 1993b. The evolution of Cenozoic southern high- and mid-latitude planktonic foraminiferal faunas. *The Antarctic paleoenvironment: a perspective on global change, Antarctic Research series, AGU*, 60: 175-194.

Johnson, J. G. 1974. Extinction of perched faunas. *Geology*, 2: 479-482.

Johnson, R. G. 1972. Conceptual models of benthic marine communities. In *Models in Paleobiology*, T. J. M. Schopf ed. Freeman, Cooper & Co., San Francisco. 148-159 pp.

Jones, J. B. and Fitzgerald, M. J. 1984. Extensive volcanism associated with the searation of Australia and Antarctica. *Science*, 226:346-348.

Jones, J. B. and Fitzgerald, M. J. 1987. An unusual and characteristic sedimentary mineral suite associated with the evolution of passive margins. *Sedimentary Geology,* 52: 45-63.

Kamp, P. J. J., Waghorn, D. B. and Nelson, C. S. 1990. Late Eocene-Early Oligocene integrated isotope stratigraphy and biostratigraphy for paleoshelf sequences in southern Australia: paleoceanographic implications. *Palaeogeography Palaeoclimatology Palaeoecology,* 80: 311-323.

Kauffman, E. G. 1977. Evolutionary rates and biostratigraphy. In *Concepts and methods of biostratigraphy,* E. G. Kauffman and J. E. Hazel eds. Dowden, Hutchinson & Ross, Inc. Pennsylvania. 109-141.

Kauffman, E. 1987. The Uniformitarian Albatross. *Palaios,* 2(6): 531.

Kauffman, E. G. and Sageman, B. B. 1992. Biological patterns in sequence stratigraphy; Cretaceous of the Western Interior Basin, North America. *5th North American Paleontological Convention Abstr&Progr,* p.158.

Kauffman, E. G., Elder, W. P. and Sageman, B. B. 1991. High-resolution correlation: a new tool in stratigraphy. In *Cycles and Events in Stratigraphy,* Einsele et. al, eds. Springer-Verlag, Berlin, pp 795-819.

Keller, G. 1983. Paleoclimatic analyses of middle Eocene through Oligocene planktic foraminiferal faunas. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 43: 73-94.

Keller, G. 1986. Stepwise mass extinctions and impact events: Late Eocene to early Oligocene. *Marine Micropaleontology,* 10: 267-293.

Keller, G., D'Hondt, S. and Vallier, T. L. 1983. Multiple microtektite horizons in upper Eocene marine sediments: No evidence for mass extinction. *Science,* 221: 150-152.

Kemp, E. M. 1978. Tertiary climate evolution and vegetation history in the Southeast Indian Ocean region. *Palaeogeography Palaeoclimatology Palaeoecology,* 24: 169-208.

Kennett, J. P. 1977. Cenozoic evolution of Antarctic glaciation, the Circum-Antarctic Ocean, and their impact on global paleoceanography. *Journal of Geophysical Research,* 82(27): 3843-3860.

Kennett, J. P. and Stott, L. D. 1991. Abrupt deep-sea warming, palaeoceanographic changes and benthic extinctions at the end of the Palaeocene. *Nature,* 353: 225-228.

Kennett, J. P., von der Borch, C., Baker, P. A., Barton, C. E., Boersma, A., Cauler, J. P., Dudley Jr, W. C., Gardner, J. V., Jenkins, D. G., Lohman, W. H., Martini, E., Merrill, R. B., Morin, R., Nelson, C. S., Robert, C., Srinivasan, M. S., Stein, R., Takeuchi, A. and Murphy, M. G. 1985. Palaeotectonic implications of increased late Eocene-early Oligocene volcanism from South Pacific DSDP sites. *Nature*, 316: 507-511.

Kerr, R. A. 1984. Ice cap of 30 million years ago detected. *Science*, 224: 141-142.

Leckie, R. M., Scott, R. W., Bralower, T. J. and Sliter, W. V. 1992. Relationship between sequence boundaries and the evolutionary history of planktonic foraminifera, calcareous nannofossils, and reef communities in the mid-Cretaceous (Barremian-Cenomanian). *5th North American Paleont Convention Abstr&Progr*, p. 179.

Legendre, S. and Hartenberger, J.-L. 1992. Evolution of mammalian faunas in Europe during the Eocene and Oligocene. In *Eocene-Oligocene Climatic and Biotic Evolution*, D. R. Prothero and W. A. Berggren eds. Princeton University Press, Princeton. Pp.515-528.

Leopold, E. B., Liu, G. and Clay-Poole, S. 1992. Low-biomass vegetation in the Oligocene. In *Eocene-Oligocene Climatic and Biotic Evolution*, D. R. Prothero and W. A. Berggren eds. Princeton University Press, Princeton., pp. 399-420.

Lindsay, J. M. 1967. Foraminifera and stratigraphy of the type section of the Port Willunga Beds, Aldinga, South Australia. *Transactions of the Royal Society of South Australia*, 91: 93-110.

Lindsay, J. M. 1973. Oligocene in South Australia. *45th. ANZAAS Conference*.

Lindsay, J. M. 1976. Tertiary history of South Australia - the foraminiferal record. *25th International Geological Congress*, Abstr.vol.1: 329-330.

Lindsay, J. M. 1981. Tertiary stratigraphy and foraminifera of the Adelaide city area, St. Vincent Basin, South Australia. Masters thesis (unpubl.). University of Adelaide. Adelaide.

Lindsay, J. M. 1981. Tertiary stratigraphy and foraminifera of the Adelaide city area, St. Vincent Basin, South Australia. Masters thesis (unpubl.). University of Adelaide. Adelaide. 2vols.

Lindsay, J. M. 1985. Aspects of South Australian Tertiary foraminiferal biostratigraphy, with emphasis on studies of Massilina and Subbotina. In *Stratigraphy, Palaeontology and Malacology: Papers in Honour of N.H. Ludbrook*, J. M. Lindsay ed. South Australian Department of Mines and Energy, Spec. Publ. 5, Adelaide, pp.187-231.

Lindsay, J. M. and Bonnett, J. E. 1971. Tertiary stratigraphy of deep bores 2W, 27W, 28W, Waikerie, Murray Basin. *S.A. Dept. Mines and Energy, Geol. Surv.*, Pal.Rept.3/71 (unpublished report).

Lindsay, J. M. and Bonnett, J. E. 1973. Tertiary stratigraphy of three bores in the Waikerie area of the Murray Basin. *Report of Investigations, Geological Survey of South Australia,* 38.

Lindsay, J. M. and McGowran, B. 1986. Eocene/Oligocene boundary, Adelaide region, South Australia. In *Terminal Eocene Events,* C. Pomerol and I. Premoli-Silva eds. Elsevier Science Publishers B.V., Amsterdam. Pp. 165-173.

Lindsay, J. M. and Williams, A. F. 1977. Oligocene marine transgression at Hartley and Monarto, southwestern margin of the Murray Basin. *Quarterly Geological Notes, Geological Survey of Sth. Australia,* (64): 9-16.

Lindsay, J.M and Barnett, S.R. 1989. Aspects of stratigraphy and structure in relation to the Woolpunda Groundwater Interception Scheme, Murray Basin, South Australia. *BMR Journal of Australian Geology & Geophysics,* 11: 219-225.

Lipps, J. H. and Mitchell, E. 1976. Trophic model for the adaptive radiations and extinctions of pelagic marine mammals. *Paleobiology,* 2(2): 147-155.

Lockley, M. G. 1983. A review of brachiopod dominated palaeocommunities from the type Ordovician. *Palaeontology,* 26(1): 111-145.

Loeblich, A. R. and Tappan, H. 1988. Foraminiferal genera and their classification. Van Nostrand Reinhold , New York. 212 pp.

Loeblich, A. R. and Tappan, H. 1994. Foraminifera of the Sahul Shelf and Timor Sea. *Cushman Foundation for Foraminiferal Research,* Spec. Pub. 31, pp.661.

Loubere, P. 1991. Deep-sea benthic foraminiferal assemblage response to a surface ocean productivity gradient: A test. *Paleoceanography,* 6(2): 193-204.

Loutit, T. S. and Kennett, J. P. 1981. New Zealand and Australian Cenozoic sedimentary cycles and global sea-level changes. *AAPG Bull,* 65: 1586-1601.

Loutit, T. S., Hardenbol, J. and Vail, P. R. 1988. Condensed sections: the key to age determination and correlation of continental margin sequences. In *Sea-level Changes: An Integrated Approach,* C. K. Wilgus, B. S. Hastings, C. G. S. C. Kendall, H. W. Posamentier, C. A. Ross and J. C. Van Wagoner eds. SEPM Spec Pub 42, Tulsa. Pp.183-213.

Ludbrook, N. H. 1957. A reference column for the Tertiary sediments of the South Australian portion of the Murray Basin. *Journal of Proceedings of the Royal Society of N.S.W.*, 90: 174-180.

Ludbrook, N. H. 1961. Stratigraphy of the Murray Basin in South Australia. *South Australian Department of Mines and Energy , Bulletin* 36

Ludbrook, N. H. 1961. Stratigraphy of the Murray Basin in South Australia. *South Australian Department of Mines and Energy , Bulletin* 36, 96pp., 8pls.

Ludbrook, N. H. 1963. Correlation of Tertiary rocks in South Australia. *Transactions of the Royal Society of South Australia,* 87: 5-15.

Ludbrook, N. H. 1967. Correlation of Tertiary rocks of the Australasian region. In *Tertiary Correlations and Climatic Changes in the Pacific*, K. Hatai ed. Eleventh Pacific Science Congress, Tokyo, 1966. Pp.7-19.

Ludbrook, N. H. 1971. Stratigraphy and correlation of marine sediments in the western part of the Gambier Embayment. In *The Otway Basin of southwestern Australia*, H.Wopfner and J.G Douglas eds. Adelaide. Pp.47-66.

Ludbrook, N. H. and Lindsay, J. M. 1966. The Aldingian Stage. *Quart. geol. Notes, geol. Surv. S. Aust.*, 19: 1-2.

Ludbrook, N. H. and Lindsay, J. M. 1969. Tertiary foraminiferal zones in South Australia. In *Proceedings 1st Int. Conf. Planktonic Microfossils*, P. Bronniman and H. H. Renz eds. Geneva. Pp.366-374.

MacArthur, R. H. and Wilson, E. O. 1967. The theory of island biogeography. Princeton University Press publ., Princeton, N.J. 203pp.

Macleod, N. 1991. Punctuated anagenesis and the importance of stratigraphy to paleobiology. *Paleobiology,* 17(2): 167-188.

Macphail, M. K. and Truswell, E. M. 1989. Palynostratigraphy of the central west Murray Basin. *BMR Journal of Australian Geology & Geophysics,* 11: 301-331.

Macphail, M. K., Colhoun, E. A., Kiernan, K. and Hannan, D. 1993. Glacial climates in the Antarctic region during the late Paleogene: Evidence from northwest Tasmania, Australia. *Geology,* 21: 145-148.

Macphail, M. K., Hill, R. S., Forsyth, S. M. and Wells, P. M. 1991. A late Oligocene - early Miocene cool climate flora in Tasmania. *Alcheringa,* 15: 87-106.

Mallett, C. D. and Heezen, B. C. 1977. Circum-polar circulation and late Tertiary changes in the carbonate compensation depth south of Australia. *Marine Geology,* 23: 89-101.

Mancini, E. and Tew, B. H. 1991. Relationships of Paleogene stage and planktonic foraminiferal zone boundaries to lithostratigraphic and allostratigraphic contacts in the eastern Gulf Coastal Plain. *Journal of Foraminiferal Research,* 21(1): 48-66.

Martin, H. 1991. Dinoflagellate and spore pollen biostratigraphy of the S.A.D.M.E. MC63 bore, western Murray Basin. *Alcheringa,* 15(1): 107-144.

Martin, H. A. 1989. Vegetation and climate of the late Cainozoic in the Murray Basin and their bearing on the salinity problem. *BMR Journal of Australian Geology and Geophysics,* 11: 291-299.

Martin, R. E., Neff, E. D., Johnson, G. W. and Krantz, D. E. 1993. Biostratigraphic expression of Pleistocene sequence boundaries, Gulf of Mexico. *Palaios,* 8: 155-171.

Marty, R., Dunbar, R., Martin, J. B. and Baker, P. 1988. Late Eocene diatomite from the Peruvian coastal desert, coastal upwelling in the eastern Pacific, and Pacific circulation before the Terminal Eocene Event. *Geology,* 16: 819-822.

Marty, R., Dunbar, R., Martin, J.B. and Baker, P. 1989. Comment and reply on "Late Eocene diatomite from the Peruvian coastal desert, coastal upwelling in the eastern Pacific, and Pacific circulation before the Terminal Eocene Event. *Geology,* 17: 958-959.

Mack, D. 1989. Sequence and cyclostratigraphic analysis of the Blanche Point Formation, St Vincent Basin, S.A. Unpublished honours thesis, The University of Adelaide.

McGhee, G. R. J., Bayer, U. and Seilacher, A. 1991. Biological and evolutionary responses to transgressive-regressive cycles. In *Cycles and Events in Stratigraphy,* G. Einsele, W. Ricken and A. Seilacher eds. Springer-Verlag, Berlin. Pp.696-708.

McGinnis, J. P., Driscoll, N. W., Karner, G. D., Brumbaugh, W. D. and Cameron, N. 1993. Flexural response of passive margins to deep-sea erosion and slope retreat: implications for relative sea-level change. *Geology,* 21(10): 893-896.

McGowran, B. 1971. Observation Bore No.2 County Robe, Hundred Ross, Section D: Micropalaeontology and Stratigraphy. *Department of Mines and Energy , Geological Survey palaeontology section* 22/71 (unpubl. rep.)

McGowran, B. 1973. Observation bore No.2, Gambier embayment of the Otway Basin: Tertiary micopalaeontology and stratigraphy. *SADME , Mineral Resources Rev.* 135

McGowran, B. 1978. Early Tertiary foraminiferal biostratigraphy in southern Australia: A progress report. *Bureau of Mineral Resources Geology & Geophysics,* 192: 84-95.

McGowran, B. 1987. Late Eocene perturbations: foraminiferal biofacies and evolutionary overturn. *Paleoceanography,* 2(6): 715-727.

McGowran, B. 1989. The later Eocene transgressions in southern Australia. *Alcheringa,* 13: 45-68.

McGowran, B. 1989a. Silica burp in the Eocene ocean. *Geology,* 17: 857-860.

McGowran, B. 1989b. Comment and reply on "Late Eocene diatomite from the Peruvian coastal desert, coastal upwelling in the eastern Pacific, and Pacific circulation before the Terminal Eocene Event. *Geology,* 17: 957-959.

McGowran, B. 1991. Maastrichtian and early Cainozoic, southern Australia: planktonic foraminiferal biostratigraphy. In *The Cainozoic in Australia: A re-appraisal of the evidence,* M. A. J. Williams, P. DeDeckker and A. P. Kershaw eds., Geological Society of Australia, Spec. Pub. 18, Sydney. 79-98 pp.

McGowran, B. 1994. Chronicling the Australian duricrusts: Relevance of the Cainozoic stratigraphic succession. *Australian Regolith Conference* '94, Abstr., p. 41.

McGowran, B. and Beecroft, A. 1985. *Guembelitria* in the Early Tertiary of southern Australia and its palaeoceanographic significance. In *Stratigraphy, Palaeontology, Malacology,* J. M. Lindsay ed. *South Australia Department of Mines and Energy Spec. Publ.,* Adelaide. 247-261 pp.

McGowran, B. and Beecroft, A. 1986. Foraminiferal biofacies in a silica-rich neritic sediment, Late Eocene, South Australia. *Palaeogeography Palaeoclimatology Palaeoecology,* 52(1986): 321-345.

McGowran, B., Lindsay, J. M. and Harris, W. K. 1971. Attempted reconciliation of Tertiary biostratigraphic systems. *Geological Surveys of South Australia and Victoria Spec. Bull.,* : 273-281.

McGowran, B., Moss, G. D. and Beecroft, A. 1992. Late Eocene and Early Oligocene in southern Australia: local neritc signals of global oceanic changes. In *Eocene-Oligocene Climatic and Biotic Evolution,* D. R. Prothero and W. A. Berggren eds. Princeton University Press, Princeton. Pp. 178-201.

McLaren, D. J. 1989. Detection and significance of mass killings. *Historical Biology,* 2: 5-15.

Mildenhall, D. C. and Pocknall, D. T. 1984. Palaeobotanical evidence for changes in Miocene and Pliocene climates in New Zealand. In *Late Cainozoic palaeoclimates of the Southern Hemisphere,* J. C. Vogel ed. A.A. Balkema, Rotterdam. Pp.159-171.

Miller, F. X. 1977. The graphic correlation method in biostratigraphy. In *Concepts and methods of biostratigraphy,* E. G. Kauffman and J. E. Hazel ed. Dowden, Hutchinson & Ross, Inc., Stroudsburg, Pennsylvania, pp.165-186.

Miller, K. G. 1994. Editorial: The rise and fall of sea level studies: Are we at a stillstand? *Paleoceanography,* 9(2):183-184.

Miller, K. G. and Kent, D. V. 1987. Testing Cenozoic eustatic changes: The critical role of stratigaphic resolution. *Cushman Foundation for Foraminiferal Res.,* Spec. Pub.(24): 51-55.

Miller, K. G., Thompson, P. R. and Kent, D. V. 1993. Integrated Late Eocene-Oligocene stratigraphy of the Alabama coastal plain: correlation of hiatuses and stratal surfaces to glacioeustatic lowerings. *Paleoceanography,* 8(2): 313-331.

Miller, K. G., Wright, J. D. and Fairbanks, R. G. 1991. Unlocking the ice house: Oligocene-Miocene oxygen Isotopes, eustasy, and margin erosion. *Journal of Geophysical Research,* 96(B4): 6829-6848.

Moore, R. C. 1954. Evolution of late Paleozoic invertebrates in response to major oscillations of shallow seas. *Harvard Mus. Comp. Zool., Bull.,* 112: 259-286.

Moore, R. C. 1955. Expansion and contraction of shallow seas as a causal factor in evolution. *Evolution,* 9: 482-483.

Morkhoven, F. P. C. M., Edwards, A. S. and Berggren, W. A. 1983. Cenozoic cosmopolitan deep-water benthic foraminifera. Industry prepared atlas, 2 vols.

Moss, G. 1989. The Port Willunga Formation: Eocene/Oligocene boundary stratigraphy and foraminiferal turnover. Honours thesis (unpubl.). University of Adelaide. South Australia.

Moss, G. and McGowran, B. 1993. Foraminiferal turnover in neritic environments: the end-Eocene and mid-Oligocene events in southern Australia. *Memoirs of the Association of Australasian Palaeontolgists,* 15: 407-416.

Moss, G. and McGowran, B. 1994. The Oligocene in southern Australia: Ecostratigraphy of extratropical neritic foraminifera. *Geological Society of Australia Abstracts,* Vol.37: 305-306.

Mullins, H. T., Thompson, J. B., McDougall, K. and Vercoutere, T. L. 1985. Oxygen-minimum zone edge effects: Evidence from the central Californian coastal upwelling system. *Geology,* 13: 491-494.

Murphy, M. G. and Kennett, J. P. 1986. Development of latitudinal thermal gradients during the Oligocene: Oxygen-isotope evidence from the southwestern Pacific. *Initial Reports of the Deep Sea Drilling Project,* 90: 1347-1360.

Murray, J. W. 1976. A method of determining proximity of marginal seas to an ocean. *Marine Geology,* 22:103-119.

Murray, J. W. 1991a. Ecology and palaeoecology of benthic foraminifera. Longman Scientific and Technical : London. 397 pp.

Murray, J. W. 1991b. Ecology and distribution of benthic foraminifera. In *Biology of Foraminifera,* J. J. Lee and O. R. Anderson eds. Academic Press, London. Pp.221-253.

Nelson, C. S. 1978. Temperate shelf carbonates in the Cenozoic of New Zealand. *Sedimentology,* 25: 737-772.

Newell, N. D. 1967. Revolutions in the history of life. *Geological Society of America Spec. Pap.,* 89:63-91.

Nocchi, M., Amici, E. and Premoli Silva, I. 1991. Planktonic foraminiferal biostratigraphy and paleoenvironmental interpretation of Paleogene faunas from the subAntarctic transect, Leg 114. In P. F. Ciesielski, Y. Kristofferson et al. eds. *Proc. ODP, Sci Results,* 112: College Station TX(Ocean Drilling Program), 114: 233-279.

Oberhänsli, H., Heinze, P., Diester-Haass, L. and Wefer, G. 1990. Upwelling off Peru during the last 430,000yr and its relationship to the bottom-dwelling environment, as deduced from coarse grain-size distributions and analyses of benthic foraminifers at holes 679D, 680B, and 681B, Leg 112. In Suess, E. , von Huene, R. et al. eds. *Proc. ODP, Sci Results,* 112: College Station TX(Ocean Drilling Program), 369-390.

Olóriz, F., Rodriguez-Tovar, F. J., Marques, B. and Caracuel, J. E. 1993. Ecostratigraphy and sequence stratigraphy in high frequency sea level fluctuations: examples from Jurassic macroinvertebrate assemblages. *Palaeogeography Palaeoclimatology Palaeoecology,* 101: 131-145.

Olsson, R. K., Miller, K. G. and Ungrady, T. E. 1980. Late Oligocene transgression of middle Atlantic Coastal Plain. *Geology,* 8: 549-554.

Owen, M. R. and Anders, M. H. 1988. Evidence from cathodoluminescence for non-volcanic origin of shocked quartz at the Cretaceous/Tertiary boundary. *Nature*, 334(6178): 145-7.

Patterson, R. T. and Richardson, R. H. 1988. Eight new genera of unilocular foraminifera. *Transactions of the American Microscopical Soc.*, 107(3): 240-258.

Patterson, R.T. and Richardson, R.H 1987. A taxonomic revision of the unilocular foraminifera. *Journal of Foraminiferal Research*, 17:212-226.

Premoli Silva, I., Orlando, M., Monechi, S., Madile, M., Napoleone, G. and Ripepe, M. 1988. Calcareous plankton biostratigraphy and magnetostratigraphy at the Eocene-Oligocene boundary transition in the Gubbio area. In *The Eocene-Oligocene boundary in the Marche-Umbria Basin (Italy)*, I. Premoli Silva, R. Coccioni and A. Montanari eds. IUGS, Ancona. 137-161 pp.

Prothero, D. R. 1985. North American mammal diversity and Eocene-Oligocene extinctions. *Paleobiology*, 11: 389-405.

Prothero, D. R. 1989. Stepwise extinctions and climatic decline during the later Eocene and Oligocene. In *Mass Extinctions: Processes and Evidence*, S. K. Donovan ed., Columbia Uni Press, New York, pp. 211-234.

Prothero, D. R. 1994a. The Eocene-Oligocene transition: paradise lost. Columbia Uni. Press, New York.

Prothero, D. R. 1994b. The Late Eocene-Oligocene extinctions. *Annual Review of Earth and Planetary Sci*, 22: 145-65.

Prothero, D. R. and Swisher, C. C. 1992. Magnetostratigraphy and geochronology of the terrestrial Eocene-Oligocene transition in North America. In *Eocene-Oligocene climatic and biotic evolution*, D. R. Prothero and W. A. Berggren eds. Princeton University Press, Princeton. Pp.46-73.

Quilty, P. G. 1974. Tasmanian Tertiary foraminifera: Part 1. Textulariina, Miliolina, Nodosariacea. *Papers and Proceedings of the Royal Society of Tasmania*, 108: 31-106.

Quilty, P. G. 1977. Cenozoic sedimentation cycles in Western Australia. *Geology*, 5: 336-340.

Quilty, P. G. 1977. Tasmanian Tertiary foraminifera: Part 2. chiefly Spirillinacea to Glabratellidae. *Papers and Proceedings of the Royal Society of Tasmania*, 111: 69-109.

Raffi, S., Stanley, S. M. and Marasti, R. 1985. Biogeographic patterns and Plio-Pleistocene extinction of Bivalvia in the Mediterranean and southern North Sea. *Paleobiology,* 11(4): 368-388.

Rahel, F. J. 1990. The hierarchical nature of community persistence: a problem of scale. *American Naturalist,* 136: 328-344.

Reed, K. J. 1965. Mid-Tertiary smaller foraminifera from a bore at Heywood, Victoria, Australia. *Bulletin of North American Paleontological Soc,* 49(220): 39-104.

Rey, J., Cubaynes, R., Qajoun, A. and Ruget, C. 1993. Foraminifera indicators of systems tracts and global unconformities. *International Association of Sedimentologists Spec. Pub.,* 18: 109-123.

Rhodes, M. C. and Thayer, C. W. 1991. Mass extinctions: Ecological selectivity and primary production. *Geology,* 19: 877-880.

Rollins, H. B., Carothers, M. and Donahue, J. 1979. Transgression, regression and fossil community succession. *Lethaia,* 12: 89-104.

Sageman, B. B., Wignall, P. B. and Kauffman, E. G. 1991. Biofacies models for oxygen-deficient facies in epicontinental seas: Tool for paleoenvironmental analysis. In *Cycles and events in stratigraphy,* G. Einsele, W. Ricken and A. Seilacher eds., Springer-Verlag, Berlin, pp. 543-564.

Sarg, J.F. 1988. Carbonate sequence stratigraphy. In *Sea-level Change: An Integrated Approach,* C. K. Wilgus, B. S. Hastings, C. G. S. C. Kendall, H. W. Posamentier, C. A. Ross and J. C. Van Wagoner eds., SEPM Spec Pub 42, Tulsa, pp.155-181.

Savrda, C. E., Bottjer, D. G. and Seilacher, A. 1991. Redox-related benthic events. In *Cycles and Events in Stratigraphy,* E. e. al eds. Springer-Verlag, Berlin. Pp.525-541.

Schröder-Adams, C. J. 1991. Middle Eocene to Holcene benthic foraminifer assemblages from the Kerguelen Plateau (southern Indian Ocean). In Barron, J., Larsen, B. et al. eds., *Proc. ODP, Sci.Results,* 119: College Station TX(Ocean Drilling Program), 611-630.

Scott, G. H. 1970. Miocene foraminiferal biotopes in New Zealand: Waitemata Group, Kaipara Northland. *New Zealand Journal of Geology and Geophysics,* 13(2): 316-342.

Seibold, E. and Berger, W.H. 1993. The Sea Floor: An introduction to marine geology. Springer-Verlag Berlin Heidelberg.

Sen Gupta, B. K.and Machain-Castillo, M. L. 1993. Benthic foraminifera in oxygen-poor habitats. *Marine Micropaleontology*, 20(1993): 183-201.

Shackleton, N. J. and Kennett, J. P. 1975. Paleotemperature history of the Cenozoic and the initiation of Antarctic glaciation: Oxygen and carbon isotope analyses in DSDP sites 277, 279, and 281. *Initial Reports of the Deep Sea Drilling Project*, 29: 743-755.

Shafik, S. 1983. Calcareous nannofossil biostratigraphy: an assessment of foraminiferal and sedimentation events in the Eocene of the Otway Basin, southeastern Australia. *BMR Journal of Australian Geology & Geophysics*, 8: 1-17.

Shaw, A. B. 1964. Time in stratigraphy. McGraw-Hill : New York. 365 pp.

Sjoerdsma, P. G. and van der Zwaan, G. J. 1992. Simulating the effect of changing organic flux and oxygen content on the distribution of benthic foraminifera. *Marine Micropaleontology*, 19: 163-180.

Spezzaferri, S. 1991. Evolution and taxonomy of the *Paragloborotalia kugleri* (Bolli) lineage. *Journal of Foraminiferal Research*, 21(4): 313-318.

Srinivasan, M. S. and Kennett, J. P. 1983. The Oligocene-Miocene boundary in the South Pacific. *Geological Soc of America Bull*, 94: 798-812.

Stanley, S. M. 1984a. Temperature and biotic crises in the marine realm. *Geology*, 12: 205-208.

Stanley, S. M. 1984b. Marine mass extinctions: A dominant role for temperature. In *Extinctions*, M. H. Nitecki eds. University of Chicago Press, Chicago, pp. 69-117.

Stanley, S. M., Wetmore, K. L. and Kennett, J. P. 1988. Macroevolutionary differences between the two major clades of Neogene planktonic foraminifera. *Paleobiology*, 14(3): 235-249.

Stehlin, H. G. 1909. Remarques sur les faunules de Mammiferes des couches Eocenes et Oligocenes du Bassin de Paris. *Bull. Soc. Geol. France*, 9: 488-520.

Stenseth, N. C. and Maynard Smith, J. 1984. Coevolution in ecosystems: Red Queen or stasis. *Evolution*, 38(4): pp.870-880.

Stott, L. D. and Kennett, J. P. 1990. Antarctic Paleogene planktonic foraminifers biostratigraphy: ODP leg 113, sites 689 and 690. In Barker P.F., Kennett, J.P. et al. eds.*Proc. ODP, Sci.Results*, 113: College Station TX(Ocean Drilling Program), 549-569.

Stuart, W. J. 1970. The Cainozoic stratigraphy of the eastern coatal area of Yorke Peninsula, South Australia. *Transactions of the Royal Society of South Australia*, 94: 151-178.

Tada, R. 1991. Compaction and cementation in siliceous rocks and their possible effect on bedding enhancement. In *Cycles and Events in Stratigraphy*, G. Einsele, W. Ricken and A. Seilacher eds. Springer-Verlag, Berlin. Pp.480-491.

Thomas, E. 1990. Late Cretaceous through Neogene deep-sea benthic foraminifers (Maud Rise, Weddel Sea, Antarctica). In Barker P.F., Kennett, J.P. et al. eds., *Proc. ODP, Sci.Results*, 113: College Station TX(Ocean Drilling Program), 571-591.

Thomas, E. 1992. Middle Eocene - Late Oligocene bathyl benthic foraminifera (Weddell Sea): Faunal changes and implications for ocean circulation. In *Eocene-Oligocene biotic and climatic evolution*, D. R. Prothero and W. A. Berggren eds. Princeton Uni. Press, Princeton, N.J. 245-266 pp.

Toumarkine, M. 1978. Planktonic foraminiferal biostratigraphy of the Paleogene of sites 360 to 364 and the Neogene of sites 362A, 363, and 364 leg 40. In Bolli, H.M. and Ryan, W.B.F. et al. eds., *Initial Reports of the Deep Sea Drilling Project*, 40: 679-721.

Vail, P. R., Mitchum, R. M. and Thompson III, S. 1977. Seismic stratigraphy and global changes of sea level. Pt. 4. Global cycles of cycles of sea level. In *Seismic stratigraphy - applications to hydrocarbon exploration*, C. E. Payton ed., *Mem. Am. Ass. Petrol. Geol.*, 26:83-97.

Vail, P. R., Audemard, F., Bowman, S. A., Eisner, P. N. and Perez-Cruz, C. 1991. The stratigraphic signatures of tectonics, eustasy and sedimentology - an overview. In *Cycles and events in stratigraphy*, G. Einsele, W. Ricken and A. Seilacher eds. Springer-Verlag, Berlin. Pp.617-618.

Valentine, J. W. 1971. Resource supply and species diversity patterns. *Lethaia*, 4:51-61.

Valentine, J. W. and Jablonski, D. 1991. Biotic effects of sea level change: the Pleistocene test. *Journal of Geophysical Research*, 96(B4): 6873-6878.

Van Valen, L. 1973. A new evolutionary law. *Evolutionary Theory*, 1:1-30.

Van der Zwaan, G. J. and Jorissen, F. J. 1993. Biofacial patterns in river-induced shelf anoxia. In *Modern and Ancient Continental Shelf Anoxia*, R. V. Tyson and T. H. Pearson eds. Geological Society Spec Pub No 58, London. Pp.65-82.

Van Wagoner, J. C., Posamentier, H. W., Mitchum, R. M., Vail, P. R., Sarg, J. F., Loutit, T. S. and Hardenbol, J. 1988. An overview of the fundementals of sequence stratigraphy and key definitions. In *Sea-level Change: An Integrated Approach*, C. K. Wilgus, B. S. Hastings, C. G. S. C. Kendall, H. W. Posamentier, C. A. Ross and J. C. Van Wagoner eds., SEPM Spec Pub 42, Tulsa. 39-45 pp.

Veevers, J. J., Powell, C. M. and Roots, S. R. 1991. Review of seafloor spreading around Australia. I. Synthesis of patterns of spreading. *Australian Journal of Earth Sciences*, 38: 373-389.

Vella, P. 1962. Determining depths of New Zealand Tertiary seas. An introduction to depth palaeoecology. *Tuatara*, 10: 19-40.

Vrba, E. S. 1985. Environment and evolution: alternative causes of the temporal distribution of evolutionary events. *South African Journal of Science*, 81: 229-236.

Vrba, E. S. and Eldredge, N. 1984. Individuals, hierarchies and processes: towards a more complete evolutionary theory. *Paleobiology*, 10(2): 146-171.

Wade, M. 1964. Application of the lineage concept to biostratigraphy. *Micropaleontology*, 10: 273-290.

Walker, K. R. and Alberstadt, L. P. 1975. Ecological succession as an aspect of structure in fossil communities. *Paleobiology*, 1: 238-257.

Wass, R. E. and Yoo, J. J. 1974. Bryozoa from site 282 west of Tasmania. In Kennett, J.P., Houtz, R.E. et al. *Initial Reports of the Deep Sea Drilling Project*, 29(Washington, U.S. Government Printing Office): 809-831.

Waterhouse, J. B. 1976. The significance of ecostratigraphy and need for biostratigraphic nomenclature. *Lethaia*, 9:317-325.

Whittaker, A., Cope, J. C. W., Cowie, J. W., Gibbons, W., Hailwood, E. A., House, M. R., Jenkins, D. G., Rawson, P. F., Rushton, A. W. A., Smith, D. G., Thomas, A. T. and Wimbledon, W. A. 1991. A guide to stratigraphical procedure. *Journal of the Geological Soc. London*, 148: 813-824.

Wolfe, J. A. 1971. Tertiary climatic fluctuations and methods of analysis of Tertiary Floras. *Palaeogeography Palaeoclimatology Palaeoecology*, 9: 27-57.

Wolfe, J. A. 1978. A paleobotanical interpretation of Tertiary climates in the Northern Hemisphere. *American Scientist*, 66: 694-703.

Wolfe, J. A. 1992. Climatic, floristic, and vegetational changes near the Eocene/Oligocene boundary in North America. In *Eocene-Oligocene biotic and climatic evolution*, D. R. Prothero and W. A. Berggren eds. Princeton Uni. Press, Princeton, N.J., pp. 421-436.

Woronow, A. 1991. Enigmas and solutions in the analysis of compositional data. *Journal of Geological Education*, 39: 299-302.

'My *name* is Alice, but...'
'Its a stupid name enough!' Humpty Dumpty interrupted impatiently. 'What does it mean?'
'*Must* a name mean something?' Alice asked doubtfully.
'Of course it must,' Humpty Dumpty said with a short laugh: 'my name means the shape I am - and a good handsome shape it is, too. With a name like yours, you might be any shape almost.'
Lewis Carroll *Through The Looking Glass*

APPENDIX A: SYSTEMATIC INDEX

All the species recognized are grouped into initially families and then genera in alphabetical order, according to Loeblich and Tappan (1988). Important references are cited where possible.

Synonyms are usually restricted to primary and corrective studies only. All photographed specimens are deposited in the Department of Geology and Geophysics at the The University of Adelaide.

1. Species in ***bold*** accompanied by synonyms *italix*.
2. The number in brackets is a taxon code (T.C.) used in this study.

Family ACERVULINIDAE Schultze, 1854

Genus GYPSINA Carter, 1877

Gypsina howchini Chapman, (496)

Gypsina sp. Howchin, 1892. in Hall & Pritchard (eds.), *Proc. Roy. Soc. Vic.*, (N.S.), 4(1):10

Gypsina howchini Chapman, 1910. *Proc. Roy. Soc. Vic.*, 22(2):291, 292, pl.2, figs. 4a,b, pl.3, figs.3-5

Family ALABAMINIDAE Hofker, 1951

Genus ALABAMINA Toulmin, 1941

Alabamina tenuimarginata (Chapman, Parr & Collins), (63) Plate 13: Figures a, b, c.

Hornibrook, 1961. *Smithsonian Contributions to Paleobiology*, 36:163, pl.17, figs.365, 366.

The compressed biconvex trochospiral test test with an acute margin differentiates this species from the typical Eocene form *A. westraliensis* (Parr). Widely distributed in small numbers in all basins throughout the Oligocene.

Genus SVRATKINA Pokorny, 1956

Svratkina australiensis (Chapman, Parr and Collins), (270) Plate 16: Figures t, u.

Discorbis tuberculata (Balkiwill and Wright); Heron-Allen and Earland, 1924. *J. Roy. micro. Soc.* , 169.

Discorbis tuberculata (Balkiwill and Wright) var. *australiensis* Chapman, Parr and Collins, 1934. *J. Linn. Soc.* , 38(262):563, pl.8, figs.9a-c.

Svratkina australiensis (Chapman, Parr and Collins); Pokorny, 1956.*Univ. Carolina Geologica*, 2(3): 257, figs.1-3.

Alabamina australiensis (Chapman, Parr and Collins); Carter, 1964. *Mem. geol. Surv. Vict.*, 23:115, pl.11, figs.217-219.

Svratkina australiensis (Chapman, Parr and Collins); Loeblich and Tappan, 1964. *Treat. Invert. Palaeont.*, C2(2):C750, fig.614, 8a-c.

Loeblich and Tappan, 1988. Foraminiferal genera and their classification. Van Nostrand Reinhold, New York, p.628, pl.706, figs.1-3.

Widely distributed but not abundant. Small trochospiral biconvex test covered with pores opening at the center of tubercles over the entire surface but more numerous on the dorsal side.

Svratkina perlata (Andreae), (385)
Pulvinulina perlata Andreae, 1884. *Abh. geol. SpezKarte Els.-Loth.*, 2:216, pl. 8, fig. 12.
Alabamina perlata Batjes, 1958. *Mem. Inst. Roy. Sci. nat. Belg.*, 143:157, pl. 8, figs.8,9.
Svratkina perlata Stuart, 1970. *Trans. Roy. Soc. S.Aust.*, 94:172, 173.

Svratkina sp., (386) Plate 16: Figures r, s.
Large test; four angular chambers in the final whorl; ventral surface has an increased number of tubercles than seen on specimens of *S. australiensis*.

Family AMPHISTEGINIDAE Cushman, 1927
Genus AMPHISTEGINA d'Orbigny, 1826
Amphistegina lessoni d'Orbigny, (42) Plate 4: Figure t.
d'Orbigny, 1826. *Annals. Sci. Nat.*, Ser.1, 7:304, modèles no.98.
Loeblich and Tappan, 1988. Foraminiferal genera and their classification. Van Nostrand Reinhold , New York, pl.677, fig. 2.
Most specimens of *A. lessoni* examined were poorly preserved, however the multiple chambers in the final whorl and the short aperture generally discernible.

Family AUSTROTRILLINIDAE Loeblich and Tappan, 1986
Genus AUSTROTRILLINA Parr, 1942
Austrotrillina howchini (Schlumberger), (4) Plate 4: Figure p.
Trillina howchini Schlumberger, 1893. *Bull. de la Société Géologique de France*, sér.3, 21:119,123.
Austrotrillina howchini (Schlumberger), Parr, 1942. *Min. & Geol. Jnl.*, 2:361.
Extremely rare in the late Oligocene. The elongate quinqueloculine test and the coarsley alveolar inner layer form distinctive characters. Figured specimen from 142m (W142) at Dunstan Rd. bore at Waikerie.

Family BOLIVINIDAE Glaessner, 1937
Genus BOLIVINA d'Orbigny, 1839
Bolivina decussata Brady, (611) Plate 10: Figure x.
Brady, 1881. *Qtly. Jnl. Microsp. Sci.*, 21:58

Bolivina elongata Hantken, (310)
Hantken, 1875. *K. Ungar. Geol. Anst., Mitt. Jahrb.*, Budapest, Ungarn Bd. 4, Heft 1, p. 65.

Bolivina gardnerae Cushman, (311)
Cushman, 1926. *Contr. Cushman Found. Foram. Res.*, 2(2) no. 27:31 Pl.4 fig. 7.

Bolivina finlayi Hornibrook, (16)
Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):75, pl. 9 fig.169-171.

Bolivina intermedia Halkyard, (312)
Halkyard, 1918. *Lit. Phil. Soc. Mem. Proc.*, 62(2) no.6:52 Pl. 3, fig. 10.

Bolivina jacksonensis Cushman and Applin, (10) Plate 10: Figure i.
Cushman and Applin, 1926. *Am. Assoc. Pet. Geol. Bull.*, 10(1) no.2:167 Pl.7 , fig. 3-4.

Bolivina lapsus Finlay (19) Plate 10: Figure l.
Finlay, 1939. *Trans. Roy. Soc. N.Z.*, 69(1):98, pl.11, fig. 9.

Bolivina maculata Cushman and Stone, (480)
Cushman and Stone, 1947, *Cushman Lab. Foram. Res., Spec.Pub.* No. 20, p. 17. Pl. 2, figs. 21, 22.

Bolivina pontis Finlay, (210) Plate 10: Figure j.
Bolivina pontis Finlay, 1939. *Trans. Roy. Soc. N.Z.*, 69(3):320
Bolivina pontis Finlay & Marwick, 1940. *Trans. roy. Soc. N.Z.*, 70(1):111.
Bolivina pontis Finlay, 1946. *Trans. roy. Soc. N.Z.*, 76(2):240,241,243 (list), 244.
Bolivina pontis Finlay & Marwick, 1947. *N.Z. J. Sci. Tech.*, B28(4):232.

Bolivina pseudoplicata Heron-Allen and Earland, (17) Plate 10: Figure p.
Heron-Allen and Earland, 1930. *Roy. Micr. Soc. Journ.*, ser.3 Vol.50:81 pl. 3 , fig. 36-40.
Common late Oligocene-Miocene species but never abundant.

Bolivina reticulata Hantken (185) Plate 10: Figure q.
Hantken, 1875. *Mitteilungen Jb. K. ungarische geologische Astalt.*, 4:65, pl. 5 fig. 6a.

Bolivina targetensis Hornibrook, (13)
Hornibrook, 1961. *N.Z. Geol. Surv. Pal. Bull.*, 34(1):74, pl. 10, fig. 182, 183

Genus BRIZALINA O.G.Costa, 1856
Brizalina spathulata (Williamson), (201)
Textularia variabilis var. *spathulata* Williamson, 1858. On the Recent foraminifera of Great Britian. London: Ray Soc.
Brizalina spathulata (Williamson), Hedley et al., 1965. *N.Z. Dep. Sci. Ind. Res. Bull.*, 163: 1-47, pl.1-7.

Genus LATIBOLIVINA Srinivasan, 1966
Latibolivina byramensis (Cushman), (45) Plate 10: Figure k.
Bolivina caelata Cushman var. *byramensis* Cushman, 1923. *U.S. Geol. Surv.*, Prof. Pap., No.133, p.19.
Latibolivina byramensis (Cushman), Srinivisan, 1966. *Roy. Soc. New Zealand, Trans.*, 3(17):240, 241.

Family BOLIVINELLIDAE Hayward, 1980
Genus BOLIVINELLINA Cushman, 1927
Bolivinella australis Cushman, (568)
Cushman, 1929. *Contr. Cushman Lab. Foram. Res.*, 5(2):28-34.
Quilty, 1974. *Papers and Proceedings of the Royal Society of Tasmania*, 108:31-106.

Bolivinella elegans (Parker&Jones), (107) Plate 10: Figure m.
Textularia elegans (Parker & Jones), Brady, 1884.*Rep. Voy. Challenger, Zool.*, 9:357,pl.42,fig.3,3b, 4,5
Bolivinella elegans Parr, 1932. *Proc. roy. Soc. Vict.* , 44:223, 24.

Bolivinella folia (Parker & Jones), (176)
Plate 10: Figure r.
Textularia folium Parker & Jones, 1865. *Phil. Trans.*, 155:370, 420, pl. 18, fig. 19.
Bolivinella folium (Parker & Jones), Parr, 1932. *Proc. Roy. Soc. Vict.*, (N.S.), 44(1):223, pl.21, fig. 23
Bolivinella folia (Parker & Jones), Albani, 1978. *Aust. J. Mar. Freshwater Res.*, 29:377.

Family BULIMINIDAE Jones, 1875
Genus BULIMINA d'Orbigny, 1826
Bulimina bortonica Finlay, (6)
Finlay, 1940. *Trans. Roy. Soc. N.Z.*, 69(1):100, pl.64, fig.25, 26.

Bulimina pupula Stache, (170)
Stache, 1864. *Novara-Expedition, Geol.*, 1(2):265, pl.24, fig.13.

Family BULIMINELLIDAE Hofker, 1951
Genus BULIMINELLA Cushman, 1911
Buliminella browni Finlay, (282) Plate 10: Figure v.
1939. *Trans. Roy. Soc. N.Z.*, 69(3):321, pl.27, fig.85,86

Buliminella seminuda (Terquem), (414)
Plate 10: Figure z.
Bulimina semi-nuda Terquem, 1882. *Soc. Géol. France, mem.*, Sér 3, 3(3):117, pl. 12, fig. 21.
Buliminella seminuda (Terquem), Boltovskoy et al., 1980. Atlas of Benthic Foraminifera of S.W. Atlantic. p. 21-22, pl. 6, fig. 11-15.

Family CANDEINIDAE Banner, 1982
Genus TENUITELLA Fleisher, 1974
Tenuitella aculeata Jenkins, (132) Plate 1: Figure e.
Jenkins, 1966. *N.Z. J. Geol. Geophys.*, 8(6):1118 fig.13 no.119-125
Very small spinose and perforate test.

Tenuitella gemma (Jenkins), (130) Plate 1: Figure l.
Jenkins, 1966, *N.Z. J. Geol. Geophys.*, 8(6):1115 fig.11 no. 97-103.
Intergrades with *T. munda* (Jenkins) but smaller and with more chambers in the final whorl, greater than four and usually six.

Genus PRAETENUITELLA Li, Radford and Banner, 1992
Praetenuitella insolita (Jenkins), (129)
Plate 1: Figure i.
Globorotalia insolita Jenkins, 1966. *N.Z. J. Geol. Geophys.*, 8(6):1120 fig.13 no.113-118.
Praetenuitella insolita (Jenkins), Li, Radford&Banner, 1992. In *Proc. ODP, Sci. Results*, Wise, Schlich et al. eds., 120(2):569-594, pl. 1, figs. 1-3.

Tenuitella munda (Jenkins), (131) Plate 1: Figure k.
Jenkins, 1966. *N.Z. Journ. Geol. Geophys.*, 8:1121; fig. 14, nos.126 133; fig. 15, nos.152-166.
According to Jenkins (1966) this species intergrades with *T. juvenilis*. It is larger than *T. gemma* but has fewer whorls. Common in Oligocene sequences.

Genus GLOBOQUADRINA Finlay, 1947

Globoquadrina dehiscens (Chapman, Parr and Collins), (127)
Globorotalia dehiscens Chapman, Parr & Collins, 1934. *Jl. Linn. Soc. (zool.)* **38**:569, pl.11, fig.36a-c.
Globoquadrina dehiscens Finlay, 1947. *N.Z. Jl. Sci. techn.* B28(5): 290.
Diagnosed by flattened inner surfaces of the final wall and incised sutures. There is often some difficulty differentiating from *Gq. praedehiscens* Blow but the latter form is usually distinguished by the more inflated chambers. The first appearance of *Gq. dehiscens* s.s. is a preferred datum to identify the N4a/b (M1 a/b) boundary in the earliest Miocene (Berggren et al., 1994 in press).

Globoquadrina dehiscens praedehiscens'Banner & Blow, (478) Plate 2: Figures h, i.
Banner & Blow, 1962. In Eames et al., *Fundamentals of Mid-Tertiary Stratigraphical Correlation*, p. 116, pl. 15, figs. Q-S.

Family CASSIGERINELLIDAE Bolli, Loeblich and Tappan, 1957
Genus CASSIGERINELLA Pokorný, 1955
Cassigerinella Chipolensis (Cushman and Ponton), (111)
Cushman and Ponton, 1932. *Bull. Fla. St. Geol. Surv.*, No.9:98 Pl.15, figs.2a-c (Fide Ellis&Messina, 1940 et seq)

Cassigerinella winniana (Howe), (113) Plate 1: Figures a, b.
Cassidulina winniana Howe, 1939. *Geol. Bull. La.*, 14:82, pl.11, figs.7-8.
Cassigerinella winniana Blow, 1979. The Cainozoic Globigerinida. E.J. Brill, Leiden. pp.828, 1363-4, pl.51, figs.6-8; pl.246, figs.8-10.
Distinguished from *C. chipolensis* by the planispiral arrangement of chambers in the early part of the final whorl. The figured specimen from the base (?Interval E) of MBT 5 in the Murray Basin is close to the top of its local range.

Family CATAPSYDRACIDAE Bolli, Loeblich, and Tappan 1957
Genus CATAPSYDRAX Bolli, Loeblich, and Tappan 1957
Catapsydrax dissimilis (Cushman and Bermudez), (236) Plate 2: Figure g.
Globigerina dissimilis Cushman & Bermudez, 1937*Contr. Cushman Lab. Lab.* 13(1):25, pl.3, figs. 4-6.
Catapsydrax dissimilis Jenkins 1964. *Nature*, 203(4941):181, fig.1(list).
Four chambers in the final whorl and a single umbilical bulla with numerous openings. Characteristic of more oceanic deposits (Hornibrook et al., 1989). Rare specimens have been recovered from MG6 at Danger Point and OB2 at Robe in the Gambier Basin.

Family CHILOGUEMBELINA Reiss 1963
Genus CHILOGUEMBELINA Loeblich and Tappan 1956
Chiloguembelina cubensis (Palmer), (114) Plate 1: Figure p.
Palmer, 1934. *Mem. Soc. Cub. Hist. Nat. "Felipe Poey"*, 8:73-76 fig.1
Populations of *Chiloguembelina* exhibit wide variation in morphologies. Very fine

longitudinal costae interdispersed with fine pores are often visible using S.E.M. In this study *Chiloguembelina ototara* (Finlay) characteristically delineated by the finely hispid test surface is regarded as a morphological variation or possible ancestor of *Ch. cubensis.*

Chiloguembelina ototara (Finlay), (114)
Plate 1: Figure o.
Guembelina ototora 1940, *Trans. Roy. Soc. N.Z.*, 49(4):453, pl.63, fig.50-62.
Chiloguembelina ototora Hornibrook, 1985. *N.Z. Geol. Surv. Record*, 9:67-69.
Hornibrook (1990) suggested that the non-costate morphotype ranges from the upper middle Eocene to the lower Oligocene and that *Chiloguembelina cubensis* s.s. continues into the lower Miocene in New Zealand. The last appearance of *Ch. cubensis* is consistently registered as the middle Oligocene in southern Australia and this coincides with observations from the majority of deep-sea sections. With the possible caveat of the New Zealand region the last appearance of *Ch. cubensis* is considered to be a reliable Zone P21a/21b datum.

Family CIBICIDIDAE Cushman, 1927
Genus CIBICIDES de Montfort, 1808
Cibicides cygnorum Carter, (206)
Carter, 1964. *Geological Survey of Victoria Memoir*, no.23, p.98, pl.7, figs.139-144.
Rare in the latest Oligocene. Carter (1964) suggests that *C. cygnorum* intergrades with *C. thiara* (Stache) in the upper part of the latter species' range the distinction is made as early as the late Oligocene.

Cibicides karreriformis Hornibrook, (249)
Plate 12: Figures u, v.
Hornibrook, 1961. *N.Z. geol. Surv. paleont. Bull.* 34(1):164, pl.26, fig.512-514
This key Oligocene species is common in the Janjukian Stage in the Otway Basin from Interval E onwards. Distinguished by a large, densely perforated flattened test. Hornibrook (1989) records the species mainly in the Whaingaroan Stage in New Zealand. The figured specimens are appear to be a transitional form to *C. karreriformis sensu stricto.*

Cibicides lobatulus (Walker and Jacob), (73) Plate 12: Figures r, s.
Nautilus lobatulus Walker & Jacob, 1798. In Adam's Essays on the Microscope, Kanmacher, F. ed., London, Dillon & Keating, p. 642, pl. 14, fig. 36.
Cibicides lobatulus (Walker & Jacob), Barker, 1960. pl. 92, fig. 10; pl. 93, fig. 1.
Cibicides mediocris Finlay, (78) Plate 12: Figure t.
Cibicides mediocris Finlay, 1940. *Trans. Roy. Soc. N.Z.*, 69(4):464, Pl.67, figs.198.199
Cibicides mediocris Finlay & Marwick, 1940. *Trans. roy. Soc. N.Z.*, 70(1):115,122.

Cibicides molestus Hornibrook, (162)
Hornibrook, 1961. *N.Z. Geol. Surv. Pal. Bull.*, 34(1):163 Pl.24 figs.478,479,483
Hayward & Buzas (1979) regard this species as morphologically indistinct from *C.perforatus* in New Zealand. Both species have coarsley perforate test walls but *C.perforatus* has a clearly distinct final whorl.

Cibicides perforatus (Karrer), (70) Plate 12: Figures n, o.
Rotalia perforatus Karrer, 1864. *Novara Exped., Geol. Theil.*, 1(2):81 Pl.16 fig.13
Cibicides perforatus (Karrer), Finlay&Marwick, 1940. *Trans.Roy.Soc.N.Z.*, 70(1):111-119
Cibicidoides perforatus (Karrer), Hayward&Buzas, 1979. *Smithsonian Contributions to Paleobiology*, 36:49.

Cibicides pseudolobatulus Perelis&Reiss, (72) Plate 12: Figure c, d, e.
Perelis&Reiss, *Israel Journ. Earth Sci.*, 24(3/4):77-78 Pl.4 figs. 1-7.

Cibicides praecipuus Copeland, (74)
Copeland, 1964, *Bull. Amer. Pal.*, 47(215):77-78 Pl.14 figs. 1-7

Cibicides refulgens de Montfort, (278)
Cibicides refulgens de Montfort, 1808. *Conchyliogie systematique et classification méthodique des coquilles.*, 123:122.

Cibicides thiara (Stache), (25)
Rosalina thiara Stache, 1864. *Novara-Exped. geol.*, 1(2):279, pl.24, fig.29a-c.
Cibicides thiara (Stache), Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):159, pl.25, fig.495,497.

Cibicides vortex Dorreen, (77)
Dorreen, 1948. *Jnl. Paleont.*, 23(3):299, pl. 41, fig. 5.

Genus CIBICIDOIDES Saidova, 1975

Cibicidoides brevoralis (Carter), (69) Plate 12: Figures i, j.
Cibicides brevoralis Carter, 1958. *Geol. Surv. Vict. Bull.*, 55:47-46 Pl. 6 figs. 54-56.
Cibicidoides brevoralis (Carter), Hayward&Buzas, 1979. *Smithsonian Contributions to Paleobiology*, 36:49.

Cibicidoides temperatus (Vella), (527) Plate 12: Figures f, g, h.
Cibicides temperata Vella, 1957. *N.Z.Geol.Surv. Pal.Bull.*, 28:40, pl.9, figs.201-203.
Cibicidoides temperatus (Vella), Hayward&Buzas, 1979. *Smithsonian Contributions to Paleobiology*, 36:49, pl.11, figs.135-137.

Cibicidoides sp. 1, (322) Plate 12: Figure p, q.
Biconvex test coarsely perforate on dorsal side. Sutures obscure. Appears similar to*Cibicidoides* sp. 15 Morkoven et al. (1983), a bathyal from the East and West Pacific occuring from middle Miocene.

Family CORNUSPIRIDAE Schultze, 1854
Genus CORNUSPIRA Schultze, 1954
Cornuspira involvens (Reuss), (659)
Operculina involvens Reuss, 1850. *K. Acad. Wiss. Wien, Math-Naturw. Cl.*, Denkschr., Wien, Österreich, Bd.1, p.370.

Genus DYOCIBICIDES Cushman and Valentine, 1930
Dyocibicides biserialis Cushman and Valentine, (80) Plate 12: Figure w.

1930. *Contrib. Dept. geol. Stanford Uni.*, 1(1):5-51.

Genus HETEROLEPA Franzenau, 1884
Heterolepa subhaidingeri Parr, (179)
Plate 12: Figures f, g, h.
Cibicides subhaidingeri Parr, 1950. *B.A.N.Z.A.R.E. Rep.*, Ser. B, 5(6):364, pl. 15, figs. 7a-c.
Heterolepa subhaidingeri (Parr), Leoblich & Tappan, 1962. *Contrib. Cush. Found. Foram. Res.*, p.57.

Family EGGERELLIDAE Cushman, 1937
Genus ARENODOSARIA Finlay, 1939
Arenodosaria antipoda (Stache), (254)
Plate 3: Figure j.
Clavulina antipodum Stache, 1864. *Novara-Exped. geol.* 1(2):161, pl. 21, figs. 3-8.
Arenodosaria antipoda (Stache), Hornibrook, 1971. *New Zealand Geological Survey palaeontological bulletin* 43:32, pl. 5, figs. 77,78.

Genus DOROTHIA Plummer, 1931
Dorothia minima (Karrer), (152) Plate 3: Figure a.
Finlay and Marwick, 1940, *Trans. Roy. Soc. N.Z.*, 70(1):113, 121.
Textilaria minima Karrer, 1864. *Novara-Expedit. geol.* 1(2):79, pl.16, fig. 9.
Dorithia minima Hornibrook, 1971. *N.Z Geol. Surv. paleont. Bull.*, 43:16, pl. 1, fig. 16-20.

Dorothia parri Cushman, (230) Plate 3: Figure b.
Dorothia parri Cushman, 1936. *Spec. Publs. Cushman Lab.*, 6:29,30., pl. 4, figs. 19a,b.
Distinguished from *D.minima* by possessing a larger and more elongate test. Both populations are often contemporaneous.

Family ELLIPSOLAGENIDAE A. Silvestri, 1923
Genus CUSHMANINA Jones, 1984
Cushmanina desmophora (Rymer-Jones) var., (301)
Lagena vulgaris Williamson var. *desmophora* F.W. Rymer-Jones, 1874. *Linn. Soc., Lond., Trans.*, p. 54, pl. 19, figs. 23-24.
Cushmanina desmophora (Rymer-Jones), Jones, 1984. *Rev. Espan. De Micropaleont.*, 16:105, pl. 2, figs. 10-12.

Cushmanina plumigera (Brady), (530)
Plate 7: Figures t, u.
Lagena plumigera Brady, 1884. *Rep. Voy. Challenger, Zool.*, 9:465, pl. 58, figs. 25-27.
C. plumigera is morphologically similar to *Lagena luciae* Parr (Plate 7: Figure k) but the latter appears to possess fewer costae and is considered here to be a synonym. Abele (1961) recorded rare specimens with up to 12 costae from the Gambier Limestone.

Cushmanina tasmaniae (Quilty), (33)
Plate 7: Figure v.
Lagena tasmaniae Quilty, 1974. *Roy. Soc. Tas., papers & proc.*, 108:70, pl.3, fig.107.
Cushmanina tasmaniae (Quilty); Patterson & Richardson,1987. *Jnl. Foram. Res.*,17:217, pl.1, fig. 1.
Test covered with raised perforated and spirally arranged costae. Perforations obscure in the

specimen figured but clearly visible with increased magnification.

Genus FAVULINA Patterson & Richardson, 1987

Favulina squamosa (Montagu), (648) Plate 7: Figure c.

Vermiculum squamosum Montagu, 1803. *Testaceas Britannica*, p. 526, pl. 14, fig. 2.

Entosolena squamosa (Montagu) var *hexagona* Williamson, 1848. *Ann. Mag. Nat. History*, Ser.2, 1:20, pl. 2, fig. 23.

Genus FISSURINA Reuss, 1850

Fissurina alveolata Brady var., (628) Plate 9: Figure n.

Brady, 1884. *Rept. Challenger Exped.*, London, Zool., pt. 22, 9:487, pl. 60, figs. 30, 32.

Fissurina annectens (Burrows & Holland), (177) Plate 9: Figure m.

Lagena annectens Burrows & Holland, *Mongr. Crag. Foram.*, pt. 2, p.103.

Fissurina annectens (Burrows & Holland), Jones, 1895. *Pt. II Palaeontogr. Soc.*, London, England, p.203.

Fissurina aperta Sequenza, (14) Plate 9: Figures a, b.

Sequenza, 1862, *Messina, Italia, T. capra*: 60 Pl. 1 fig. 60.

Fissurina crassianulata Collins, (11) Plate 9: Figure p.

Collins, 1974, *Vic. Nat. Mus. Mem.* No.35:28 Pl. 2 fig. 17 a-b.

Fissurina furcata Collins var., (38) Plate 9: Figure w.

Collins, 1973. *Mem. Nat. Mus. Vic. Melbourne*, 15:1-61.

Collins, 1974. *Vic. Nat. Mus. Mem.* No.35:28 Pl. 2 fig. 18 a-b.

Fissurina cf. globosocaudata Albani & Yassini , (639) Plate 9: Figure r.

Albani & Yassini, 1989. *Aust. Jnl. of Marine and Freshwater Res.*, 40:369-401, fig. 6c,d.

Fissurina kerguelenensis Parr, (205)

Parr, 1950. *B.A.N.Z.R.E., 1926-1931*, Ser. B, 5(6):305.

Fissurina marginata (Walker and Boys), (149) Plate 9: Figure q.

Serpula (Lagena) marginata Walker and Boys, 1784, *Testacea Minuta Rariora, Nuperrime detecta in Arena Littoris Sanvicencus*. 25pp. London: J.March.

Fissurina marginata (Walker and Boys), Albani, *Australian Jnl. of Marine and Freshwater Res.*, 29:1978. 379, fig. 8C.

Figure f is considered to be a variation of *F.marginata* with a distinctive broad rim around aperture.

Fissurina orbignyana Seguenza, (418)

Fissurina orbignyana Seguenza, 1862. *Dei terreni Terziarii del distretto di Messina*, p. 66, pl. 2, figs. 25, 26.

Morphotypically variable. Test compressed, central part of test appears circular, smooth wall, entosolenian aperture. F. orbignyana var. (pl. 9, fig. m) has a an extended apertural end, thick costae parallel to lateral margin, may be synonymous with *F. quadricostulata* (Reuss).

Fissurina orbignyana (Seguenza) var. ***bicarinata*** Terquem, (196)
Fissurina orbignyana Seguenza, 1862. *Dei terreni Terziarii del distretto di Messina*, p. 66, pl. 2, figs. 25, 26.
Fissurina orbiganyana (Seguenza) var. *bicarinata* Terquem, 1878. *Soc. Geol. France Mem.*, ser.3 tome 2(3):31 Pl.1 fig. 24a-b.

Fissurina orbignyana (Seguenza) var. ***Flintii*** Cushman, (418) Plate 9: Figure l.
Cushman, 1922. *U.S. Geol. Surv., Prof. Pap.*, Washington, D.C.,no.129F, p. 129, pl. 29, fig. 11.

Fissurina paralucida Jones, (502) Plate 9: Figure u.
Jones, 1984. *Revista Española De Micropaleontología*, 16:114, pl.3, figs. 21-22.
The test is compressed and has a rounded periphery. The wall is smooth. Similar to *F. lucida* (Williamson) but has a shorter test and a longer entosolenian tube. Common in the late Oligocene in the Gambier Basin.

Fissurina quadrata (Williamson), (195) Plate 9: Figure h.
Entosolenia marginata (Montagu) var. *quadrata* Williamson, 1858. *On Recent Foraminifera of Great Britian*. London, Ray Soc., p.11, pl.1, figs. 27, 28.
Lagena quadrata (Williamson) var. Millet, 1901. *Jnl. Roy. Micro. Soc.*, 1901: 496, pl.8, fig.18.

Fissurina semimarginata (Reuss), (208)
Lagena semimarginata (Walker&Boys) var *semimarginata* Reuss, 1870. *K. Acad. Wiss. Wien, Math.-Naturw. Cl.*, Sitzber., Wien, Bd. 62, Abt. 1, p. 468.
Fissurina semimarginata (Reuss), Loeblich&Tappan, 1953. *Smith. Misc. Coll.*, 121(7):78.

Fissurina seguenziana (Fornasini), (536)
Lagena sequenziana Fornasini, 1886. *Boll. Soc. Geol. Ital.*, 5:350.

Fissurina submarginata (Boomgart), (191)
Entosolenia submarginata Boomgart, 1949. Smaller foraminifera from Bodjonegoro (Java). Utrecht Univ., Ph.D. thesis, p.149.
Fissurina submarginata (Boomgart), Barker, 1960. *Soc. Econ. Paleont. Min., Spec. Pub. No. 9*, p.124, pl. 59, figs. 21, 22.

Genus GALWAYELLA
Patterson&Richardson, 1987
Galwayella trigonornata Albani&Yassini, (646)
Albani&Yassini, 1989. *Aust. Jnl. of Mar. and Freshwtr. Res.*, 40:390, fig. 4L.

Genus HETEROMORPHINA Jones, 1984
Heteromorphina calomorpha (Reuss), (237)
Nodosaria calomorpha Reuss, 1866. *K. Akad. Wiss.Wein, Math.-Naturw. Cl., Wein Osterreich*, 25(Abt.1):129, pl. 1, fig. 15.
Heteromorphina calomorpha (Reuss), Jones, 1984. *Revista Espan. De Micropal.*, 16:99, pl. 1, fig. 3.

Regarded by Loeblich and Tappan (1988) as a juvenile of *Dentalina* this species is placed here into genus *Heteromorphina.*

Genus HOMALOHEDRA Patterson and Richardson, 1987

Homalohedra acuticostata (Reuss), (35) Plate 7: Figure q.
Lagena acuticostata Reuss, 1862. *Akad. Wiss. Berlin, Math. Naturwiss., Kl., Abh.*, 46(1):305, pl. 1, fig. 4.

Genus LAGENOSOLENIA McCulloch, 1977

Lagenosolenia largicostata Albani & Yassini, (632)
Albani & Yassini, 1989. *Aust. Jnl. of Mar. and Freshwtr. Res.*, 40:395, fig. 5B.

Lagenosolenia sp. 1, (586) Plate 9: Figure g.
Test ovate, compressed with narrow marginal keel; wall surface smooth, imperforate; aperture on the end of a slender neck.

Lagenosolenia sp. 2, (587) Plate 9: Figure w.
Flanged and rounded main body chamber, aperture with rim on end of a long neck.

Genus LAGNEA Popescu, 1983

Lagnea foliformis (Buchner), (585)
Lagena foliformis Buchner, 1940. *Nova Acta Leopoldina*, 9(62):454, pl. 8, figs. 128-32
Solenina foliformis (Buchner), Jones, 1984. *Revista Española*, 16:122, pl. 5, figs. 6-8

Genus OÖLINA d'Orbigny 1839

Oolina cf. ***apiopleura*** Loeblich and Tappan, (638)
Loeblich&Tappan, 1953. *Smithsonian Misc. Coll.*, 121(7):59, pl. 10, figs. 14-15.

Oolina collaripolygonata Albani & Yassini (631) Plate 7: Figure q.
Albani & Yassini, 1989. *Aust. Jnl. of Mar. and Freshwtr. Res.*, 40:386, fig.3T,U.

Oolina confluenta McCulloch, (631) Plate 7: Figure p.
McCulloch, 1977. Qualitative observations on Recent foraminiferal tests with emphasis on the eastern Pacific. Univ. S. Calif., Los Angeles, 3pts:77, pl.54, fig.1.
Typically possess very thick reticulate costae as in figured specimen.

Oolina globosa (Montagu), (52)
Vermiculum globosa Montagu, 1803. *Testacea Britannica,* 606 pp., Ramsay, England, J.S. Hollis.
Oolina globosa (Montagu), Barker, 1960. *Society of Economic Paleontologists and Mineralogists , Tulsa.* Spec. Pub. no.9., pl.56, figs.1-3.

Oolina hexagona (Williamson), (31) Plate 7: Figure a.
Entosolenia squamosa (Montagu) var. *hexagona* Williamson, 1848, *Ann. Mag. Nat. Hist.*, ser.2(1):20 Pl.2 fig.23
Oolina hexagona (Williamson); Albani, 1978. *Aust. Jnl. Mar. & Freshwtr. Res.*, 79:79, fig. 7N.

Oolina melo d'Orbigny, (285) Plate 7: Figure b.
Oolina melo d'Orbigny, 1839. *Voyage dans l'Amérique Méridionale; Foraminiféres,* 5(5):1-86.

Genus PALLIOLATELLA Patterson & Richardson, 1987
Palliolatella radiata (Rhumbler), (610)
Lagena radiata Rhumbler, 1922. *Plankton-Exped. Humboldt-Siftung, Ergeb.*, Bd. 3, L.c., Teil 1, pl. 22, figs. 16-17.
Lagena radiata Rhumbler, 1949. *Micropaleontlogist* (Amer. Mus. Nat. Hist.), 3(2): expl. pl. 22.
Test small, compressed; distinctive costae radiating from central part of test within carina. Appears very similar and may be synonomous the Oligocene species *Lagena distincta* var. *arborea* Matthes.

Palliolatella radiata (Rhumbler) var., (656) Plate 9: Figure i.
Test larger than *P. radiata* and more elongate; multiple radiating costae. Very similar to fig. 17 (Rumbler, 1922) with a distinctive notch in the carina at the base of the test.

Palliolatella bradyiformis (McCulloch), (640) Plate 9: Figure c.
Fissurina bradyiformis McCulloch, 1977. 54, pl. 61, fig. 14.
Palliolatella bradyiformis (McCulloch), Albani & Yassini, 1989. *Aust. Jnl. Mar. & Freshwtr. Res.*, 40:394, figs. 5D, E.

Palliolatella laevis (Montagu), (199) Plate 7: Figure f.
Vermiculum laevis Montagu, 1803. Testacea Britannica, or a natural history of British Shells, marine, land and fresh-water, including the most minute. Romsey, England, p. 524.

Palliolatella cf. ***L. pulcherrima*** Cushman and Jarvis, (551) Plate 9: Figure k.
Cushman and Jarvis, 1929. *Contrib. Cushman Lab. Foram. Res.*, Sharon, Mass., USA, v.5 pt.1 (72):8, pl. 2, fig. 10.
Large test, central area regularly pitted, peripheral area covered with elongate slits radiating outwards; aperture slightly elongate.

Genus PARAFISSURINA Parr, 1947
Parafissurina carinata (Buchner), (581) Plate 9: Figure t.
Lagena lateralis Cushman forma carinata Buchner, 1940. *Nova Acta Leopoldina,* 9(62):521, pl. 23, figs. 497-500.
Parafissurina subcarinata Parr, 1950. *B.A.N.Z.A.R.E.*, 1929-1931, rept. ser. B, 5(6):318, pl. 10, fig. 9.

Parafissurina costulata Jones, (650)
Jones, 1984. *Rev. Espan. De Micropaleont.*, 16:128, pl. 6, fig. 15.

Genus PSEUDOFISSURINA R.W. Jones, 1984
Pseudofissurina mucculloch ae Jones, (516) Plate 9: Figure v.
Jones, 1984. *Rev. Españ. De Micropal.*, 16:119, pl. 4, figs. 16-18.

Family ELPHIDIIDAE Galloway, 1933
Genus ELPHIDIELLA Cushman, 1936
Elphidiella sp., (453) Plate 15: Figures d, e.

Large, planispiral test with ten chambers, single row of openings along sutures, periphery rounded. Smooth surface. Multiple interiomarginal foramina. Very rare, specimen from OB2, Otway Basin.

Genus ELPHIDIUM de Montfort, 1808

Elphidium chapmani Cushman, (607)
Cushman, 1936. *Contr. Cushman Lab. Foram. Res.*, 12:80, pl.14, figs. a, b.

Elphidium crispum (Linné), (214)
Nautilus crispus Linne, 1758. *Systema Naturae*, 10th ed. vol.1 Holmiae, (Stockholm): L.Salvii, p.709.
Themeon rigatus Montfort, 1808. *Conchyl. System. et Classificat. Méthod. des Coquilles*, Vol.1, Paris: F.Schoell, p.203.
Polystomella crispus (Linné), Lamarck, 1822. *Hist. natur. des animaux sans vertèbres*, V.7, Paris: L'auteur, p.625.
Elphidium crispum (Linné), Cushman, 1933. *Spec. Publ. Cush. Lab. Foram. Res*, 4:47, pl.41, fig.4.

Elphidium crassatum Cushman, (601)
Cushman, 1936. *Contr. Cush. Lab. Foram. Res.*, 12(4):81, 82, pl. 14, figs. 8a,b.
Figured specimen (Plate 15: Figures q,r) is interpreted to be variation of *E. crassatum* Cushman, showing acute margin on an unusually inflated test. Sutures are raised and recurved.

Elphidium pseudonodosum Cushman, (202) Plate 15: Figure a.
Cushman, 1936. *Contr. Cushman Lab. Foram. Res.*, 12(4):82.

Elphidium subrotatum Hornibrook, (454)
Plate 15: Figure b.
Polystomella sibirica Goës, Chapman, 1926.*N.Z. Geol. Bull.* 11:89, pl.17, fig. 14 (not of Goës).
Elphidium subrotatum Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):129, pl.18, figs. 384,385.

Elphidium sp.1 (453)
Elphidium sp. 2 (342)

Subfamily NOTOROTALIINAE Hornibrook, 1961
Genus CRIBROROTALIA Hornibrook, 1961
Cribrorotalia dorreeni Hornibrook, (457)
Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):139, pl.18, figs. 396-398, pl.28, fig.556.

Genus DISCOROTALIA Hornibrook, 1961
Discorotalia tenuissima (Karrer), (256)
Plate 15: Figure j.
Polystomella tenuissima Karrer, 1865. Novara-Exped. Geol. Theil, 1(2):183, pl.16, fig. 16a-c.
Notorotalia tenuissima (Karrer) Finlay & Marwick, *Trans. Roy. Soc. N.Z.*, 70(1):114.
Discorotalia tenuissima (Karrer), Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):141, pl.18, figs. 387, 388, pl.28, fig.547.
Common throughout the late Oligocene, distinguished by small, flattened test with irregular ribs.

Discorotalia sp cf. ***D. tenuissima*** (Karrer), (440) Plate 15: Figure k.
Small test similar to *D. tenuissima*(Karrer) but larger and less discoidal.

Genus NOTOROTALIA Finlay, 1939
Notorotalia clathrata (Brady), (173) Plate 15: Figure f.
Rotalia clathrata Brady, 1884. *Rep. scient. Results Voyage H.M.S. Challenger*, 9(Zool):709, pl.107, fig.8
Notorotalia clathrata (Brady), Finlay, 1939. *Trans. Roy. Soc. N.Z.*, 68:517.

Notorotalia howchini (Chapman, Parr & Collins), (247) Plate 15: Figures g, h.
Rotalia howchini Chapman, Parr & Collins, 1934. *Jnl. Linn. Soc. Lond. Zool.*, 38:566, pl.9, fig.20a-c.
Notorotalia howchini (Chapman, Parr & Collins), Crespin, 1943. *Pall. Bull.*, no.4, p.82 (list).

Genus PARRELLINA Thalmann, 1951
Parrellina centrifugalis Carter, (463) Plate 15: Figure l.
Elphidium (Parrellina) centrifugalis Carter, 1958. *Geol. Surv. Vict.*, Bull. No. 55, p. 63, pl. 9, figs. 98-100.
The large test is umbonate on both sides. Less common than *P. crespinae* (Cushman).

Parrellina crespinae (Cushman), (85) Plate 15: Figure m, n.
Elphidium crespinae Cushman, 1936, *Contr. Cushman Lab. Foramin. Res.*, 12:78, Pl.14 figs.1a,b.
Common to abundant from the late early Oligocene in southern Australia onwards (Janjukian), and is both stratigraphically and geographically widespread occurring in all basins. The test is compressed and has an acute periphery. Depending upon the quality of preservation, a row of pores may be distinguished at the base of the apertural face.

Genus POROSOROTALIA Vololoshinova, 1958
Porosorotalia crassimura (Carter), (92) Plate 15: Figure i.
Notorotalia crassimura Carter, 1958, *Bull. Geol. Surv. Vict.*, 55:64, pl.10, figs.101-103
Porosorotalia crassimura Lindsay, 1967. *Trans. Roy. Soc. S.Aust.*, 91:107.
Common in the Oligocene Pt Willunga Formation, St Vincent Basin. Epifaunal species characteristic of inner shelf (Murray, 1991).

Family EPONIDIDAE Hofker, 1951
Eponides lornensis Finlay, (61) Plate 16: Figure k, l.
Finlay, 1939, *Trans. Roy. Soc. N.Z.*,69(1):121-122 Pl13 figs.52-53

Eponides repandus (Fitchell and Moll), (62) Plate 16: Figure m, n.
Nautilus repandus Fitchell & Moll, 1798. *Testa microscopica etc.*, p.35, pl.3, figs a-d.
Eponides repandus (Fitchell and Moll) Cushman, 1946 *Cush. Lab. Foram. res., Spec.Publ.* No.17, p.6, pl.1, figs.5,a-c.
The dorsal surface is much flatter than *E. lornensis* and the aperture does not expand

ventrally. Tends to be the more common of the two species in the Oligocene.

Family FURSENKOINIDAE Loeblich and Tappan, 1961
Genus SIGMAVIRGULINA Loeblich & Tappan, 1957
Sigmavirgulina tortuosa (Brady), (174) Plate 10: Figure o.
Bolivina tortuosa Brady, 1881. *Qtly. Jnl. Microscop. Soc.*, new ser., 19:57.
Sigmavirgulina tortuosa Loeblich & Tappan, 1957. *Bull. U.S. natnl. Mus.*, 215:227.

Family GLABRATELLIDAE Loeblich and Tappan, 1964
Genus GLABRATELLA Dorreen, 1948
Glabratella crassa Dorreen, (60) Plate: 15: Figure d.
Dorreen, 1948, *Journ. Palaeont.*, 22(3):294 Pl.39 figs 1a-c.

Genus GYROIDINOIDES Brotzen, 1942
Gyroidinoides allani (Finlay), (59) Plate 11: Figures p, q.
Gyroidina allani Finlay, 1939, *Trans. Roy. Soc. N.Z.*, 69:323, Pl.28, figs. 134-136.
Gyroidinoides allani (Finlay), Finlay, 1946. *Trans. Roy. Soc. N.Z.*, 76(2):244(list).
Gyroidinoides allani Reed, 1965. *Bull. Am. Paleont.*, 49(220):77.
Common Oligocene species found in all basins.

Gyroidinoides zealandica (Finlay), (164) Plate 11: Figures m, n, o.
Gyroidina zelandica Finlay, 1939, *Trans. Roy. Soc. N.Z.*, 69(3):231 Pl.28 figs. 138-140.
Gyroidinoides zelandica (Finlay), Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):113, pl.16, figs.339, 344.

Gyroidinoides sp., (633) Plate 11: Figure r.
Very rare. A few specimens obtained from the Gambier Basin section OB2.

Family GLOBANOMALINIDAE Loeblich and Tappan, 1984
Genus PSEUDOHASTIGERINA Banner and Blow, 1959
Pseudohastigerina micra (Cole), (159) Plate 1: Figure d, h.
Nonion micrus Cole, 1927. *Bull. Am. Paleont.*, 14(5):22, Pl.5, fig. 12.
Globigerinella micra Hornibrook, 1958. *Micropal.*, 4(1):34, pl. 1, fig. 22-24.
Pseudohastigerina micra (Cole), Banner, 1982. In *Aspects of Micropalaeontology*, Banner&Lord eds., London, George, Allen&Unwin, pp. 185, 186, fig. 5.64.

Family GLOBIGERINIDAE Carpenter, Parker and Jones, 1862
Genus GLOBIGERINOIDES Cushman, 1927
Globigerinoides primordius (Blow&Banner), (182)
Globigerinoides quadrilobatus (d'Orbigny) subsp. primordius Blow & Banner, 1962. Eames et al., *Fundamentals of Mid-Tertiary Stratigraphical Correlation*. Cambridge University Press):115, pl. 9, figs. Dd-Ff.

Globigerinoides triloba (Reuss), (474)
Globigerina triloba Reuss, 1850. *K, Akad. Wiss. Wien., Math-Nat. Denkschr.*, 1:374, pl.47, fig.11

Globigerinoides triloba (Reuss), Blow, 1956. *Micropal.*, 2(1):62, figs.36a-c

Genus GLOBIGERINA d'Orbigny, 1826

Globigerina anguliofficinalis Blow, (261) Plate. 2: Figure b.
Blow, 1969. *Proc. 1st. Int. Conf. Plankt. Microfossils*, Geneva, E.J. Brill Leiden, 1:199-422.

Globigerina ciperoensis angulisuturalis Bolli, (121)
Bolli, 1957. *Bull. U.S. Natn. Mus.*, 215:109, Pl.22, figs.11a-c.
Globigerina ciperoensis Bolli subsp.*angulisuturalis* Jenkins, 1960. *MIcropaleontology*, 6(4):350, pl.1, fig.4a-c.

Globigerina angulisuturalis Blow and Banner, (273) Plate: 2: Figure e.
Blow & Banner, 1962. In Eames et al., *Fundamentals of Mid-Tertiary Stratigraphical Correlation*. Cambridge University Press):84, pl.9, Aa-Cc.
Globigerina ciperoensis angulisuturalis Jenkins 1966, *Contr. Cushman Fdn.*, 17(1):4, pl.1, fig. 6a-c.
The deeply incised and angular sutures are clearly illustrated in the figured specimen. A member of the *G. ciperoenesis-G. angustiumbilicata* group.

Globigerina angustiumbilicata Bolli, (518) Plate 2: Figure d.
Bolli, 1957. *Bull. U.S. Natn. Mus.*, 215:109, Pl.22, figs.12a-13c

Globigerina ampliapertura Bolli, (119)
Bolli, 1957, *Bull. U.S. Natn. Mus.*, 215:108, Pl. 22, figs. 4a-7b.

Globigerina brazieri Jenkins, (125)
Globigerina brazieri Jenkins, 1966. *N.Z. Journ. Geol. Geophys.*, 8(6):1098, fig.6, nos.43-51.

Globigerina brevis Jenkins, (346)
Jenkins, 1966, *N.Z. Journ. Geol. Geophys.*, 8:1100 fig.7 nos.58-63.

Globigerina ciperoensis Bolli, (121)
Plate 2: Figure a.
Bolli, 1954. *Contr. Cush. Found. Foram. Res.*, 5(1):1-3.

Globigerina bulloides d'Orbigny, (120)
Plate 2: Figure q.
Cushman, 1941. *Contr. Cushman Lab. Foram. Res.*, 17:38, Pl.10, figs.1-13.

Globigerina euapertura Jenkins, (122)
Plate 2: Figures k, l.
Jenkins, 1960, *Micropal.*, 6(4):351, Pl.1, figs.8a-c.

Tenuitellinata juvenilis (Bolli), (275)
Plate 2: Figure c.
Globigerina juvenilis Bolli, 1957. *Bull. U.S. natn. Mus.* 215:110, pl. 24, fig. 5a-c.
Tenuitellinita juvenilis (Bolli), Li, Radford&Banner, 1992. In *Proc. ODP, Sci. Results*, Wise, Schlich et al. eds., 120(2):569-594, pl. 2, figs. 3-6.
Common the late early Oligocene and late Oligocene, often with intermediates in the transition from *T. munda* (Jenkins) to *T.*

juvenilis. Very small test, narrow apertural lip, wall finely perforate and hispid.

Globigerina officinalis Subbotina, (126)
Subbotina, 1953. *Trudy VNIGRI*, 76(N.S.):78, Pl.11, figs.1a-7c.

Globigerina ouachitaensis
Howe&Wallace, (287)
Howe&Wallace, 1932. *Bull. La. Conserv. geol. Surv.* 2:74, pl.10, figs. 7a-b.

Globigerina praebulloides Blow and Banner, (116)
Blow and Banner, 1962. *Fundam. Mid Tert. Strat. Correl.*, Camb. Uni. Press, Cambridge, Pt.2, pp.61-151, Pls.8-17,fig.20.

Globigerina woodi Jenkins, (117) Plate 2: Figures h, i.
Globigerina woodi Jenkins, 1960. *Micropaleontology*, 6(4):352, pl.2 fig.2a-c.
Globigerina woodi Jenkins, 1971. *N.Z. Geol. Surv. paleont. bull.*, 42:159,160, pl.18, fig.548-550.
Globigerina (Zeaglobigerina woodi) Kennett & Srinivasan, 1983. Neogene Planktonic Foraminifera, Hutchinson Ross, pp.42,43, pl.7, figs.4-6.

Globigerina woodi connecta Jenkins, (513) Plate 2: Figure s.
Jenkins, 1964. *Micropal.*, 10(1):72, text-fig. 1a-c.

Genus SUBBOTINA Brotzen & Pozaryska, 1961

Subbotina linaperta (Finlay), (109) Plate 1: Figure f.
Globigerina linaperta Finlay, 1939. *Trans. Roy. Soc. N.Z.*, 69:89-128 Pls.11-14
Globigerina aff. *G.linaperta* McGowran, 1965. *Proc. R. Soc. Vict.* 79:9-74, 60, fig.9 (2,3, in part).
Globigerina linaperta linaperta Finlay; Blow & Banner, 1962. In Eames ed.1962,*Fund. of mid Tert. strat. Correlat.* Camb. Uni. Press, Cambridge pt.2,pp.61-151, pls.8-17, fig.20.
Subbotina linaperta Srinivasan, 1968. *Contr. Cushman Fdn foramin. Res.* 19:149, pl.16, figs.7,10.
Differentiated from *S. angiporoides* (Hornibrook) by the characteristically compressed final chamber although this is often extremely difficult to.confirm in overlapping populations. Intermediates are common.

Subbotina angiporoides (Hornibrook), (110) Plate 1: Figure g.
Stache, 1865. *Novara Exped. Geol. Theil.*, 1(2):161-304 Pls.21-24
Hornibrook, 1965. *N.Z. Journ. Geol. Geophys.*, 8:834-838

Genus GLOBIGERINATHEKA Brönniman, 1952

Globigerinatheka index (Finlay), (118) Plate 1: Figure c.
Globigerinoides index Finlay, 1939. *Trans. Roy. Soc. N.Z.*, 69(1):125 Pl.14 figs.85-88
Globigerapsis index (Finlay), Hornibrook, 1961. *N.Z. geol. Surv. paleont. Bull.*, 34(1):152.

Globigerinatheca (Globigerapsis) index Jenkins, *N.Z. geol. Surv. paleont. Bull.*, 42:187, pl.22, figs.641-645.

Although specimens range through a wide morphological spectrum investigated samples contained forms that conform to the criterion of Blow (1979) and Loeblich and Tappan (1988), that *Globigerinatheka* possesses a spinose wall while *Globigerinapsis* is muricate.

Genus GLOBIGERINELLA Cushman, 1927

Globigerinella obesa (Bolli), (235) Plate 2: Figures n, o, p.

Globorotalia obesa Bolli, 1957. *Bull. U.S. Natl. Mus.*, 215:119, pl.29, fig.2a-3

Globigerinella obesa Kennett and Srinivasan, 1983. Neogene Planktonic Foraminifera. Hutchinson Ross. pp.234-236, pl.59, fig.2-5.

The figured specimen may be a transitionary form between *Globigerina bulloides* (d'Orbigny) and *Globigerinella obesa*.s.s.

Family GLOBOROTALIIDAE Cushman, 1927

Genus PARAGLOBOROTALIA Cifelli, 1982

Paragloborotalia kugleri (Bolli), (265) Plate 2: Figure e.

Globorotalia kugleri Bolli, 1957. *Bull. U.S. natn. Mus.*, 215:118, pl.28, fig.5a-6.

Globorotalia kugleri Jenkins, 1963. *Nature*, 200(4911):1087.

Paragloborotalia opima (Bolli), (479) Plate 1: Figure m.

Globorotalia opima subsp.*opima* Bolli, 1957. *U.S. Natnl. Mus. Bull.*, 215:117

Paragloborotalia opima (Bolli), Cifelli, 1982. *Jnl. Foram. Res.*, 12:114

Paragloborotalia opima nana (Bolli), (124) Plate 1: Figure q.

Globorotalia opima nana Bolli, *1957. Bull. U.S. natl. Mus.*, 215:118, pl. 28, figs. 3a-c.

Genus TURBOROTALIA Cushman & Bermúdez, 1949

Turborotalia increbescens (Bandy), (133) Plate 2: Figure m.

Bandy, 1949, *Bull. Am. Paleont.*, 32:(131):120-121, pl.23, figs.3a-c

Genus GLOBOROTALOIDES Bolli, 1957

Globorotaloides testarugosus (Jenkins), (274) Plate 1: Figures r, s.

Globorotalia testarugosus Jenkins, 1960. *Micropaleontology*, 6(4):368, pl.5 figs.8a-c.

Globorotaloides testarugosus Jenkins, 1965. *N.Z. Journl. Geol. Geophys.*, 8(6):1092, fig. 2.

Globorotaloides labiacrassata (Jenkins), (123) Plate 1: Figure j.

Jenkins, 1966, *N.Z. Journ. Geol. Geophys.*, 8:1102, fig.8, nos.64-71.

Globorotaloides suteri Bolli, (189) Bolli, 1957. *Bull. U.S. Natl. Mus.*, 215:117, pl. 27, fig. 9a-13b.

Genus HANZAWAIA Asano, 1944

Hanzawaia scopos (Finlay), (242) Plate 16: Figures g, h.

Discorbis scopos Finlay, 1940. *Trans. Roy. Soc. N.Z.*, 69(4):466, pl.67, figs. 212,213.

Hanzawaia turgida (Finlay), (447)

Discorbis turgidus, 1942. *Trans. Roy. Soc. N.Z.*, 69(4):467, pl.67,figs.214-216.
Discopulvinulina turgida Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):105, pl.14, figs.287, 291, 295.

Family HAUERINIDAE Schwager, 1876
Genus MASSILINA Schlumberger, 1893
Massilina torquayensis (Chapman), (150) Plate 4: Figure e.
Spiroloculina torquayensis Chapman, 1921, *Rec. Geol. Surv. Vict.*, 4:315-324 Pl.51.
Massilina torquayensis Crespin, 1950, *Contr. Cushman Fdn foramin. Res.*, 1:70-75.

Genus NUMMOLOCULINA Steinmann, 1881
Nummoloculina contraria (d'Orbigny), (588) Plate 4: Figure j.
Biloculina contraria d'Orbigny, 1846. *Foraminifères fossiles du Bassin Tertiaire de Vienne (Autriche)*, Paris:Gide et Comp., p.266.

Nummoloculina irregularis (d'Orbigny), (655) Plate 4: Figure f.
Biloculina irregularis d'Orbigny, 1839. *Voyage dans l'Amérique Méridionale; Foraminifères.* Strasbourg, France, Levrault, tome5(5):67.

Genus PYRGO Defrance, 1824
Biloculina bulloides d 'Orbigny, (481) Plate 4: Figure i.
d'Orbigny, 1826, *Ann. Sci. Nat.*, 1(7):297.

Genus QUINQUELOCULINA d'Orbigny, 1826
Quinqueloculina crassicostata Terquem, (9) Plate 4: Figure l.
Terquem, 1882. *Soc. Géol. France, Mém.*, Paris, sér. 3, tome 2, no. 3, p. 185.

Quinqueloculina cf***bicornis*** (Walker&Jacob), (652)
Serpula bicornis Walker & Jacob, 1798. In *Adams' Essays on the Microscope*, Kanmacher, F., Ed.2, London, p.633.

Quinqueloculina intricata Terquem var., (659) Plate 4: Figure o.
Terquem, 1878. *Mém. Soc. Géol.*, sér. 3, pt. 1, p. 73, pl. 8, figs. 16-21.

Quinqueloculina laevigata (d'Orbigny), (1)
d'Orbigny, 1826, *Ann. Sci. Nat.*, 1(7):301 no.6

Quinqueloculina lamarckiana d'Orbigny, (412) Plate 4: Figure o.
d'Orbigny, 1839. Foraminifères. In *Histoire physique et naturelle de l'Ile de Cuba*, Ramon de la Sagra ed., A. Bertrand, Paris, p.189.

Quinqueloculina cf ***seminulum*** (Linnaeus), (623)
Serpula seminulum Linnaeus, 1758. Systema naturae. *Ed.10 Holmiae, Suecia* (Sweden), *impensis L., Salvii, tomus* 1, p. 786.

Quinqueloculina weaveri Rau, (405) Plate 4: Figure b.
Rau, 1948, *Journ. Palaeont.*, 22:159-160 Pl.28 fig.1-3

Quinqueloculina zealandica Srinivasan, (407) Plate 4: Figure

Srinivasan, 1966, *Trans. Roy. Soc. N.Z.*, 3(17):235

Genus TRILOCULINA d'Orbigny, 1826

Triloculina brochita Carter, (175)
Carter, 1964. *Mem. geol. Surv. Vict.*, 23, 59, pl.1, figs.3,4.
Triloculina brochita Reed, 1965. *Bull. Am. Paleont.*, 49(220), 73.

Triloculina cf tricarinata d'Orbigny, (409)
d'Orbigny 1826. *Ann. Sci. Nat.*, 1(7):299

Triloculina gilboei Beck, (413)
Beck 1943. *Journ. Palaeont.*, 17(6):594 Pl.101 fig.1-3

Triloculina trigonula (Lamarck), (538) Plate 4: Figure g.
Miliolites trigonula Lamarck, 1804. *Ann. Mus. natn. Hist. nat.*, 5:351, (figs. vol. 9, pl. 17, figs. 4a-c.
Triloculina trigonula (Lamarck), d'Orbigny, 1826. *Annls. Sci. nat.*, ser. 1, 7:299, pl. 16, figs. 5-9.

Family HERONALLENIIDAE Loeblich and Tappan, 1986

Heronallenia lingulata (Burrows & Holland), (90) Plate 14: Figures o, p.
Discorbis lingulata Burrows & Holland, 1895. in Jones, *Palaeontogr. Soc. Lond.* 1895, pl.7, figs.33a-c.
Heronallenia lingulata (Burrows & Holland), Chapman, Parr & Collins, 1934. *Journ. Linn. Soc. Lond. (Zool.)*, Vol.38, p.564, pl.8, figs. 11 a-c.

Heronallenia parri Carter, (89) Plate 14: Figure q.
Discorbis wilsoni Heron-Allen & Earland, 1924. *Journ. Roy. Micr. Soc.*, 1924, p.172.
Heronallenia wilsoni (Heron-Allen & Earland), Chapman & Parr, 1931. *Proc. Roy. Soc. Vic.*, Vol. 43, pt.2, pl.9, fig.7.
Heronallenia wilsoni (Heron-Allen & Earland), Chapman, Parr & Collins, 1934. *Journ. Linn. Soc. Lond. (Zool.)*, Vol.38, p.564, pl.8, figs. 11 a-c.
Carter, 1958. *Geol. Surv. Vict. Bull.*, 55:43-44 Pl.5 figs.43-45.
Heronallenia sp. Parr, 1950. *B.A.N.Z.A.R.E. Reports, series B.* Vol.5, pt.6, p.357.

Family HETEROHELICIDAE Cushman, 1927

Guembelitria triseriata (Terquem), (115) Plate 1: Figure n.
Textilaria triseriata Terquem, 1882, *Mem. Soc. Geol. France*, ser.3, 2:1-193 Pls.1-28
Guembelitria triseriata (Terquem); LeCalvez, 1970. *Cah. Paléont.*, p.171, pl.36, fig.6.
Previous identifications in southern Australia are interpreted to be synonyms ie. *G. stavensis* Bandy, *G. samwelli* Jenkins.

Family KARRERIIDAE Saidova, 1981
Genus KARRERIA Rzehak, 1891

Karreria maoria (Finlay), (71) Plate 16: Figure c.
Vagocibicides maoria Finlay, 1939. *Trans. Proc. Roy. Soc. N.Z.*, 69(3):326, pl.29, figs.148-151.
Karreria maoria (Finlay), Hayward and Buzas, 1979. *Smithsonian Contributions to Paleobiology*, 36:61, pl.19, figs. 233,234.

Karreria pseudoconvexa (Parr), (98) Plate 16: Figures a, b.
Cibicides pseudoconvexus Parr, 1938. *Jnl. Proc. Roy. Soc. West Aust.*, 24:86, Pl.3, figs.5a-c.
Karreria pseudoconvexa McGowran, 1965. *Proc.Roy. Soc. of Vict.*, 79(1): 56, pl.5, figs.9,10.
Common in assemblage zones B and C.

Family LAGENIDAE Reuss 1862
Genus LAGENA Walker & Jacob 1768
Lagena curvicostata Heron-Allen&Earland, (636) Plate 7: Figure h.
Heron-Allen&Earland, 1924. *Roy. Micro. Soc. Lond.*, Jour., p. 148, pl. 9, fig. 36.

Lagena gibbera Buchner, (178)
Buchner, 1940. *Nova Acta Leopoldina*, n.f., 9(62):423

Lagena hirtshalsensis Anderson, (194) Plate 7: Figure r.
Anderson, 1971. In Knudsen et al., *Denmark Geol. Soc.*, Bull. (Dansk Geol. Foren., Meddel.), 21(2-3):206, 207, pl. 4, fig. 2, pl. 16, figs. 10,11.

Lagena hispida Reuss, (32)
Reuss, 1863, *Sber., Akad., Wiss.,Wien*, 46(1):335 Pl.6 fig.77-79.

Lagena sp. cf. ***L. hexacostata*** McCulloch, (425) Plate 7: Figure m.
McCulloch, 1977. *Qualitative observations on Recent foraminiferal tests with an emphasis on the eastern Pacific*. University of Southern California, L.A., U.S.A., p. 36, pl. 53, figs. 5a, b.

Lagena nebulosa (Cushman), (560) Plate 7: Figure g.
Lagena laevis (Montagu) var *nebulosa* Cushman, 1923. *Bull. U.S. natn. mus.*, 104:29, pl. 5, figs. 4-5.

Lagena spiralis (Brady), (584)
Brady, 1884. *Rept. Challenger Expd.*, London, England, Zool., Pt. 22, Vol. 9, p. 468.

Lagena striata (d'Orbigny), (36) Plate 7: Figure s.
Oolina striata d'Orbigny, 1839. *Voyage dans l'Amerique Meriodionale-Foraminiferes*, Pitois Levrault & Co, Paris.
Lagena striata Chapman & Parr, 1926. *J. Linn. Soc.*, 36:374, pl. 17, fig. 5.

Lagena substriata Williamson, (34) Plate 7: Figure n.
Williamson, 1848, *Ann. Mag. Nat. Hist.*, ser.2(1):15 fig. 12.]
Figured specimen similar to the Holocene subspecies*L. substriata ornaticollis* Jones but with the neck showing a hexagonal development of cross-bars.

Lagena sulcata Walker & Jacob, (280)
Serpula (Lagena) sulcata Walker & Jacob, 1798. In *Adam's Essays on the Microscope*, Kanmacher, F. ed., London, Dillon & Keating, p. 634, pl. 14, fig. 5.
Lagena sulcata Walker & Jacob, Cushman, 1913. *U.S. natl. Mus. Bull.*, 71:22, pl. 9, fig. 2.

Lagena sulcata Walker & Jacob, Ludbrook, 1961, *Bull. Geol. Surv. S. Aust.*, 36:19.

Lagena sulcata (Walker & Jacob) var. ***spicata*** Cushman & McCulloch, (594) Plate 7: Figure d.
Lagena sulcata Walker & Jacob, 1884. *Rept. Voy. Challenger, Zool.*, V.9, pl.58, figs.4,17.
Lagena sulcata (Walker & Jacob) var. *apiculata* Cushman, 1913. *U.S. Nat. Mus., Bull.* 71(3):23, pl.9, figs.3-4.
Lagena sulcata (Walker and Jacob) var. *spicata* Cushman & McCulloch, 1950. *Southern California Univ., Publ., Allan Hancock Pacific Exped.*, L.A., Calif., 6(6):360.

Genus PROCEROLAGENA Puri, 1954
Procerolagena cylindrocostata Albani & Yassini, (636) Plate 7: Figure i.
Albani & Yassini, 1989. *Aust. J. Mar. Freshwater Res.*, 40:381, fig. 3a.

Procerolagena distoma (Parker&Jones), (625) Plate 7: Figure e.
Lagena distoma (Parker&Jones), In Brady, 1864. *Linn. Soc. London, Trans.* 24(3):467.
Lagena gracillima (Seguenza) var. *mollis* Cushman, 1944. *Cush. Lab. Foram. Res, Spec. Publ.* 12:21, pl. 3, fig.3.

Procerolagena elongata (Ehrenberg), (559)
Miliola elongata Ehrenberg, 1884. K. Preuss. Akad. Wiss., Berlin, p. 274, pl. 25, fig. 1
Lagena elongata (Ehrenberg), Albani, 1978. *Aust. Jnl. Mar. Freshwater Res.*, 29:376, fig. 7H
Procerolagena elongata (Ehrenberg), Albani&Yassini, 1989. *Aust. Jnl. Mar. Freshwater Res.*, 40:83, fig. 3H

Procerolagena gracillima (Seguenza), (168)
Amphorina gracillima Seguenza, 1862. *Messina, T. Capra*, 1,2, p.51, pl.1, fig. 37.
Lagena gracillima (Seguenza); Brady. 1884. *Challenger Expedition Reports, Zool*, 9:456, pl.56, figs. 19-26.
Procerolagena gracillima Albani & Yassini, 1989. *Aust. Jnl. Mar. Freshwater Res.* 40:414, fig.3J.
Fusiform test, lacking ornamentation.

Procerolagena gracilis (Williamson), (294)
Williamson, 1848. *Ann. Mag. Nat. Hist.*, London, England Ser.2, V.1, p.13.

Procerolagena meridionalis (Weisner), (605)
Lagena gracilis Williamson var. *meridionalis* Weisner
Weisner, 1931. *Deutsche Sudpolar Exped. 1901-1903, herausgegeben von Erich von Drygalski*, 20, Zool. 12, 53-165, 24pls.
Lagena gracilis Williamson subsp. *meridionalis* Weisner, Jones, 1984. *Revista Española de Micropal.*, 132, pl.7, fig.3.
Procerolagena meridionalis (Weisner), Loeblich & Tappan, 1994. *Cush.Found. Foram. Res.*, 31:79, pl.143, figs.7-11.

Genus PYGMAEOSEISTRON Patterson and Richardson, 1987

Pygmaeoseistron sp., (654) Plate 7: Figure o.

Test free, globular and unilocular. Wall smooth, aperture circular.

Family LOXOSTOMATIDAE Loeblich and Tappan, 1962

Genus LOXOSTOMUM Ehrenberg, 1854

Loxostomum lobatum (Brady), (192)

Bolivina lobatum Brady, 1884. *Rep. Sci. Res. Voy. H.M.S. Challenger*, 4(Zool.)

Loxostomum lobatum (Brady), Cushman, 1937. *Cush. Lab. Foram. Res.*, Spec. Pub. No. 9, p.188

Family MISSISSIPPINIDAE Saidova, 1981

Genus STOMATORBINA Dorreen, 1948

Stomatorbina concentrica (Parker and Jones), (108) Plate 14: Figures w, x.

Pulvinulina concentrica Parker and Jones in Brady, 1864 *Trans. Linn. Soc. (Lond.) Zool.* Vol.24, pp. 463-475. pl. 48.

Eponides concentiricus (Parker & Jones). Chapman, Parr & Collins, 1934. *J. Linn. Soc. (Lond.) Zool.* Vol.38, p.565, pl.9, figs.17 a-c.

Stomatorbina concentrica Carter, 1958. *Geol. Surv. Vict. Bull.* 55:40, pl.4, fig. 37-39, pl.4, fig.75.

Stomatorbina toddae Haque, (600)

Haque, 1960. *Geol. Surv. Mem., Pal., Pakistan*, 2(2):32, pl.2, fig. 6.

Stomatorbina sp. (600) Plate 16: Figure e.

Biconvex test; sutures thickened by secondary layers on spiral side, rounded periphery.

Family NODOSARIIDAE Ehrenberg, 1838

Genus AMPHICORYNA Schlumberger, 1881

Amphicoryna cf. ***A. halkyardi*** Cushman, (279) Plate 5: Figure e.

Cushman, 1933. *Cush. Lab. Foram. Res.*, 9:pt.1, p.9.

Test surface covered with fine hispid spines indispersed with broken or interrupted longitudinal costae. Abele (1961) recorded this species as rare in the Gambier Limestone and suggested variable morphologies with specimens similar to *A. hirsuta* (d'Orbigny).

Amphicoryna scalaris (Batsch), (225)

Nautilus scalaris Batsch, 1860. *Sechs Kupfertafeln mit Conchylien des Seesandes, gezeichnet und gestochen von A.J.G.K. Batsch*, Jena, 6 pls.

Nodosaria scalaris (Batsch), Brady, 1884. *Rept. on the Scientific results of the Voy. HMS Challenger*, *Zool.*, 9:510, pl. 63, fig. 16

Amphicoryne scalaris (Batsch), Parr, 1950. *Brit. Aust. N.Z. Antarct. Res. Exped. Rep.*, Ser.B, 5:328, pl. 11, fig. 24.

Amphicoryna scalaris (Batsch) var., (240) Plate 6: Figure s.

Some variation noted with neck broader and flatter than the narrow, slender neck of *A. scalaris* s.s.

Genus ASTACOLUS de Montfort, 1808

Astacolus crepidulus (Fitchel & Moll), (613) Plate 5: Figure n.

Cristellaria crepidula Fitchel&Moll, 1798. *Testacea microscopica aliaque minuta ex*

generibus Argonauta et Nautilus, Wien, Österreich, Camesina, p.107.
Astacolus crepidulus (Fitchel&Moll), Barker, 1960. *Soc. Econ. Paleont. Min.*, Spec. Pub. No. 9, p. 140, pl.67, fig. 20

Astacolus neolatus Vella, (590)
Vella, 1957. *N.Z. Geol. Surv. Palaeont. Bull.*, 28:30, pl7, fig.143, 146-8

Genus CHRYSALOGONIUM Schubert, 1908
Chrysalogonium verticale (Stache), (138)
Dentalina verticaleis Stache, 1865. *Novar-Epedit ., Geol.Theil.*, 1(2):202, pl.2, fig.38,39.
Nodosaria (Dentalina) lorneiana d'Orbigny; Chapman, 1926. *N.Z. geol. Surv. palaeont. Bull.*, 11:49, pl.3 fig.28.
Chrysalogonium verticalis Finlay, 1946. *Trans. Roy. Soc. N.Z.*, 76(2):243 (list).
Chrysalogonium verticale Hornibrook, *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):48 Pl.6 fig.102

Genus DENTALINA Risso, 1826
Dentalina advena (Cushman), (161)
Nodosaria advena Cushman, 1923. *U.S.N.M. Bull.*, 104(4):79
Dentalina advena (Cushman), Barker, 1960. *Soc. Econ. Palaeont. Min.*, Spec. Pub. No. 9, p.132, pl. 63, fig.1

Dentalina soluta Reuss, (12)
Reuss, 1851, *Deutsch. Geol., Zeitschr.*, Berlin, Bd.3:60

Dentalina subcostata Chapman, (417)
Nodosaria (Dentaline) obliqua Linne var. *subcostata* Chapman, 1926. *N.Z. Geol. Survey Palaeont. Bull.*, 11:51 Pl. 11, fig.3
Dentalina subcostata Finlay, 1946. *Trans. R. Soc. N.Z.*, 76(2):243.
Dentalina subcostata Hornibrook, 1961. *N.Z. geol. Surv. paleont. Bull.* 34(1):45, pl.6, fig.88.

Dentalina subsoluta (Cushman), (420)
Plate 5: Figure q.
Nodosaria subsoluta Cushman, 1923. *Bull. U.S. natn. Mus.*, 104(4):74, pl. 13, fig. 1.
Dentalina subsoluta (Cushman), Crespin, 1943. *Palaeont. Bull.*, 4, 78.

Dentalina kaicherae McLean, (331)
McLean, 1956. *Bull. Amer. Pal.*, 36(160): 328, pl. 38, figs.14,15, 18,19.

Dentalina mutata Costa, (140)
Costa, 1894, *R. Accad. Sci. Inst. Bologna Mem. Sci. Nat.* ser.5 tome 4:209, Pl.1, fig.28.

Dentalina sp. 1 (492)
Dentalina sp. 2 (506)

Genus HEMIROBULINA Stache, 1864
Hemirobulina sp., (552) Plate 5: Figure j.
Elongate unornamented smooth test, sutures oblique, chambers added at slight curve at the base. Rare in the early Oligocene in the Otway Basin.

Genus LINGULINA d'Orbigny, 1826
Lingulina bartrumi Chapman, (423)
Chapman, 1926. *N.Z. geol. Surv. palaeont. Bull.* 11:54, pl.11, fig.12

Lingulina semilineata Chapman, (2)
Chapman, 1926. *Lingulina semilineata* d'Orb., var. *semilineata* ; *N.Z. Geol. Surv. Palaeont. Bull.* 11:54, pl.12 fig.1.

Lingulina sp., (604) Plate 5: Figure r.
Test elongate, depressed; smooth surface, sutures sharply curved towards an elongate terminal aperture in plane of compression.

Genus NODOSARELLA Rzehak, 1895
Nodosarella sp., (148) Plate 5: Figure g.
Elongate test, appears circular in cross-section. Inflated chambers are separated by straight sutures.

Genus NODOSARIA Lamarck, 1812
Nodosaria vertebralis (Batsch) var., (257) Plate 5: Figure k, l.
Brady, 1884 (not Batsch). Rep. Yoy. Challenger, Zool. 9:514, pl. 63, fig. 35.
Test elongate ornamented with longitudinal costae; numerous chambers, distinct with initial chamber inflated; short stout spine at base of test.

Nodosaria facile Franzenau
Franzenau, 1890, *Math. Naturw. Ber. Ungarn.* Budapest, Ungarn, Bd.7 (1888-1889) art.5 p.72.

Nodosaria longiscata d'Orbigny, (497)
d'Orbigny, 1846. *Foraminifères Fossiles du Bassin Tertaire de Vienne.* Paris, p.32, pl.1, fig. 10-12.

Nodosaria mutabilis Costa, (136) Plate 5: Figures b, c.
Costa, 1855. R. *Accad. Sci. Napoli, Mem.*, 2:134.
Fig. f is interpreted to be a variation of *N. mutabilis*, with thicker neck distinguishing character.

Nodosaria seperans (Brady), (303)
Nodosaria scalaris (Batsch) var *seperans* Brady, 1884. *Rept. on the Scientific results of the Voy. HMS Challenger, Zool.*, 9:510, pl. 63, figs. 16-19
Amphicoryna seperans (Brady), Parr, 1950. *B.A.N.Z.A.R.E.*, 1929-1931, Ser. B, 5(6):328
Nosaria separans (Brady), Quilty, 1974. *Pap. Proc. Roy. Soc. Tas.*, 108:77, pl. 4, fig. 125

Nodosaria simplex Hantken, (246)
Hantken, 1868. *Magyarh. Földt. Társ., Munk., Pest, Magarország*, köt. 4, p. 87, pl. 1, fig. 11.

Genus PLECTOFRONDICULARIA Liebus, 1902
Plectofrondicularia awamoana Finlay, (461)
1939. *Trans. Roy. Soc. N.Z.*, 69(1):100

Plectofrondicularia proparri Finlay, (221) Plate 6: Figure v.
1947. *N.Z. Jnl. sci. tech.*, B28(5):276, pl.4, fig.46-48.

Genus PSEUDONODOSARIA Boomgaart, 1949

Pseudonodosaria coronata (Grzybowski), (30) Plate 5: Figure u.
Lagena (Cidaria) coronata Grzybowski, 1896. 30(ser. 2, v.10): 292, pl. 10, fig. 6a-b.

Family NUMMULITIDAE de Blainville, 1827
Genus OPERCULINA d'Orbigny, 1826
Operculina victoriensis Chapman & Parr (79) Plate 4: Figure s.
Chapman & Parr, 1938. *Pall. Bull.*, No.4, p.82(list)

Family PATELLININAE Rhumbler, 1906
Genus PATELLINA Williamson, 1858
Patellina corrugata Williamson, (250) Plate 13: Figure i.
Williamson, 1958. *Roy. Soc.*, London, p.46, pl.3, fig.86-89.

Family PLANORBULINIDAE Schwager, 1877
Planorbulinella roseanna Lindsay, (450)
Lindsay, 1981, *Q. Geol. Notes Geol., Surv. S.Aust.*, 78:13

Family PLANULINIDAE Bermúdez 1952
Genus CRESPINELLA Parr 1942
Crespinella parri Quilty, (539)
Crespinella sp. nov. Ludbrook, 1961 *Bull. geol. Surv. S. Aust.*, 36, pp.74,87, pl.3, figs.7-9.
Crespinella parri Quilty, 1980. *Alcheringa*, 4:302, figs. 4-6.

Genus PLANULINA d'Orbigny, 1826
Planulina evoluta LeRoy, (44) Plate 16: Figure n.
LeRoy, 1939. *Natuurk. Tijdschr. Nederl. - Indië, Batavia, Java*, dl. 99, afl. 6, p. 266, pl. 7, figs. 16,17.

Planulina wuellerstorfi (Schwager), (283)
Schwager, 1866. *Novara-Exped. geol.*, 2(2):258, 259, pl.7, fig. 5, 6.

Family POLYMORPHINIDAE d'Orbigny, 1839
Genus GLOBULINA d'Orbigny, 1839
Globulina gibba (d'Orbigny), (30) Plate 8: Figure j.
Polymorphina (Globuline) gibba d'Orbigny, 1826. *Ann. Sci. nat.* 7:266, 10, Modèles 63.
Globulina gibba Crespin, 1943. *Palaeont. Bull.*, Canberra, 4:80.

Globulina inaequalis Reuss, (293) Plate 8: Figure i.
Reuss, 1850. *K. Akad. Wiss. Wien, Math. - Nat. Cl., Denkschr.*, Bd. 1, p. 377, pl. 48, fig. 9a, b.

Genus GUTTULINA d'Orbigny, 1839
Guttulina communis (d'Orbigny), (422) Plate 8: Figure a, d, ?o.
Polymorphina (Guttulina) communis d'Orbigny, 1826. *Annls. Sci Nat.* ser. 1,7, 26.
Guttulina problema Parr & Collins, 1937. *Proc. R. Soc. Vict.*, 50:191, pl. 12, fig.1.
Guttulina communis Quilty, 1974. *Pap. Proc. R. Soc Tas.*, 108:79, pl.4, figs. 128,129.

Guttulina frankei Cushman and Ozawa, (353) Plate 8: Figure e.
Cushman and Ozawa, 1930, *U.S. Nat. Mus. Proc.*, 77(6):28 Pl. 4, fig. 1.

Guttulina irregularis (d'Orbigny), (421)
Cushman & Thomas, 1929 *Journ. Palaeont.*, 3:177 Pl. 23, fig. 2a-c.

Guttulina otiakensis Hornibrook, (354)
Hornibrook, 1961. 55, *N.Z. geol. Surv. paleont. Bull.* 34(1):55, pl.7, fig.121

Guttulina pacifica (Cushman & Ozawa), (355) Plate 8: Figure l.
Sigmoidella pacifica Cushman & Ozawa, 1928. *Contrib. Cush. Lab. Foram. Res.*, 4(57):19, pl. 2, fig. 13.
Guttulina pacifica (Cushman & Ozawa), Cushman & Ozawa, 1930. *Proc. U.S. nat. Mus.*, 77(6):50, pl. 37, figs. 3-5.

Guttulina problema d'Orbigny, (27) Plate 8: Figure c.
Guttulina problema d'Orbigny 1826, *Ann.Sci.nat.*, 7:266, 14.
?*Polymorphina problema* (d'Orbigny) Chapman 1926, *N.Z.geol. Surv. palaeont. Bull.*, 11:68, pl.5, fis.10-12.
Guttulina problema Cushman & Ozawa, *Proc. U.S. nat. Museum*, 77(2829):19, pl.2, figs.1-6; pl.3, fig.1.
Guttulina problema Parr & Collins 1937, *Proc. Roy.Soc. Victoria (n.s.)*, 50(1):191, pl.12, fig1.
? *Guttulina sp.* Dorreen 1948, *J. Palaeont.*, 22(3):289, pl. 37, fig. 8.

Guttulina regina (Brady, Parker & Jones), (426) Plate 8: Figure b.
Polymorphina regina Brady, Parker & Jones, 1870. *Trans. Linn. Soc.*, 27:241, pl. 41, fig. 32.
Guttulina regina (Brady, Parker & Jones), Cushman & Ozawa, 1930. *Proc. U.S. nat. Mus.*, 77(2829):34, pl. 6, fig. 1, 2.
Guttulina regina (Brady, Parker & Jones), Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):55, pl. 7, fig. 123.

Guttulina yabei Cushman and Ozawa, (233)
Polymorphina oblonga Brady, 1884. *Rep. Voy. Challenger, Zool.*, 9, 569, pl. 73, figs.2,3.
Guttulina yabei Cushman & Ozawa, 1929. *Jap. J. Geol. Geogr.*, 6:68, pl.13, fig.2; pl. 14, fig.6.

Genus PYRULINA d'Orbigny, 1839
Pyrulina fusiformis (Roemer), (207)
Polymorhina (Globulinen) fusiformis Roemer, 1838. *Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefakten-Kunde*, p.386, pl.3, fig.37
Pyrulina fusiformis (Roemer), Cushman & Ozawa, 1930. *Proc. U.S. Natnl. Mus.*, 77(6):54, pl.13, figs.3-8
Pyrulina fusiformis (Roemer), Barker, 1960. Soc. Econ. Palaeont. Min., Spec.Pub. no. 9, p. 148, pl. 71, figs. 17-19

Pyrulina gutta d'Orbigny, (24) Plate 8: Figure f.
d'Orbigny, 1826. *Annals des Sciences Naturalles*, 7:267, no.28, "Modele" 30.

Genus SIGMOIDELLA Cushman & Ozawa, 1928

Sigmoidella bortonica Finlay, (380)
Plate 8: Figure p.
Finlay, 1939(b), *Trans. Roy. Soc. N.Z.*, 69(3):318 Pl.25 fig.43-44

Sigmoidella elegantissima (Parker & Jones), (231)
Polymorphina elegantissima Parker & Jones, 1865. *Phil. Trans. R. Soc.*, 155, 438.
Sigmoidella elegantissima Cushman & Ozawa, 1929. *Jap. J. Geol. Geogr.*, 6:76, pl.16, figs.10,11.
Sigmoidella elegantissima Quilty, 1974. *Pap. Proc. R. Soc. Tas.*, 108:85, pl.4, fig.142.

Genus SIGMOILINA Schlumberger 1887

Sigmoilina aspera (d'Orbigny), (626) Plate 4: Figure m.
Quinqueloculina aspera d'Orbigny, 1826. *Annls. Sci. nat.*, ser. 1, 7:301.
Quinqueloculina aspera Parker & Brady, 1871. *Ann. Mag. nat. Hist.*, ser. 4, 8, pl. 8, fig. 11.

Sigmoilina obesa Heron-Allen & Earland, (435) Plate 4: Figure h.
Sigmoilina obesa Heron-Allen & Earland, 1932. *"Discovery" Reps.*, 4:320, pl. 7, figs. 1-4.

Genus SIGMOILOPSIS Finlay, 1947

Sigmoilopsis schlumbergeri Silvestri,
Sigmoilina schlumbergeri Silvestri, 1904. *Accad. Pont. Romana Nuovi Lincei, Mem.*, Roma, Italia, 22:267,269.
Sigmoilopsis schlumbergeri (Selvestri), Barker, 1960. *Society of Economic Paleontologists and Mineralogists*, Tulsa. Spec. Pub. no.9, p.16, pl. 8, figs. 1-4

Genus SIGMOMORPHINA Cushman & Ozawa, 1928

Sigmomorphina lornensis Hornibrook, (134)
Sigmomorphina lornensis Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):59 Pl. 7 fig. 130.

Sigmomorphina obesa Hornibrook, (435)
Plate 8: Figure h.
Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):59, pl. 7, figs. 122, 128

Sigmomorphina wynyardensis Parr & Collins, (167) Plate 8: Figure g.
Sigmomorphina wynyardensis Parr & Collins, 1937. *Proc. roy. Soc. Vict.*, 50:203, pl. 15, fig. 3a-c.

Genus REUSSELLA Galloway, 1933

Reussella finlayi Dorreen, (405)
Dorreen, 1948. *Journ. Palaeont.*, 22:292, Pl.38, fig.4
Hornibrook, 1961. *N.Z. Geol. Surv. Pal. Bull.*, 34(1):78.

Family ROTALIIDAE Ehrenberg, 1839
Genus SHERBONINA Chapman, 1922

Sherbornina atkinsoni Chapman, (637)
Plate 14: Figure q.
Chapman, 1922, *J. Linn. Soc., Zool.*, 34:501-503. Pl.32, figs.1-5.

Sherbornina cuneimarginata Wade, (634) Plate 14: Figure s.

Wade and Carter, 1957. *Micropal.*, 3: 155-164, pp.158-159, pl.1, figs.6,7; pl.2, figs.7-11; pl.3, figs.7-10.

Genus PARAROTALIA Y.Le Calvez, 1949
Pararotalia verriculata (Howchin&Parr), (83) Plate 12: Figures o, p.
Rotalia verriculata Howchin&Parr, 1983. *Trans. Roy. Soc. S.Aust.*, 62:310, pl.19, figs.8,9,11,15
Calcarina verriculata (Howchin&Parr), Ludbrook, 1961. *S.Aust. Dept.of Mines and Energy , Bull.*, 36:50,59,79,87, pl.4, figs.6,7
Pararotalia verriculata (Howchin&Parr), Lindsay, 1969. *Bull. geol. Surv. S. Aust.*, 42:23.
Common to restricted facies in the Murray and St Vincent basins. Oligo-Miocene.

Pararotalia mackayi (Karrer), (455)
Rosalina mackayi Karrer, 1864. *Novara-Exped. geol.*, 1(2):82, pl.16, fig.14
Pararotalia mackayi (Karrer), Hornibrook, 1971. *N.Z. Geol. Surv. pal. Bull.*, 43:19, 20, pl.3, figs.55-57.

Genus AMMONIA Brünnich, 1772
Ammonia beccarii (Linné), (65) Plate 13: Figure e.
Nautilus beccarii Linné, 1767. *Syst. Nat.*, Ed.12, p.1162.

Ammonia nanus (Hornibrook), (465)
Streblus nanus Hornibrook, 1961. *N.Z. geol. Surv. paleont. Bull.* 34(1):128, pl.20, figs. 425-427.

Family SPIROLOCULINAIDAE Weisner, 1920
Genus SPIROLOCULINA d'Orbigny, 1826
Spiroloculina angulata Cushman, (517)
Spiroloculina grata Brady, 1884. *"Challenger" Expedit., Sci. Res., Zool.*, 9:155, pl. 10, figs. 16, 17, 22, 23.
Spiroloculina grata Brady var. *angulata* Cushman, 1917. *Bull. U.S. natn. Mus.*, 71:36, pl. 7, fig. 5.
Spiroloculina angulata Cushman & Todd, 1944. *Spec. Publns. Cushman Lab.*, 11:50.
Spiroloculina angulata Cushman & Todd, Quilty, 1974 *Pap. Proc. Roy. Soc. Tas.*, 108:42-43, pl. 1, fig. 23.

Spiroloculina sp. 1, (515) Plate 4: Figure a.
Fusiform test with flattened sides, porcelaneous, imperforate, planispirally wound tubular chambers, short neck. Figured specimen is from a depauperate assemblage of miliolids in the lower part of Interval D in OB2.

Spiroloculina sp. 2, (509)

Family SPIROPLECTAMMINIDAE Cushman, 1927
Genus BOLIVIOPSIS Yakovlev, 1891
Bolivinopsis cubensis (Cushman and Bermudez), (5) Plate 10: Figure t.
Spiroplectoides cubensis Cushman & Bermudez, 1937. *Contr. Cushman Lab. foram. Res.*, 13(1):13, pl.3, fig.44,45
Finlay and Marwick, 1940. *Trans. Roy. Soc. N.Z.*, 70(1):107.

Bolivinopsis sp., (541) Plate 10: Figure s.

Hayward and Buzas, 1979. *Smithsonian Contributions to Paleobiology,* 36:33. Pl.1, fig.12.
Lindsay, 1981. Tertiary stratigraphy and foraminifera of the Adelaide city area, St. Vincent Basin, South Australia. Masters thesis (unpubl.). University of Adelaide. Adelaide, 2:554, pl.37, figs.2,3.
Lindsay considered this to be the microspheric form of *B. cubensis,* while the distinctive raised ribs and evolute planispiral are considered here to be diagnostic of a separate species.

Family TEXTULARIIDAE Ehrenberg, 1838
Genus BIGENERINA d'Orbigny, 1826
Bigenerina nodosaria d'Orbigny, (599) Plate 3: Figure e.
d'Orbigny, 1826. *Ann. des Sci. Natur.,* 7:261.

Genus SIPHOTEXTULARIA Finlay, 1939
Siphotextularia awamoana Finlay , (153)
Finlay, 1939. *Trans. Roy. Soc. N.Z.,* 69(1):92, pl.14, fig.89,90.

Siphotextularia gladizea (Finlay), (49) Plate 3: Figure c.
Textularia gladizea Finlay, 1947. *N.Z. Journ. Sci. Technol.,* sec. B, 28(5):267.
Textularia gladizea Hornibrook, 1968. *N.Z. Geol. Surv. Handbook Info. ser.,* 2:35, 36, 71-72, table H, fig. 13.

Siphotextularia concava (Karrer), (272) Plate 3: Figure d.
Plecanium concavum Karrer, 1868. *Sitzungsberichte der Kaiserlich Akad. der Wissenschaften,* 58(1):121-193.
Textularia concava (Karrer), Brady, 1884. *Challenger" Expedit., Sci. Res., Zool.,* 9, pl. 42, figs. 13,14.
Siphotextularia concava (Karrer), Finlay, 1938. *Trans. Roy. Soc. N.Z.,* 68:510.

Genus TEXTULARIA Defrance, 1824
Textularia cuneazea Hornibrook, (143)
Hornibrook, 1961. *N.Z. geol. Surv. paleont. Bull.* 34(1):19,pl.1, figs. 4, 5.

Textularia hayi Karrer, (662) Plate 3: Figure n, o.
Karrer, 1864. *"Novara" Exped., Geol. Theil,* 1:78. pl. 16, fig. 7.

Textularia jutsoni Quilty, (490) Plate 3: Figure u.
Quilty, 1981. *Journ. Roy. Soc. W.A.,* 64(3):85, fig.5,13

Textularia magallanica Todd and Kniker, (389) Plate 3: Figure m.
Todd and Kniker, 1952. *Cushman Found. Foram. Res., spec.pub.,* Washington 13., no.1 p.7

Textularia marsdeni Finlay, (54)
Finlay, 1939. Trans.Roy. Soc. N.Z., 69(1):90, pl.14, fig.67.

Textularia nanarupensis Quilty, (390)
Quilty, 1981. *Roy. Soc. Western Australia, Jnl.,* 64(3):82-84

Textularia semicarinata Hornibrook, (511) Plate 3: Figure k.

Hornibrook, 1961. *N.Z. geol. Surv. paleont. Bull.* 34(1):19, pl.1, figs.2-3.

Textularia sp. 4 , (661) Plate 3: Figure i.
Large biserial test, coarsely arenaceous, inflated final chamber. Similar to a late Eocene species *Textularia* sp. 2, pl. 1, fig.2 of Beecroft (1980).

Family VERNEUILINIDAE Cushman, 1911
Genus GAUDRYINA d'Orbigny, 1839
Gaudryina attenuata Chapman, (181) Plate 3: Fig. l.
Cushman, 1913. *U.S. Nat. Mus., Proc.*, Washington, D.C., USA, 144(1973):636, pl. 80, fig. 3.

Gaudryina crespinae Cushman, (53) Plate 3: Figure p.
Gaudryina rugosa Cushman, 1926. *N.Z. geol. Surv. Paleont. Bull.*, 11:35, pl. 8, fig. 7.
Gaudryina (Pseudogaudryina) crespinae Cushman, *Spec. Publ. Cushman Lab.*, 6:14, pl. 2, fig. 15.
Gaudryina crespinae Hornibrook, 1961. *N.Z. geol. Surv. paleont. Bull.* 34(1):26, pl. 2, fig. 29.
Common with a wide geographic distribution through the Oligocene.

Gaudryina convexa (Karrer), (569) Plate 3: Figure h.
Textularia convexa Karrer, 1865. *"Novara" Expedn. Geol. Theil.*, 1:78, pl. 16, figs. 8a-c.
Gaudryina convexa (Karrer), Burdett et al., 1963. *N. Z. Journ. Sci.*, 6(4):513-530.
Gaudryina convexa (Karrer), Hornibrook, 1971. *N.Z. Geol. Surv. Palaeont. Bull.* 43:16, pl. 1, figs. 8-15.

Gaudryina cf. ***reussi*** Stache, (569)
Stache, 1864. *Novara-Exped. geol.* 1(2):171, pl. 21, fig.11.

Genus TRITAXIA Reuss, 1860
Tritaxia victoriensis (Cushman), (200) Plate 3: Figure f.
Clavinulina angularis Chapman, 1907. *J. Linn. Soc.*, 30:29, pl.4, figs.68-73.
Clavinulinoides szaboi (Hantken) var. *victoriensis* Cushman, 1936. *Spec. Publs. Cushman Lab.*, 6:22, pl. 3, figs.19,22.
Clavinulinoides victoriensis Reed, 1965. *Bull. Am. Paleont.*, 49(220):73, pl.11, figs.2,9
Tritaxia victoriensis (Cushman), Quilty, 1974. *Pap. Proc. Roy. Soc. Tas.*, 108:40, pl. 1, figs. 16, 17

Genus VERNEUILINA d'Orbigny, 1839
Verneuilina browni Finlay, (404)
Finlay, 1939. *Trans. Roy. Soc. N.Z.*, 69(2):91-92 pl. 14 fig.72-73

Family CHAPMANINIIDAE Thalman, 1938
Genus SHERBONINA Chapman, 1922
Sherbonina cuneimarginata Wade, (634) Plate 14: Figure s.
Wade, in Wade & Carter, 1957. *Micropaleontology*, 3(2):158,159, pl.1, figs.7-11. Pl.3, figs.7-10.

Family VALVULINIDAE Berthelin, 1880
Genus CRIBROBULIMINA Cushman, 1927

Cribrobulimina mixta (Parker & Jones), (292)
Cushman, 1927. *Cush. Lab. Foram. Res.*, pl.11, figs. 1-5.
Lindsay, 1981. *Tertiary Stratigraphy and Foraminifera, Adelaide, S.Aust.* Masters Thesis, Adel. Uni., p. 559, pl. 40, fig. 1.

Family MILIOLIDAE Ehrenberg, 1839
Genus OPHTHALMIDIUM Zwingli & Kübler
Ophthalmidium sp., (406) Plate 4: Figure k.
Small flattened test, rounded in outline; globular proloculus, planispiral coiling of tubular chambers; wall porcelaneous, imperforate.

Family POLYMORPHINIDAE d'Orbigny, 1839
Genus GLANDULINA d'Orbigny
Glandulina symmetrica (Stache), (51) Plate 8: Figure k.
Pseudonodosaria symmetrica Stache, 1864. *Novara-Exped. Geol.*, 1(2):187, pl. 22, figs. 9a,b.
Glandulina symmetrica (Stache), Hornibrook, 1961. *N.Z. geol. Surv. paleont. Bull.* 34(1):61, pl.8, fig.132.

Family CASSIDULINIDEA d'Orbigny, 1839
Genus CASSIDULINA d'Orbigny, 1826
Cassidulina carapitana Hedberg, (188) Plate 8: Figures w, x.
Hedberg, 1937. *Journal of Paleontology*, 11(8):680, pl. 92, fig. 6.
Common in late Oligocene. The biconvex test has a sharp periphery; and an elongate aperture.

Cassidulina cuneata Finlay, (135) Plate 8: Figure r.
Finlay, 1940. *Trans Roy. Soc. N.Z.*, 64(4):456, pl.63, figs. 62-66
Hornibrook et al., 1989. *N.Z. Geol. Surv. Pal. Bull.*, 56:88, fig.18:23.
Occurs in the Duntroonian of New Zealand has a similar range in South Australia. Occassional appearance in the Gambier Basin and very rare in the St Vincent or Murray Basins.

Cassidulina laevigata d'Orbigny, (415) Plate 8: Figure t.
Cassidulina laevigata d'Orbigny, 1826. Ann. Sci. nat. Sér. 1,7:282, pl.15, figs.4,5.
Cassidulina laevigata Cushamn, 1925. *Contr. Cushman Lab.* 1 (3):52, pl.8, fig.1,2.
Cassidulina laevigata Finlay, 1946. *Trans. Roy. Soc. N.Z.* 76(2):243 (list).
Cassidulina laevigata Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):85, pl. 10, fig. 199.

Genus EVOLVOCASSIDULINA Eade, 1967
Evolvocassidulina orientalis (Cushman), (165) Plate 8: Figure s.
Cassidulina bradyi Norman; Brady, 1884. *Rep. Voy. Challenger, Zool.* 9:pl.54,fig.10.
Cassidulina orientalis Cushman, 1922. *U.S. nat. Mus. Bull.*, 104:129.
Evolvocassidulina orientalis (Chapman) Eade, 1967. *N.Z. j. Mar. Freshwater Res.*, 1(4):421-454.

Genus GLOBOCASSIDULINA Voloshinova, 1960
Globocassidulina crassa (d'Orbigny), (15) Plate 8: Figure v.

Cassidulina crassa d'Orbigny, 1826. *Ann. Sci. Nat.*, sér 1, 7:357, pl. 9, figs. 26-33.
Globocassidulina crassa Barker, 1960.
Taxonomic notes - on the species figured by H.B. Brady in his report on the foraminifera dredged by H.M.S. *Challenger* during the years 1873-1876. Society of Economic Paleontologists and Mineralogists , Tulsa. Spec. Pub. no.9, Pl.54.
Rare in the early late Oligocene in the Otway Basin.

Globocassidulina subglobosa (Brady), (8) Plate 8: Figure q.
Cassidulina globosa Brady, 1881. *Quart. Journ. Micr. Sci.*, London, 21:60
Globocassidulina subglobosa (Brady), Hornibrook et al., 1989. *New Zealand Geological Survey, Bull.56*, p.93, fig. 15:33.

Globocassidulina pseudocrassa (Hornibrook), (137) Plate 8: Figure u.
Cassidulina pseudocrassa Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):86, pl. 11, figs. 202, 203.

Family VICTORIELLIDAE Chapman & Crespin 1930
Subfamily VICTORIELLINAE Chapman & Crespin 1930
Genus MASLINELLA Glaessner and Wade, 1959
Maslinella chapmani Glaessner and Wade, (462)
Glaessner and Wade, 1959, *Micropal.*, 5(2):203 Pl. 1 figs. 7-8.

Genus WADELLA Srinivasan 1966
Wadella globiformis Chapman, (154) Plate 4: Figure r.
Carpentaria globiformis Chapman, 1926. *N.Z. Geol. Survey Palaeont. Bull.*, 11:81, pl. 16, fig. 6.
Wadella globiformis Srinivasan, 1966. *Trans. Roy. Soc. N.Z. geol.*, 3(17):249, 250.

Genus VICTORIELLA Chapman and Crespin
Victoriella conoidea (Rutten), (145) Plate 4: Figures q, u.
Carpentaria conoidea Rutten, 1914. *Uitk. ned. N.-Guinea Exped.* 1903, 6(Geol.) (2):47, pl.7, fig. 3.
Carpentaria proteiformis Goës var. *plecte* Chapman, 1921. *Geol. Surv. Vict. Rec.* 4(3):320, pl.51, fig.3.
Victoriella plecte Chapman & Crespin, 1930. *Proc. roy. Soc. Vic.* n.s.42(2):art. 14, 111.
Victoriella aff.*plecte* Finlay & Marwick, 1940. *Trans. roy. Soc. N.Z.* 70(1):95, 17.
Victoriella plecte Crespin, 1943. *Dep. Supply Shipp. Min. Resour. Surv. Canberra, paleont. Bull.* 4:13, 56, 65, 67, 70, 84.
Victoriella conoidea (Rutten); Glaessner & Wade, 1959. *Micropaleontology* 5(2):199, pl.1, fig.1-5; pl.2, fig. 1-5, 7-10, pl.3; Text fig. 1-4.
Distinguished by the distinctive large trochospiral test with a thickly layered wall covered in regular tubercles and coarse pores. This key species is common to the Janjukian Stage, abundant in the Gambier Limestone.

Genus HOFKERINA Chapman and Parr, 1931
Hofkerina semiornata (Howchin), (157)

Pulvinulina semiornata Howchin, 1889. Trans. Roy. Soc. S.Aust., 12:14, pl.1, figs.12a-c.
Hofkerina semiornata (Howchin), Crespin, 1943. Pal. Bull., No.4, p.80 (list).

Family SPHAEROIDINIDAE Cushman, 1927
Genus SPHAEROIDINA d'Orbigny 1826
Sphaeroidina bulloides d'Orbigny, (410)
Plate 10: Figure y.
d'Orbigny, 1826. *Ann. Sci. Nat.*, ser. 1, 7:267 Modeles 65

Sphaeroidina variabilis Reuss, (226)
Reuss, 1851. *Z. dtsch. geol. ges.*, 3:88, pl.7, fig. 61-64
Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):89 Pl.27 fig.534-535.

Genus VIRGULINA d'Orbigny
Virgulina schreibersiana Czjzek, (512)
Virgulina schreibersiana Czjzek, 1848. *Haidinger's Naturw. Abh.* 2:11, pl.13, fig.18-21.
Virgulina schreibersiana Cushman, 1937. *Spec. Publ. Cushman Lab.* 9:13, fig.11-20.

Family TRICHOHYLIDAE Saidova, 1981
Genus BUCCELLA Anderson, 1952
Buccella lotella Hornibrook, (234) Plate 13: Figures h, i.
Hornibrook, 1961. *N.Z. Geol. Surv. Pal, Bull.*, 34(1):110 Pl.15 figs.314-315.

Family BAGGINIDAE Cushman, 1927
Genus CANCRIS de Montfort, 1808
Cancris intermedius Cushman and Todd, (534)
Cancris auricula (Fitchell&Moll), Chapman, Parr&Collins, 1934. *Jnl. Linn Soc. Lond. Zool.*, 38:567, pl. 10, figs. 24a-c
Cancris intermedius Cushman&Todd, 1942. *Contr. Cush. Lab. Foram. Res.*, 18(4):88, 89, pt. 22, figs. 11, 12

Cancris laevinflatus Hornibrook, (264)
Plate 13: Figures f, g.
Hornibrook, 1961. *N.Z. Geol. Surv. Pal, Bull.*, 34(1):120, pl.15, fig.328,331,332

Genus VALVULINERIA Cushman, 1926
Valvulineria kalimnensis (Parr), (620)
Plate 14: Figures r,s.
Planulina kalimnensis Parr, 1939. *Min. & Geol. Jnl.*, 1(4):69, pl.1, figs.19a-c
Valvulineria kalimnensis Carter, 1958. *Geol.Surv.Vict. Mem.no.23*, p.101, pl.8, figs157-167

Family DISCORBIDAE Ehrenberg, 1838
Genus COLONIMILESIA McCulloch, 1977
Colonimilesia sp., (570) Plate 13: Figures f, g, h.
Small trochospiral test has a circular outline. Six broken final chambers show small rounded openings at the center of chamber; test wall covered with small pustules, finely perforate; periphery limbate. Resembles *Discorbitina* Sellier cf. *D. pustulata* Heron-Allen and Earland. Rare specimens are identified from MBT-5 at Wirha - the late Oligocene in the Murray Basin.

Genus DISCORBIS Lamarck, 1804
Discorbis balcombensis Chapman, Parr & Collins, (56)

1934. *Jnl. Roy. Soc. Lond. Zool.*, 38:562,563, pl. 8, figs. 10a-c.

Discorbis cycloclypeus Howchin and Parr, (91)
Howchin and Parr, 1938, *Trans. Roy. Soc. S.Aust.*, 62:287-317, Pls.15-19

Discorbis pseudodiscoides van Bellen, (57) Plate 13: Figures l, m.
van Bellen, 1946. *Geol. Stichting, Meded., Haarlem*, ser. C, 5(4):53, pl. 6, figs. 10-12.

Family DISCORBINELLIDAE Sigal, 1952
Genus DISCORBINELLA Cushman and Martin, 1935
Discorbinella biconcava (Jones and Parker), (203) Plate 13: Figure d, e.
Carter, 1964, *Geol. Surv. Vict.*, Mem.no.23:86 Pl.5 figs.97-100

Discorbinella papillata (Carter), (93) Plate 16: Figure g, h.
Discorbis betheloti var. *papillata* (Chapman, Parr&Collins), 1934. *Journ. Linn. Soc. Lond. Zool.*, 38:561, pl. 9, figs. 14a-c.
Discorbinella papillata (Chapman, Parr&Collins), Carter, 1964, *Geol. Surv. Vict., Mem.* no.23:87-88 Pl.5 figs.105-107

Discorbinella rarescens (Brady), (277)
Discorbina rarescens Brady, 1884. *Rep. Voy. Challenger, Zool.* (9):651, pl.90, fig. 2-3
[*non*] *Discorbina rarescens* Chapman, 1926. *N.Z. geol. Surv. paleont. Bull.* 11:76, pl.15, fig.8
Planodiscorbis rarescens Vella, 1957. *N.Z. geol. Surv. paleont. Bull.* 28:10 (list).
Discorbinella rarescens (Brady), Hornibrook, 1961. *N.Z. Geol. Surv. Pal, Bull.*, 34(1):117, pl.14, fig.292-294, 298

Genus LATICARININA Galloway and Wissler, 1927
Laticarinina altocamerata (Heron-Allen & Earland), (95) Plate 13: Figure a.
Truncatulina tenuimargo Brady, 1884. *Rep. Voy. Challenger, Zool.*, 9:662, pl. 93, fig. 2.
Truncatulina tenuimargo var. *alto-camerata* Heron-Allen & Earland, 1922. *Brit. Antarct. (Terra Nova) Exped. Rep., Zool.* 6(2):209, pl. 7, figs. 24-27.
Truncatulina tenuimargo Chapman, 1926. *N.Z. geol. Surv. paleont. Bull.* 11:78, pl.16, fig.1.
Parvicarinina altocamerata Finlay, 1940. *Trans. Roy. Soc. N.Z.* 69(4):467, pl.62, fig.30-34.
Parvicarinina altocamerata Finlay & Marwick, 1940. *Trans. Roy. Soc. N.Z.* 70(1):111.

Boersma (1985) suggested that *Laticarinina altocamerata* and *Heronallenia spp.* migrated into the Atlantic by about Zone P21 during the Oligocene. This species and more typically *L.coronata* occurs occasionally in the Oligocene in the all basins.

Laticarinina coronata (Heron-Allen & Earland), (94) Plate 13: Figure b, c.
Discorbis coronata Heron-Allen & Earland, 1932. *Discovery Rept.* 4:416, pl.14, fig.25-30.
Parvicarinina coronata (Heron-Allen&Earland), Hornibrook, 1961. *N.Z. Geol. Surv. Pal, Bull.*, 34(1):118, pl. 15, figs. 311, 310, 318

Family ROSALINIDAE Reiss, 1963

Genus GAVELINOPSIS Hofker, 1951

Gavelinopsis pukeuriensis Hornibrook, (449)

Hornibrook, 1961. *N.Z. Geol. Surv. Pal, Bull.*, 34(1):104, pl.13, fig.267, 270, 271

Genus NEOCONORBINA Hofker, 1951

Neoconorbina terquemi (Rzehak), (229)

Rosalina orbicularis Terquem, 1876. *Essai sur le classement des animaux qui vivent sur la plage et dans les environs de Dunkerque*, Fasc. 2. Paris, p. 75

Discorbina terquemi Rezhak, 1888. *Verhandlungen der Geologischen Bundesanstalt*, p.228

Genus PLANODISCORBIS Bermúdez, 1952

Planodiscorbis irregularis Carter, (519)

Carter, 1964. *Geol. Surv. Vict., Mem. 23*, p.88, pl. 6, figs. 108-112.

Genus ROSALINA d'Orbigny, 1826

Rosalina augur Hornibrook, (458)

Hornibrook, 1961. *N.Z. Geol. Surv. Pal. Bull.*, 34(1):102, pl. 13, fig. 263, 265, 268

Rosalina concinna (Brady), (101)

Rosalina concinna Brady, 1884. *Rep. Voy. Challenger, Zool.*, 9:646, pl. 90, fig. 7-8.

Genus TROCHULINA d'Orbigny 1839

Trochulina dimidiata (Jones & Parker), (624)

Discorbis dimidiata Parker & Jones, 1862. In 'Introduction to the study of foraminifera', Carpenter, W.B., Parker, W.K. & Jones, T.R. London:Ray Soc., p. 201.

Family EPISTOMINIDAE Wedekind, 1937

Genus HOEGLUNDINA Brotzen, 1948

Hoeglundina elegans (d'Orbigny), (156)

Plate 16: Figure f.

Rotalia (Turbinuline) elegans d'Orbigny, 1826. *Ann. Sci. Nat. Ser.*, 1, 7:276.

Höglundina elegans Brotzen, 1948. *Sverig. geol. Unders. Avh.*, Ser.C, 493:92.

Family SIPHONINIDAE Cushman, 1927

Genus SIPHONINA Reuss 1850

Siphonina australis Cushman, (139) Plate 13: Figure u.

Siphonina australis Cushamn, 1927. *Proc. U.S. nat. Mus.*72(2716):8pl.2, fig.6, pl.3 fig.7-8.

Family HETEROLEPIDAE Gonzales-Donoso, 1969

Genus ANOMALINOIDES Brotzen, 1942

Anomalinoides pinguinglabra (Finlay), (67) Plate 11: Figure l.

Anomalina pinguinglabra Finlay, 1940, *Trans. Roy. Soc. N.Z.*, 69(4):460 Pl.66 figs.160-165.

Anomalinoides granosa (Hantken), (307)

Plate 11: Figure e.

Truncana granosa Hantken, 1875. *Mitt. Jahrb. Ung. Geol. Anst.*, 4:74-75, pl.10, figs. 2a-b.

Anomalina (Anomalina) granosa (Hantken), Fursenko & Fursenke, 1961. *Pal. Strat. BSSR, sbornik*, 3:289, pl. 6, figs. 1a-c.

Anomalinoides granosa (Hantken), Saperson & Janal, 1980. *Micropal.*, 26(4):398, pl. 1, figs. 4a-c, 5a-c.

Anomalinoides macralabra (Finlay), (66) Plate 11: Figures c, d.
Anomalinoides macralabra Finlay, 1940, *Trans. Roy. Soc. N.Z.*, 69(4):460 Pl.66 figs.141-143
Anomalinoides macralabra Finlay & Marwick, 1940. *Trans. roy. Soc. N.Z.*, 70(1):114, 122.

Anomalinoides nonionoides (Fursenko & Fursenko), (198) Plate 11: Figures a, b.
Anomalina (Anomalina) nonionoides Fursenko & Fursenko, 1961. *Pal. Strat. BSSR, sbornik*, 3:290, pl. 6, figs. 7a-b.
Anomalinoides nonionoides (Fursenko & Fursenko), Saperson & Janal, 1981. *Micropal.*, 26(4):399, pl. 1, figs. a-c.

Anomalinoides procolligera Carter, (241) Plate 11: Figure i.
Carter, 1958. *Bull. Geol. Surv. Vict.*, No.55, p.49, pl.6, figs. 60-63.

Anomalinoides umbonata Cushman, (180)
Cushman, 1925, *Amer. Assoc. Petr. Geol. Bull.*, 9(2):300 Pl. 7 figs. 5-6.

Family CERATOBULIMINIDAE Cushman, 1927
Genus LAMARCKINA Berthelin, 1881
Lamarckina airensis Carter, (469) Plate 16: Figures. i, j.
Carter, 1958. *Geol. Surv. Vict. Bull.*, 55:65, pl.10, figs107-109.

Lamarckina glencoensis Chapman & Crespin, (104) Plate 16: Figures k, l.
Lamarckina glencoensis Chapman & Crespin, 1930, *Proc. Roy. Soc. Vict.*, 43(N.S.):99, 100; Pl.5
Lamarckina glencoensis Chapman & Crespin,. Crespin, 1950. *Contr. Cush. Foram. Res.* Vol.1 pts.3&4, p.74. pl.10, figs. 13 a,b.
Lamarckina glencoensis Chapman & Crespin. Raggatt & Crespin, 1955. *Proc. Roy. Soc. Vic. (n.s.)* Vol.67. pt.1. pl.7, figs. 13 a,b.

Family NONIONIDAE Schultze, 1854
Genus ASTRONONION Cushman and Edwards, 1937
Astrononion australe Cushman and Edwards, (276) Plate 11: Figure g.
Cushman and Edwards, 1937, *Contr. Cushman Lab. Foram. Res.*, 13(1):33 Pl.3 figs.13-14

Astrononion centroplax Carter, (86) Plate 11: Figure f.
Carter, 1958, *Bull. Geol. Surv. Vict.*, 55:61-63, Pl. 9, figs. 95-97.

Genus NONIONELLA Cushman, 1926
Nonionella excavata (d'Orbigny) var *nammaliensis* Haque (452)
Haque, 1956, *Geol. Surv. Mem., Pal. Pakistanica*, Quetta, 1:11.

Genus PULLENIA Parker and Jones, 1862
Pullenia bulloides (d'Orbigny), (81) Plate 11: Figure u.
Nonionina bulloides d'Orbigny, 1846. *Foraminifères Fossilels du Bassin Tertiaire de Vienne. Gide et Comp.*, Paris, p.107, pl.5, fig.9-10.

Pullenia sphaeroides d'Orbigny, 1926.
Chapman, *N.Z. geol.Surv. palaeont. Bull.*, 11:74, pl.15, fig.1.
Pullenia bulloides Finlay, 1946. *Trans. Roy. Soc. N.Z.*, 76(2):243 (list).
Pullenia sphaeroides Dorreen, 1948. *J. Palaeont.*, 22:(3):298.
Pullenia bulloides Vella, 1957. *N.Z. geol. Surv. palaeont. Bull.*,28:10 (list).
d'Orbigny, 1826, *Ann. Sci. Nat.*, 7:293.

Pullenia quinqueloba (Reuss), (82) Plate 10: Figure s,t
Nonionina quinqueloba Reuss, 1851. *Zeitschr. deutsch. Geol. Ges.*, 19(1):71, pl.5, fig.31.
Pullenia quinqueloba (Reuss) Chapman and Todd, 1943, *Contr. Cushman Lab. Foram. Res.*, 91(1):10-11, pl.2, fig.5, pl.3, fig.8.(NB.Carter, A.N. 1958. Tertiary foraminifera from the Aire District, Victoria. *Geological Survey of Victoria*, Bull.No.55, p.32)
Pullenia quinqueloba Finlay, 1946. *Trans. roy. Soc. N.Z.*, 76(2):243 (list).
Pullenia bulloides Vella, 1957. *N.Z. geol. Surv. palaeont. Bull.* 11:10 (list).
Figure 10s appears similar to *P. elegans* Cushman & Todd with six chambers in the final whorl but has been combined with *P. quinqueloba* in this study.

Genus ZEAFLORILUS Vella, 1962
Zeaflorilus stachei (Cushman), (269)
Nonion stachei Cushman, 1936. Contr. Cushman Lab., 12(3):66, pl. 12, fig. 7.
Zeaflorilus stachei Hornibrook et al., 1989. *N.Z. Geol.Surv., Bull.56*, p.103, fig. 20:9

Zeaflorilus victoriense (Cushman), (268)
Plate 16: Figure m.
Nonion victoriense Cushman, 1936. *Contr. Cush. Lab. Foram. Res.*, 12(3):67, 68, pl.12, figs. 10 a, b.
Family ROBERTINIDAE Reuss, 1850
Genus CEROBERTINA FINLAY, 1939
Cerobertina bartrumi Finlay, (495)
Finlay, 1939. *Trans. Roy. Soc. N.Z.*, 69(1):118, pl. 11, fig. 2,3

Cerobertina kakahoica Finlay, (105) Plate 16: Figures o, p.
Finlay, 1939. *Trans. Roy. Soc.N.Z.*, 69(1):120, pl. 13, fig. 59.

Family SPIRILLINIDAE Reuss, 1862
Genus SPIRILLINA Ehrenberg, 1843
Spirillina decorata Brady, (64) Plate 3: Figure t.
Spirillina decorata Brady, 1884, *"Challenger" Exped. Sci. Results*, Zool.,9
Spirillina decorata Brady. Chapman, Parr & Collins, 1934. *J. Linn.Soc. Lond. Zool.*, 38:558,559, pl.8, fig.1.
Spirillina decorata Brady. Parr, 1950. *B.A.N.Z.A.R.E. Repts. Ser. B.*, Vol.5(6):348.

Spirillina medioscabra Carter, (635) Plate 3: Figure q.
Carter, 1958. *Geol. Surv. Vict.*, Bull. 55, p. 36, pl. 3, figs. 24, 25

Spirillina striatogranulosa Terquem, (446)
Terquem, 1882. *Mem. Soc. Geol. de France* Ser. 3, tome 2, No. 3, p. 33.

Very rare. A single specimen identified from in Magrath Flat 1 in the Murray Basin.

Spirillina tuberosa Carter, (212)
Carter, 1958. *Geol. Surv. Vict.*, Bull. 55, p. 38, pl. 4, figs. 30, 31.

Spirillina unilatera Chapman, (259)
Spirillina decorata Brady var. *unilatera* Chapman, 1902. *Jnl. Linn. Soc. Lond. (Zool.)*, 28:410.
Spirillina unilatera Brady, Carter, 1958. *Geol. Surv. Vict.*, Bull. 55, p.38, pl. 4, figs. 26-29.

Spirillina cf. **grosseperforata** Zheng, (218) Plate 3: Figures r, s.
Zheng, 1979. *Studia Marina Sinica*, 16:174, 222, pl.19, fig. 12.
Planispiral, irregularly perforated test. Has depressed spiral suture both sides of test. Undivided tubular chamber with increasingly enlarged later walls.

Family STILOSTOMELLIDAE Finlay, 1947
Genus STILOSTOMELLA Guppy, 1894
Stilostomella antipoda (Stache), (227)
Nodosaria antipodum Stache, 1865. *Novara-Exped., Geol. Theil*, 1(2):194, pl. 22, fig. 19.
Nodosaria radicula Linnaeus, Chapman, *N.Z. geol. Surv. Palaeont. Bull.*, 11:52, pl. 3, fig. 19.
Stilostomella antipoda (Stache), Hornibrook, 1961. *N.Z. geol. Surv. paleont. Bull.* 34(1):49, pl. 6, fig. 98.

Family TRUNCOROTALOIDIDAE Loeblich and Tappan, 1961
Genus ACARININA Subbotina, 1953
Acarinina collactea (Finlay), (286)
Globorotalia collactea Finlay, 1939. *Trans. Roy. Soc. N.Z.*, 69(3):327, pl. 29, fig. 164-165

Family UVIGERINIDAE Haeckel, 1894
Genus ANGULOGERINA Cushman, 1927
Angulogerina camagüeyana (Bermudez), (556) Plate 10: Figure h.
Uvigerina camagüeyana Bermudez, 1937. *Soc. Cubana Hist. Nat. Mus.*, 11:144, pl. 17, fig. 10.

Angulogerina carinata Cushman, (209)
Cushman, 1927. *Bull. Scripps Inst. Oceanogr., California Univ.*, Tech. Ser., 1:159

Angulogerina elliptica Dorreen, (305)
Dorreen, 1948. *Journ. Palaeont.*, 22(3):293 Pl.38 figs.9a-b

Angulogerina esuriens Hornibrook, (18)
Hornibrook, 1961. *N.Z. Geol. Surv. Pal. Bull.*, 34(1):69 Pl.9, figs.154-155

Angulogerina tenuistrata (Reuss), (58) Plate 10: Figure d.
Reuss, 1870. *K.Akad. Wiss. Wien, Math-Naturw, Cl.,Sitzber.*, Wien, Bd.62 Abt.1:485, Pl.22 figs.34-37

Genus KOLESNIKOVELLA N.K.Bykova, 1958
Kolesnikovella australis (Heron-Allen&Earland), (20) Plate 10: Figures a, b.
Uvigerina canariensis var. *australis* Heron-Allen&Earland, 1924. *Jnl. Roy. Micros. Soc.*, p.64, pl.11, fig. 67-70

Angulogerina australis (Heron-Allen&Earland), Hornibrook, 1961. *N.Z. Geol. Surv. Pal. Bull.*, 34(1):67, pl.9 fig. 157

Kolesnikovella australis (Heron-Allen&Earland), Hornibrook et al., 1989. *N.Z. Geol.Surv., Bull.56*, p.94, fig.17:4.

Small smooth sub-cylindrical test, aperture on lipped neck. Very common species in all basins in the Oligocene.

Genus NEOUVIGERINA Thalman, 1952

Neouvigerina porrecta (Brady), (596)

Uvigerina porrecta Brady, 1884. *"Challenger" Exped. Sci. Results*, Zool.,9

Neouvigerina porrecta (Brady), Hofker, 1951. *Siboga Exped.*, Foram. Pt. 3, p. 213

Genus SIPHOUVIGERINA Parr, 1950

Siphouvigerina proboscidae (Schwager), (21) Plate 10: Figure g.

Uvigerina proboscidea Schwager, 1866. *Novara Exped. Geol. Theil.*, Bd.2, Abt.2:250, Pl.7, fig.96

Siphouvigerina proboscidea (Schwager), Hayward&Buzas, 1979. *Smithsonian Contrib. to Paleobiology*, No.36, p.74, pl.27, fig.334.

Very common to abundant throughout the Oligocene, particularly the Gambier Basin.

Genus TRIFARINA Cushman, 1923

Trifarina bradyi Cushman, (22) Plate 10: Figure e.

Rhabdogonium tricarinatum (d'Orbigny), Brady, 1884. *Rep. Zool.*, 9:525, pl.67, figs.1-3.

Cushman, 1923. *U.S. Nat. Mus. Bull.*, 104:99, pl.22, figs.3-9

Trifarina costornata (Hornibrook), (219)

Angulogerina costornata Hornibrook, 1961. *N.Z. geol. Surv. paleont. Bull.* 34(1):68, pl.9, figs.149.150.

Trifarina costornata (Hornibrook), Hayward & Buzas, 1979. *Smithsonian Contributions to Paleobiology*, 36:76, pl.28, fig.345.

Trifarina parva Hornibrook, (370)

Hornibrook, 1961. *N.Z. Geol. Surv. Pal. Bull.*, 34(1):71 Pl.9 figs. 161-162

Trifarina tortuosa (Hornibrook), (147)

Plate 10: Figure f.

Angulogerina costornata Hornibrook, 1961. *N.Z. geol. Surv. paleont. Bull.* 34(1):68, pl.9, figs.151, 152.

Trifarina tortuosa (Hornibrook), Hayward & Buzas, 1979. *Smithsonian Contributions to Paleobiology*, **36**::76, pl.28, fig.345.

Genus UVIGERINA d'Orbigny, 1826

Uvigerina abbreviata Terquem, (400)

Terquem, 1882. *Soc. Geol. Mem. Ser.*, 3(2) no.3:120, Pl. 12 fig. 33.

Uvigerina alabamensis Cushman and Garrett, (401)

Cushman and Garrett, 1939. *Contr. Cushman Lab. Foram. Res.*, 15(4):83.

Uvigerina cushmani Todd, (352)

Todd, 1913. *Allan Hancock Pacific Exped.*, 6(5):257.

Uvigerina bortotora (Finlay), (23)

Hopkinsina bortotora Finlay, 1939. *Trans. roy. Soc. N.Z.* 69(1):104, pl.12, fig22-24.
Hopkinsina bortotora Finlay & Marwick, 1940. *Trans. roy. Soc. N.Z.* 70(1):108,111.
Uvigerina bortotors Finlay & Marwick, 1947. *N.Z. Sci. Tech.* B28(4):232.
Uvigerina bortotors Dorreen, 1948. *J. Paleont.* 22(3):292, pl.38 fig.6.
Uvigerina bortotors (Finlay), var. *costata* Dorreen, Ibid.:293, pl. 38. fig. 5.

Uvigerina gallowayi Cushman, (100)
Plate 10: Figure w.
Cushman, 1929. *Contrib. C`ushman Lab. Foram. Res.*, 5(4):94, pl. 13, figs. 33,34.

Uvigerina russelli Howe, (29)
Howe, 1939. *Louisiana Dept. Conserv. Geol. Surv., Geol. Bull.* no.14:71 Pl.8 figs.21-22.

Uvigerina rustica Cushman and Edwards, (402) Plate 10: Figure c.
Cushman and Edwards, 1938. *Contr. Cushman Lab. Foram. Res.*, 14(4):83 Pl. 14, fig. 6.

Uvigerina spinulosa Hadley, (28) Plate 10: Figure u.
Uvigerina spinulosa Hadley, 1934. Bull. Amer. Pal., Ithaca, N.Y. USA, 20(70A):18.
Uvigerina spinulosa Hadley, Boersma, 1984. Handbook of common Tertiary Uvigerina, Microclimates Press, N.Y., p. 163-165, fig. 6.

Family VAGINULINIDAE Reuss, 1860
Genus LENTICULINA Lamarck 1804
Lenticulina convergens (Bornemann), (351) Plate 6: Figure g.
Cristellaria convergens (Bornemann), Brady, 1884. *Sci. Res. of Voy. of H.M.S. Challenger*, V.9, pl. 69, figs. 6,7.
Lenticulina convergens (Bornemann), Barker, 1960, *Soc. Econ. Paleont. Min.*, Spec. Pub. No.9, p. 144, pl.69, figs. 6, 7.

Lenticulina (Robulus) cultrata (de Montfort), (521)
Robulus cultratus Montfort, 1808. *Conchyliologie Systematique et Classification Méthodique des Coquilles.* Paris, 1:215, text fig. p.214.
Lenticulina cultrata (de Montfort), Quilty, 1974. *Pap. Proc. Roy. Soc. Tas.*, 108:72, pl. 4, fig. 111.

Lenticulina denticulifera (Cushman), (220)
Cristellaria denticulifera Cushman, 1913. *U.S.N.M. Bull.*, 71(3):75
Lenticulina denticulifera (Cushman), Thalman, 1937. *Eclog. geol. Helvet.*, 30(2)

Lenticulina erratica Hornibrook, (41)
Hornibrook, 1961. *N.Z. geol. Surv. paleont. Bull.* 34(1):38, pl.4, fig.65, 66

Lenticulina foliata (Stache), (244) Plate 6: Figure b.
Robulina foliata Stache, 1864. *Novara-Exped., Geologie*, 1(2):284, pl.23, fig.24.
Lenticulina foliata (Stache), Hayward&Buzas, 1979. *Smithsonian Contributions to Paleobiology*, 36:63.

Lenticulina gibba (d'Orbigny), (245) Plate 6: Figure c.

Cristellaria gibba d'Orbigny, 1839. *Histoire physique politique et naturelle de l'Ile de Cuba,* Bertrand, Paris, p.40, pl.7, figs.20,21.
Lenticulina gibba (d'Orbigny), Hornibrook, 1961. *N.Z. geol. Surv. paleont. Bull.* 34(1):39, pl.3, fig.50.

Lenticulina (Robulus) gyroscalprum (Stache), (43) Plate 6: Figure a.
Cristellaria gyroscalprum Stache, 1865. *Novara-Exped., Geol. Theil.*, 1:245 Pl. 23 fig. 22
Cristellaria gyroscalprum Chapman, 1926. *N.Z. Geol. Survey Palaeont. Bull.* 11:62, pl. 4, fig. 22.
Robulus gyroscalprum Dorreen, 1948. *J. Paleont.* 22(3):288, pl. 4, fig. 22.
Subcircular test in outline, with marked keel, radial bars at the aperture. Appears similar to *R. orbicularis* (d'Orbigny). This species is common in late Eocene to Oligocene assemblages in all basins.

Lenticulina loculosa (Stache), (528)
Robulus loculosa Stache, 1864. *Novara-Exped. geol.* 1(2):246, pl. 23, fig. 25.
Lenticulina loculosa (Stache), Hayward, B. W. and Buzas, M. A. 1979. *Smithsonian Contributions to Paleobiology,* 36:63

Lenticulina* cf *nitida (Reuss), (39) Plate 6: Figure k.
Reuss, 1863 (b), *Naturwissenschaftlichen Classe*, 55(1):54 Pl. 6, fig. 60.

Lenticulina planula (Galloway & Heminway), (428) Plate 6: Figure j.
Robulus planula Galloway & Heminway, 1941. *Sci. Surv. of Porto Rico & the Virgin Is.*, 3(4):350, pl.11, fig.14.
Lenticulina planula (Galloway & Heminway), Hayward & Buzas, 1979. *Smithsonian Contrib. to Paleobiol.*, 36:64, pl.20, figs. 250-252.
Referred to as *Robulus* cf. *venezuelanus* (Hedberg) by Abele (1961) who recorded rare specimens in the 'uppermost zones' of the Gambier Limestone. Figured specimen is a very rare example from Interval C.

Lenticulina (Robulus) pliocaenicus (Silvestri), (166) Plate 6: Figure d.
Polymorphina pliocaenicus Silvestri, *Atti. Accad. Pont. Nouvi Lincei,* 56
Robulus pliuocaenicus (Silvestri), Thalman, 1932. *Eclog. geol. Helvet.*, 25(2):252

Genus MARGINULINA d'Orbigny, 1826
Marginulina duracina Stache, (211) Plate 6: Figure p.
Stache, 1865. Novara-Exped., Geol. Theil, 1(2):211, pl. 22, fig. 42

Marginulina obesa Cushman, (572)
Marginulina obesa Cushman, 1923. *U.S.N.M. Bull.*, 104(4):128
Marginulina obesa Barker, 1960. *Soc. Econ. Paleont. Min.*, Spec. Pub. No.9, p. 136, pl. 65, figs. 5,6.

Marginulina sp. [369] Plate 5: Figure v.
Very rare in early Oligocene samples, Otway Basin.

Genus MARGINULINOPSIS A.Silvestri, 1904

Marginulinopsis allani (Finlay), (429)
Marginulina allani Finlay, 1939. *Trans. Roy. Soc. N.Z.*, 69(3):318, pl.26, figs.55,56.
Marginulinopsis allani Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):43, pl.5, fig. 69

Marginulinopsis bradyi (Goës), (217)
Cristellaria bradyi Goës, 1894. *Kong. Sven. Vet. - Akad. Handl.*, 25(9):64, fig. 11.
Marginulinopsis bradyi (Goës), Barker, 1960. *Soc. Econ. Paleont. Min.*, Spec. Pub. No.9, p.136, pl. 65, fig. 10, 12, 13

Marginulinopsis hydropica Hornibrook, (97) Plate 5: Figure n.
Hornibrook, 1961, *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):43

Genus PLANULARIA Defrance, 1826

Planularia australis Chapman, (215) Plate 6: Figure t.
Chapman, 1915. *"Endeavor", Sci. Res.*, 3(1):24

Genus SARACENARIA Defrance, 1824

Saracenaria arcuatula (Stache), (557) Plate 6: Figure r.
Hemirobulina arcuatulata Stache, 1864. Novara-Exped. Geol., 1(2):227, pl. 23, figs. 6a,c.
Hemicristellaria procera Stache, 1864. Novara-Exped. Geol., 1(2):222, pl. 23, figs. 1a,b.
Saracenaria arcuatula (Stache), Hornibrook, 1961. *N.Z. geol. surv. Palaeont. Bull.*, 34(1):40.
Saracenaria arcuatula (Stache), Hornibrook, 1971. *N.Z. geol. surv. Palaeont. Bull.*, 43:41, pl. 8, figs. 130, 131.

Saracenaria obesa Cushman&Todd, (223)
Cushman&Todd, 1945. *Spec.Pub. Cushman Lab. Foram. Res.*, 25(3):31, pl.5, fig.2
Very rare occurrences in the late Oligocene in the Gambier Embayment. Assemblage zones G and H.

Genus VAGINULINA d'Orbigny, 1826

Vaginulina americana Cushman, (563)
Cushman, 1923. *US Nat. Mus Bull.*, Washington, D.C., No.104, p.135.

Vaginulina awamoana Hornibrook, (489)
Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):44, pl.5, fig.77, 81, 82

Vaginulina elegans d'Orbigny, (148) Plate 5: Figure h.
d'Orbigny, 1826. *Annls. Sci Nat,* 7:257 'Modèles' 54.
Hornibrook, 1961. *N.Z. Geol. Survey Palaeont. Bull.*, 34(1):44, pl.5, fig. 87.
Listed as *V. elegans* but figured specimen is very similar to the northern hemisphere species *Dentalina baggi* Galloway & Wissler, with an elongate test and a round initial chamber.

Genus VAGINULINOPSIS Silvestri, 1904

Vaginulinopsis acanthonucleus Carter, (501) Plate 5: Figure a.
Carter, 1958. *Geol. Surv. Vict., Bull. No. 55*, p. 30, pl. 2, fig. 4.

Vaginulinopsis hochstetteri (Stache),
(499)
Cristellaria (Marginulina)hochstetteri Stache,
1865. *Novara-Exped., Geol. Theil,* 1(2):221,
pl.22, fig.55
Vaginulinopsis hochstetteri (Stache),
Hornibrook, 1971. *N.Z. geol. Surv. paleont. Bull.,* 43:39, 40, pl.8, fig.127

APPENDIX B - SPECIES LIST

SPECIES	T.C.	FAMILY	SPECIES	T.C.	FAMILY
Alabamina tenuimarginata (Chapman, Parr & Collins)	63	ALABAMINIDAE Fig. 14a-c	Lagena curvicostata Heron-Allen&Earland	636	LAGENIDAE Fig. 7h
Ammonia beccarii (Linné)	65	ROTALIIDAE Fig. 14e	Lenticulina (Robulus) atlanticus Barker	591	VAGINULINIDAE
Ammonia nanus (Hornibrook)	465	ROTALIIDAE	Lenticulina (Robulus) colorata (Stache)	629	"
Amphicoryna cf A. halkyardi (Cushman)	279	VAGINULINIDAE Fig. 5e	Lenticulina (Robulus) cultratus (de Montfort)	521	"
Amphicoryna paucilocatulata (Cushman)	302	" Fig. 6d	Lenticulina (Robulus) gyroscalprus (Stache)	43	" Fig. 6a
Amphicoryna proxima var	239	"	Lenticulina (Robulus) loculosa (Stache)	222	"
Amphicoryna scalaris (Batsch)	225	"	Lenticulina (Robulus) pliocaenicus (Silvestri)	166	" Fig. 6d
Amphicoryna scalaris (Batsch) var	240	" Fig. 6s	Lenticulina (Robulus) plummerae	364	"
Amphicoryna sp.1	178	"	Lenticulina cf L. nitida (Reuss)	39	" Fig. 6k
Amphistegina lessonii d'Orbigny	42	AMPHISTEGIN. Fig. 4t	Lenticulina convergens (Bornemann)	351	" Fig. 6g
Angulogerina (Trifarina) tortuosa (Hornibrook)	147	UVIGERINIDAE	Lenticulina denticulifera (Cushman)	220	"
Angulogerina angulosa Cushman	255	"	Lenticulina erratica Hornibrook	41	"
Angulogerina carnegieyana (Bermudez)	483	"	Lenticulina foliata (Stache)	244	" Fig. 6b
Angulogerina carinata Cushman	209	"	Lenticulina gibba (d'Orbigny)	245	" Fig. 6c, h.
Angulogerina esuriens Hornibrook	18	"	Lenticulina lucida (Cushman)	532	"
Angulogerina multistriata (Hantken)	556	"	Lenticulina peregrina (Schwager)	184	" Fig. 6q
Angulogerina tenuistrata (Reuss)	58	"	Lenticulina planula (Galloway&Heminway)	428	" Fig. 6j
Anomalinoides (Bore#3, Millicent)	306	HETEROLEPIDAE	Lenticulina punctata (Rzehak)	537	"
Anomalinoides granosa (Hantken)	307	"	Lenticulina sp (Dun., 2W)	365	"
Anomalinoides macralabra (Finlay)	66	" Fig. 11c,d	Lenticulina sp (WMC507)	564	"
Anomalinoides nonionoides (Fursenko&Fursenko)	198	"	Lenticulina sp.2 (OB2)	432	"
Anomalinoides pinguinglabra (Finlay)	67	"	Lenticulina thalmanni (Hessland)	216	" Fig. 6i
Anomalinoides procolligera Carter	241	" Fig. 11f	Liebusella rudis	368	GLOBOTEXTULARIIDAE
Anomalinoides sp 1	68	"	Liebusella soldanii (Jones&Parker)	571	GLOBOTEXTULARIIDAE
Anomalinoides sp. 2 (=A. umbonata)	180	"	Linderina sp (MBT)	451	LINDERINIDAE
Anomalinoides sp.3	308	"	Linderina sp (OB2)	75	LINDERINIDAE
Arenodosaria antipoda (Stache)	254	EGGERELLIDAE Fig. 3j	Lingulina bartrumi (Chapman)	423	NODOSARIIDAE
Arenodosaria sp. (Dun., 2W)	448	"	Lingulina semilineata Chapman	2	"
Arenodosaria sp. (MF1)	436	"	Lingulina sp nov	604	"
Astacolus cf. A. judyae Hornibrook	252	" Fig. 6n	Lingulina sp.2 (2W)	609	"
Astacolus crepidulus (Fitchel&Moll)	613	VAGINULINIDAE Fig. n	Lingulina sp.2 (OB2)	614	"
Astacolus neolatus Vella	590	"	Loxostomum cf. L. limbatum (Brady)	288	LOXOSTOMATIDAE
Astacolus sp*	51	" Fig. 6l, m	Loxostomum lobatum (Brady)	192	"
Astacolus sp.1	96	"	Marginulina coronata	30	POLYMORPHINIDAE
Astacolus sp.2	567	"	Marginulina duracina Stache	211	NODOSARIIDAE Fig. 6p
Astacolus sp.3	99	"	Marginulina obesa Cushman	572	VAGINULINIDAE
Asterigerina adelaidensis (Howchin)	558	ASTERIGERINA	Marginulina sp (WMC507)	369	"
Asterigerina lornensis Finlay	608	ASTERIGERINA	Marginulinopsis allani (Finlay)	429	"
Astrononion australe Cushman&Edwards	276	NONIONIDAE	Marginulinopsis bradyi (Goës)	217	"
Astrononion centroplax Carter	86	"	Marginulinopsis hydropica Hornibrook	97	"
Astrononion sp	456	"	Maslinella chapmani Glaessner&Wade	462	VICTORIELLIDAE
Astrononion sp.1	309	"	Massilina torquayensis (Chapman)	150	HAUERINIDAE
Austrotrillina howchini (Schlumberger)	4	AUSTROTRILLIN. Fig. 4p	Miliolinella oblonga (Montagu)	267	"
Bigenerina nodosaria d'Orbigny	599	EGGERELLIDAE Fig. 3e	Miliolinella subrotunda (Montagu)	263	"
Biloculina bulloides d'Orbigny	481	HAUERINIDAE	Neoconorbina terquemi (Rzehak)	229	ROSALINIDAE
Bolivina decussata Brady	611	BOLIVINIDAE	Neouvigerina porrecta (Brady)	596	ROSALINIDAE
Bolivina elongata Hantken	310	"	Nodosaria albatrossi Cushman	257	NODOSARIIDAE
Bolivina finlayi Hornibrook	16	"	Nodosaria lamnulifera Boomgart	262	"
Bolivina gardnerae Cushman	311	"	Nodosaria longiscata d'Orbigny	497	"
Bolivina intermedia Halkyard	312	"	Nodosaria mutabilis Terquem	136	" Figs. 5b,c,?f
Bolivina jacksonensis Cushman&Applin	10	"	Nodosaria radicula (Linnaeus)	227	"
Bolivina lapsus Finlay	19	"	Nodosaria simplex Silvestri	246	"
Bolivina maculata Cushman&Stone	480	"	Nodosaria sp. 1	50	" Fig. 5o
Bolivina nitida Brady	248	"	Nodosaria sp. 2	371	"
Bolivina osloni (Hornibrook)	151	" Fig. 10j	Nonion sp	299	NONIONIDAE
Bolivina pontis Finlay	210	"	Nonionella excavata (d'Orbigny)	452	"
Bolivina pseudoplicata Heron-Allen&Earland	17	"	Nonionella novozealandica Cushman	460	"
Bolivina reticulata Hantken	185	" Fig. 10q	Nonionella sp (WMC507)	372	"
Bolivina sp.1	313	"	Nonionella sp. (Dun.)	268	"
Bolivina sp.2	314	"	Notorotalia clathrata (Brady)	173	ELPHIDIIDAE
Bolivina targetensis Hornibrook	13	"	Notorotalia howchini (Chapman, Parr&Collins)	247	"
Bolivinella australis Cushman	568	BOLIVINELLIDAE	Notorotalia sp (WMC507)	373	"
Bolivinella elegans Parr	107	BOLIVINELLIDAE Fig. 10m	Notorotalia sp. (AbE, OB2, MBT)	88	"
Bolivinella folia (Parker&Jones)	176	" Fig. 10r	Notorotalia spinosa (Chapman)	87	"
Bolivinopsis cubensis (Cushman&Bermudez)	5	SPIROPLECT. Fig. 10t	Nummoloculina contraria (d'Orbigny)	588	HAUERINIDAE
Bolivinopsis sp.	541	SPIROPLECT. Fig.10s	Nummoloculina irregularis	655	"
Brizalina spathulata (Williamson)	201	BOLIVINIDAE Fig. 10l	Oolina apiculata var	644	ELLIPSOLAGENIDAE
Buccella lotella Hornibrook	234	TRICHOHYAL. Fig. 14h,i	Oolina cf. apiopleura Loeblich&Tappan	638	"
Bucherina sp.2	651	" Fig. 9e	Oolina collaripolygonata Albani&Yassini	630	" Fig. 7q
Bulimina bortonica Finlay	6	BULIMINIDAE	Oolina confluenta McCulloch	631	" Fig. 7p
Bulimina cf. exilis	598	"	Oolina hexagona (Williamson)	31	" Fig. 7a
Bulimina costata d'Orbigny	260	"	Oolina melo d'Orbigny	285	" Fig. 7b
Bulimina pupula Stache	170	"	Oolina sp.	52	"
Bulimina striata d'Orbigny	204	"	Operculina victoriensis Chapman&Parr	79	NUMMULITIDAE
Buliminella basicostata Parr	468	BULIMINELLIDAE	Ophthalmidium sp.	406	OPHTHALMIDIIDAE
Buliminella browni Finlay	282	"	Palliolatella arborea (Matthes)	610	ELLIPSOLAGEN. Pl. 9i
Buliminella cf. californica	411	"	Palliolatella cf bradyiformis (McCulloch)	640	" Fig. 9c
Buliminella seminuda (Terquem)	414	" Fig.10z	Palliolatella cf. L. pulcherrima Cushman&Jarvis	551	"
Buliminella sp.	316	"	Palliolatella laevis (Montagu)	199	" Fig. 7f
Buliminoides chattonesis (Finlay)	37	"	Palliolatella semialata (Balkwill&Millett)	271	" Fig. 9o
Calcarina calcar d'Orbigny	183	CALCARINIDAE Fig. 15u	Parafissurina carinata (Buchner)	581	"
Calcarina mackayi (Karrer)	48	CALCARINIDAE Fig. 15v	Parafissurina costulata Jones	650	"
Cancris intermedius Cushman&Todd	534	BAGGINIDAE	Pararotalia mackayi (Karrer)	455	ROTALIIDAE
Cancris laevinflatus Hornibrook	264	" Fig. 14f,g	Pararotalia verriculata (Howchin&Parr)	83	ROTALIIDAE
Carpentaria rotaliformis Chapman&Crespin	317	VICTORIELLIDAE Fig. 4r	Parrellina centrifugalis Carter	463	ELPHIDIIDAE
Cassidulina carapitana Hedberg	188	CASSIDULIN. Fig. 8w,x	Parrellina crespinae (Cushman)	85	ELPHIDIIDAE
Cassidulina cf margareta Karrer	284	"	Patellina corrugata Williamson	250	PATELLINIDAE
Cassidulina cuneata (Finlay)	135	" Fig. 8r	Patellina sp.	440	"
Cassidulina laevigata d'Orbigny	415	" Fig. 8t	Patellina sp.2	441	"
Cassidulina sp.1	318	"	Planodiscorbis irregularis Carter	519	ROSALINIDAE
Cassidulina sp.2	319	"	Planodiscorbis sp	442	ROSALINIDAE
Cassidulina sp.3	320	"	Planorbulina sp	374	PLANORBULINIDAE
Ceratobulimina lornensis Finlay	106	CERATOBULIMINIDAE	Planorbulinella plana (Heron-Allen&Earland)	103	"
Ceratobulimina sp.	466	CERATOBULIMINIDAE	Planorbulinella roseanna Lindsay	450	"

APPENDIX B - SPECIES LIST

Cerobertina bartrumi Finlay	495	ROBERTINIDAE	Planularia australis	215	VAGINULINIDAE
Cerobertina kakaboica Finlay	105	ROBERTINIDAE Figs. 16o,p	Planularia sp 1	507	* Fig. 6u
Cerobertina sp.	472	ROBERTINIDAE	Planularia sp 2 (?=Vaginulina tenuissima)	433	* Fig. 6t
Cerobertina sp.2	641	ROBERTINIDAE	Planulina evoluta LeRoy	44	PLANULINIDAE Fig. 16n
Chrysalogonium verticale (Stache)	138	NODOSARIIDAE	Planulina halophora	430	*
Cibicides cygnorum Carter	206	CIBICIDINAE	Planulina sp	375	*
Cibicides karreriformis (Hornibrook)	249	* Fig. 12u,v	Planulina wuellerstorfi (Schwager)	283	*
Cibicides lobatulus (Walker&Jacob)	73	* Fig. 12r,s	Plectofrondicularia awamoana Finlay	461	NODOSARIIDAE
Cibicides mediocris Finlay	78	*	Plectofrondicularia proparri (Finlay)	221	* Fig. 6v
Cibicides molestus Hornibrook	162	*	Pleurostomella sp	376	PLEUROSTOMELL. Fig. 5l
Cibicides opacus Carter	321	*	Porosorotalia crassimura (Carter)	92	ELPHIDIIDAE
Cibicides praecipuus Copeland	74	*	Porosorotalia sp.	660	*
Cibicides pseudolobatulus (Perelis & Reiss)	72	*	Procerolagena distoma (Parker&Jones)	625	LAGENIDAE Fig. 7e
Cibicides refulgens de Montfort	278	*	Procerolagena elongata (Ehrenberg)	559	*
Cibicides sp.1 (WMC507)	322	*	Procerolagena gracillima (Seguenza)	168	*
Cibicides sp.2 (WMC507)	324	*	Procerolagena seperans (Batsch)	303	VAGINULINIDAE
Hetorolepa subhaidingeri Parr	179	* Fig. 12f-g	Pseudofissurina obscurocostata	658	ELLIPSOLAGENIDAE
Cibicides thiara (Stache)	25	*	Pseudononion stachi	84	NONIONIDAE
Cibicides vortex Dorreen	77	*	Pseudopatellinoides sp	378	ROSALINIDAE
Cibicides westi Howe	529	* Fig. 12k-m	Pseudopolmorphina tasmanica Parr & Collins	296	POLYMORPHININDAE
Cibicidina sp 1	326	*	Pseudopolymorphina sp	438	*
Cibicidina sp 2	327	*	Pullenia bulloides (d'Orbigny)	81	NONIONIDAE
Cibicidoides brevoralis (Carter)	69	* Fig. 12a,b	Pullenia quinqueloba (Reuss)	82	*
Cibicidoides perforatus (Karrer)	70	* Fig. 12n,o	Pygmaeoseistron sp.	654	LAGINIDAE Fig. 7o
Cibicidoides sp. (OB2)	323	*	Pyrgo cf vespertilio	561	HAUERINIDAE
Cibicidoides temperatus (Vella)	527	* Fig. 12i,j	Pyrgo elongata	228	*
Colonimilesia sp.	570	DISCORBINELL. Fig.13f-h	Pyrgo lucernula	653	HAUERINIDAE
Crespinella sp.	539	PLANULINIDAE	Pyrulina angusta	266	POLYMORPHINIDAE
Crespinina kingscotensis Wade	147	CHAPMANINIDAE	Pyrulina fusiformis (Roemer)	207	*
Cribrigoesella sp.	328	VALVULAMMINIDAE	Pyrulina gutta d'Orbigny	24	* Fig. 8f
Cribrobulimina mixta Cushman	292	*	Pyrulina polita	576	*
Cribrogoesella robusta (Brady)	621	*	Quinqueloculina cf bicornis (Walker&Jacob)	652	HAUERINIDAE
Cribrorotalia cf okokoensis	445	ELPHIDIIDAE	Quinqueloculina cf seminulum (Linnaeus)	623	*
Cribrorotalia dorreeni Hornibrook	457	ELPHIDIIDAE	Quinqueloculina crassicostata Terquem	9	*
Cushmanina desmophora (Rymer-Jones) var	301	ELLIPSOLAGENIDAE	Quinqueloculina intricata Terquem	659	*
Cushmanina plumigera (Brady)	530	* Fig. 7u, t	Quinqueloculina laevigata (d'Orbigny)	1	*
Cushmanina sp.1	657	*	Quinqueloculina lamarckiana d'Orbigny	412	*
Cushmanina spiralis (Brady)	584	*	Quinqueloculina simplex Terquem	297	*
Cushmanina tasmaniae (Quilty)	33	* Fig. 7v	Quinqueloculina sp.1	379	*
Cyclammina incisa (Stache)	46	CYCLAMMINIDAE	Quinqueloculina sp.2	281	*
Cyclogyra involvens (Reuss)	47	CORNUSPIRIDAE	Quinqueloculina tropicalis Cushman	553	*
Dentalina advena (Cushman)	161	NODOSARIIDAE	Quinqueloculina weaveri Rau	3	*
Dentalina cf. communis	330	*	Quinqueloculina zealandica	407	*
Dentalina crassicostata Terquem	155	*	Rectoglandulina cf comatula (Cushman)	578	NODOSARIINAE
Dentalina intorta (Dervieux)	186	*	Rectoglandulina rotunda (Reuss)	243	*
Dentalina johnsoni McLean	141	*	Reussella spinulosa (Reuss)	597	BULIMINIDAE
Dentalina kaicherae McLean	331	*	Robertina cf tasmanica	606	ROBERTINIDAE
Dentalina mutata Costa	140	*	Robertina lornensis Finlay	102	ROBERTINIDAE Fig. 16q
Dentalina semicostata Chapman	332	*	Robertina sp.	467	*
Dentalina semirugosa (d'Orbigny)	333	*	Rosalina augur Hornibrook	458	ROSALINIDAE
Dentalina soluta Reuss	12	*	Rosalina concinna (Brady)	101	*
Dentalina sp. 1	492	*	Saracenaria arcuatula (Stache)	557	VAGINULIN. Fig. 6r
Dentalina sp. 2(Beecroft) =Orthomorphina sp	506	*	Saracenaria cf. S. obesa Cushman&Todd	223	NODOSARIIDAE Fig. 6o
Dentalina subcostata Chapman	417	*	Sherbonina atkinsoni Chapman	637	CHAPMANINIDAE
Dentalina subsoluta (Cushman)	420	* Fig. 5q	Sherbonina cuneimarginata Wade	634	*
Dentostomina sp/Massilina lapidigera (Howchin & Parr)	187	HAUERINIDAE	Sigmavirgulina tortuosa (Brady)	174	FURSENKOINIDAE
Discorbina lucida Karrer	334	DISCORBIDAE	Sigmoidella bortonica Finlay	380	POLYMORPHIN. Fig. 8p
Discorbinella biconcava (Jones&Parker)	203	DISCORBINELLIDAE	Sigmoidella elegantissima (Parker&Jones)	231	POLYMORPHINIDAE
Discorbinella complanata (Sidebottom)	232	*	Sigmoilina asperta	626	HAUERINIDAE
Discorbinella galera (Finlay)	251	*	Sigmomorphina obesa Hornibrook	435	POLYMORPHIN. Fig. 8h
Discorbinella papillata (Chapman, Parr&Collins)	93	*	Sigmomorphina williamsoni (Terquem)	589	*
Discorbinella raresoens Brady (=Planodiscorbis rarescen	277	*	Sigmomorphina wynyardensis Parr&Collins	167	* Fig. 8n
Discorbinella sp	459	*	Sigmopolymorphina lornensis (Hornibrook)	134	*
Discorbinella stachi (see Hayward et al)	335	*	Siphonina australis Cushman	139	SIPHONINIDAE Fig. 14u
Discorbinella timida Hornibrook (=Planodiscorbis timida	336	*	Siphotextularia awamoana Hornibrook	153	TEXTULARIIDAE
Discorbis balcombensis Chapman, Parr&Collins	56	DISCORBIDAE	Siphotextularia concava (Karrer)	272	* Fig. 3d
Discorbis cf finlayi	443	*	Siphotextularia gladizea (Finlay)	49	* Fig. 3c
Discorbis cycloclypeus Howchin&Parr	91	*	Siphotextularia lornensis	580	*
Discorbis finlayi cf balcombensis	56	*	Siphouvigerina proboscidae (Schwager)	21	BULIMINIDAE Fig. 10g
Discorbis pseudodiscoides van Bellen	57	* Figs. 15q,r	Solenenia foliformis (Bruchner)	585	POLYMORPHINIDAE
Discorbis sp.1	55	*	Solenia sp	300	ELLIPSOLAGENIDAE
Discorbis sp.2	337	*	Sphaeroidina bulloides d'Orbigny	410	SPHAEROIDINIDAE
Discorbis sp.3	55	*	Sphaeroidina variabilis Reuss	226	*
Discorbis sp.4	338	*	Spirillina cf. grosseperforata Zheng	218	SPIRILLINIDAE Fig. 3r,s
Discorotalia tenuissima (Karrer)	256	ELPHIDIDIIDAE Fig. 15j	Spirillina decorata Brady	64	* Fig. 3q
Dorothia minima (Karrer)	152	EGGERELLIDAE Fig. 3a	Spirillina medioscabra Carter	635	* Fig. 3t
Dorothia parri	230	EGGERELLIDAE Fig. 3b	Spirillina striatogranulosa Terquem	446	*
Dyocibicides biserialis Cushman&Valentine	80	CIBICIDINAE Fig. 12w	Spirillina tuberosa Carter	212	*
Dyocibicides sp.*	340	CIBICIDINAE	Spirillina unilatera Chapman	259	*
Eggerella propinqua (Brady) ?ihungia	304	EGGERELLIDAE	Spiroloculina angulata Cushman	517	SPIROLOCULINIDAE
Elphidiella sp.	453	ELPHIDIDIIDAE	Spiroloculina sp.1	515	*
Elphidium cf crassatum	601	*	Spiroloculina sp.2	509	*
Elphidium chapmani Cushman	607	*	Spiroloculina tenuis/Spirophalmidium pusillum	515	*
Elphidium crassatum Cushman	601	* Figs. 15q,r	Stilostomella awamoana Hornibrook	484	STILOSTOMELLIDAE
Elphidium craticulatum	258	*	Stilostomella bortonica Hornibrook	424	*
Elphidium crispum (Linné)	214	*	Stilostomella verneuilii (d'Orbigny)	493	*
Elphidium pseudonodosum Cushman	202	*	Stomatorbina concentrica (Parker&Jones)	108	MISSISSIPPIN. Fig. 14w,x
Elphidium sp.	342	*	Stomatorbina sp.	600	* Fig. 16e
Elphidium subrotatum Hornibrook	454	*	Svratkina australiensis	270	ALABAMINIDAE Figs.16t,u
Eoeponidella zealandica (Hornibrook)	146	DISCORBIDAE	Svratkina perlata (Andreae)	385	*
Eponides broeckhianus (Karrer)	444	EPONIDIDAE	Svratkina sp	386	* Figs. 16r,s
Eponides lornensis Finlay	61	* Fig. 14k,l	Tappanina olsoni (Hornibrook)	562	BOLIVINIDAE
Eponides repandus (Fitchel&Moll)	62	* Fig. 14m,n	Textularia awamoana Hornibrook	494	TEXTULARIIDAE
Eponides sp	619	*	Textularia colemani Quilty	158	* Fig. 3g
Evolvocassidulina orientalis (Cushman)	165	CASSIDULINIDAE Fig.8s	Textularia cuneazea Hornibrook	143	*

APPENDIX B - SPECIES LIST

Favulina squamosa (Montagu)	648	ELLIPSOLAGENIDAE	Textularia jutsoni Quilty	490	*
Fissurina (Parafissurina) lateralis	253	*	Textularia magallanica Todd&Kniker	389	*
Fissurina alveolata (Brady) var	628	*	Textularia marsdeni Finlay	54	*
Fissurina annectens (Burrows&Holland)	177	* Fig. 9m	Textularia nanarupensis Quilty	390	*
Fissurina aperta Seguenza	14	* Fig. 9a, b	Textularia semicarinata Hornibrook	511	*
Fissurina aperta var	14	*	Textularia sp.1 (MBT)	391	*
Fissurina aureoligera (Bruchner)	526	*	Textularia sp.1 (WMC507)	491	*
Fissurina bifida (Heron-Allen&Earland)	190	*	Textularia sp.3	392	*
Fissurina cf fimbriata Brady	617	*	Textularia sp.4	393	*
Fissurina crassiannulata Collins	11	* Fig. 9p	Textularia vertebralis Cushman	181	*
Fissurina flintiana Cushman	160	*	Trifarina anguloca	471	UVIGERINIDAE
Fissurina furcata Collins	38	*	Trifarina bradyi Cushman	22	*
Fissurina globosocaudata Albani&Yassini	639	*	Trifarina costornata (Hornibrook)	219	*
Fissurina kerguelenensis Parr	205	*	Trifarina elliptica (Dorreen)	305	*
Fissurina lagenoides (Williamson)	586	*	Trifarina parva Hornibrook	370	*
Fissurina marginata (Walker&Boys)	149	* Fig. 9q	Trifarina sp.1	395	*
Fissurina orbignyana (Seguenza)	418	*	Trifarina sp.2	396	*
Fissurina orbignyana var flintii Cushman	224	*	Triloculina brochita Carter	175	HAUERINIDAE
Fissurina paralucida Jones	502	* Fig. 9u	Triloculina cf. T. tricarinata d'Orbigny	409	*
Fissurina quadrata (Williamson)	195	* Fig. 9h	Triloculina gilboei Beck	413	*
Fissurina quadrata (Williamson) var.	196	*	Triloculina laevigata d'Orbigny	522	*
Fissurina radiato-marginata (Parker&Jones)	656	*	Triloculina trigonula (Lamarck)	538	*
Fissurina seguenziana (Fornasini)	536	*	Tritaxia victoriensis (Cushman)	200	VERNEUILIN. Fig. 3f
Fissurina semimarginata (Reuss)	208	*	Trochulina dimidiata (Jones&Parker)	624	DISCORBIDAE
Fissurina sequenziana var	554	*	Trochulina turbo	579	DISCORBIDAE
Fissurina sp.1	193	*	Uvigerina spinulosa Hadley	28	BULIMINIDAE Fig. 10u
Fissurina sp.2	415	*	Uvigerina abbreviata Terquem	400	*
Fissurina sp.2 (OB2)	593	*	Uvigerina alabamensis Cushman&Garrett	401	*
Fissurina subcircularis	295	*	Uvigerina bortotora Finlay	23	*
Fissurina submarginata Boomgart	191	*	Uvigerina cushmani Todd	352	*
Florilus stachei (Cushman)	269	GAVELINELLIDAE	Uvigerina gallowayi Cushman	100	* Fig. 10w
Florilus victoriense (Cushman)	268	* Fig.16m	Uvigerina reussella	29	*
Frondicularia hydropica	343	NODOSARIIDAE	Uvigerina sp. (=U.schwageri)	602	*
Frondicularia mucronata Reuss	37	*	Uvigerina sp.1	402	*
Frondicularia sp	344	*	Uvigerinella sp	403	*
Galwayella trigonornata Albani&Yassini	646	ELLIPSOLAGENIDAE	Vaginulina americana Cushman	563	VAGINULINIDAE
Gaudryina attenuata	603	VERNEUILINIDAE Fig. 3l	Vaginulina awamoana Hornibrook	489	*
Gaudryina convexa (Karrer)	569	* Fig. 3h	Vaginulina elegans d'Orbigny	148	*
Gaudryina crespinae Cushman	53	* Fig. 3p	Vaginulina sp	615	*
Gavelinopsis pukeuriensis Hornibrook	449	GAVELINELLIDAE	Vaginulina subelegans	238	VAGINULINIDAE
Glabratella crassa Dorreen	60	GLABRATELLIDAE Fig.16d	Vaginulinopsis acanthonucleus Carter	501	* Fig. 5a
Glabratellina sigali Seiglie&Bermudez	289	* Fig. 13n,o	Vaginulinopsis cf tasminica	573	*
Glandulina symmetrica (Stache)	51	GLANDULINIDAE Fig. 8k	Vaginulinopsis hochstetteri (Stache)	499	*
Globocassidulina crassa (d'Orbigny)	15	CASSIDULINIDAE Fig. 8v	Vaginulinopsis sp	565	*
Globocassidulina pseudocrassa (Hornibrook)	137	* Fig. 8u	Vaginulinopsis sp.1	503	*
Globocassidulina subglobosa (Brady)	8	* Fig. 8q	Vaginulinopsis sp.2	504	*
Globulina inaequalis Reuss	293	POLYMORPHIN. Fig. 8i	Valvulineria kalimnensis (Parr)	620	BAGGINIDAE Fig. 14r, s
Guttulina cf pacifica (Cushman&Ozawa)	298	*	Vernuelina browni Finlay	404	VERNEUILINIDAE
Guttulina communis (d'Orbigny)	422	* Figs. 8a,d	Victoriella conoidea (Rutten)	145	VICTORIELLIDAE Fig. 4q
Guttulina frankei Cushman&Ozawa	353	* Fig. 8e	Virgulina schreibersiana	512	FURSENKOINIDAE
Guttulina irregularis (d'Orbigny)	421	*	Virgulopsis sp	508	STAINFORTHIIDAE
Guttulina otiakensis Hornibrook	354	*	Wadella globoformis (Chapman)	154	VICTORIELLIDAE
Guttulina pacifica (Cushman&Ozawa)	355	* Fig. 8l			
Guttulina problema d'Orbigny	27	* Fig. 8c			
Guttulina regina (Brady, Parker & Jones)	426	* Fig. 8b	sub-total	241	
Guttulina semiplana Reuss	26	*			
Guttulina sp.1	356	*	Acarinina collactea (Finlay)	286	TRUNCOROTALOIDIDAE
Guttulina sp.2	357	*	Cassigerinella chipolensis (Cushman&Pontin)	111	CASSIGERINELLIDAE
Guttulina yabei Cushman&Ozawa	233	* Fig. 8g	Cassigerinella winniana (Howe)	113	* Fig. 1a,b
Gypsina howchini Chapman	496	ACERVULINIDAE	Catapsydrax dissimilis (Cushman&Bermudez)	236	CATAPSYDRAC. Fig. 2g
Gyroidinoides aff. novozelandicus	358	GAVELINELLIDAE	Chiloguembelina cubensis (Palmer)	114	CHILOGUEMB. Figs. 1o,p
Gyroidinoides allani (Finlay)	59	*	Globigerina angulіofficinalis Blow	261	GLOBIGERINIDAE Fig. 2b
Gyroidinoides sp. (=G. danvillensis Howe&Wallace)	633	*	Globigerina angulisuturalis Bolli	273	* Fig. 2e
Gyroidinoides sp.1	359	*	Globigerina angustiumbilicata Bolli	518	* Fig. 2d
Gyroidinoides sp.2	360	*	Globigerina apertura Cushman	476	* Fig. 2j
Gyroidinoides zelandica (Finlay)	164	*	Globigerina brazieri Jenkins	125	*
Hanzawaia scopos (Finlay)	242	* Figs. 16g, h	Globigerina brevis Jenkins	346	*
Hanzawaia turgida (Finlay)	447	*	Globigerina bulloides d'Orbigny	120	* Fig. 2q,r
Haplophragmoides sp.	361	HAPLOPHRAGMOIDIDAE	Globigerina ciperoensis Bolli	121	* Fig. 2a
Hemirobulina sp.	552	VAGINULINIDAE	Globigerina eamesi Blow	172	*
Heronallenia lingulata (Burrows&Holland)	90	HERONALLEN. Fig. 16o,p	Globigerina eoceana	347	*
Heronallenia parri Carter	89	*	Globigerina euapertura Jenkins	122	* Fig. 2k,l
Heteromorphina calomorpha (Reuss)	237	ELLIPSOLAGENIDAE	Globigerina officinalis Subbotina	126	*
Hoeglundina elegans (d'Orbigny)	156	EPISTOMINIDAE Fig. 16f	Globigerina ouchitaensis Howe&Wallace	287	*
Hofkerina semiornata (Howchin)	157	EPONIDIDAE	Globigerina praebulloides Blow	116	*
Homalohedra acuticosta (Reuss)	35	ELLIPSOLAGEN. Fig. 7q	Globigerina pseudoampliapertura	348	*
Karreria maoria (Finlay)	71	KARRERIIDAE Fig. 16c	Globigerina selli	349	*
Karreria pseudoconvexa (Parr)	98	* Fig. 16a,b	Globigerina sp.1	350	*
Karreria sp. 1	464	*	Globigerina woodi connecta Jenkins	513	* Fig. 2s
Karreriella sp.	362	*	Globigerina woodi Jenkins	117	* Fig. 2t
Kolesnikovella australis (Heron-Allen & Earland)	20	UVIGERINIDAE Fig. 10a,b	Globigerinatheka index (Finlay)	118	* Fig. 1c
Lagena cf. L. hexacostata McCulloch	425	* Fig. 7m	Globigerinella obesa (Bolli)	235	* Figs. 2n,o,p
Lagena feildeniana Brady	595	LAGENIDAE	Globigerinoides primordius (Blow&Banner)	182	*
Lagena gibbera Brady var.	171	*	Globigerinoides sp.	475	*
Lagena gibbera Buchner	178	*	Globigerinoides triloba	474	GLOBIGERINIDAE
Lagena gracilis Williamson	294	*	Globoquadrina 'praedehiscens'	478	CATAPSYDRAC. Fig. 2h,i
Lagena gracilis Williamson var meridionalis Weisner	605	*	Globoquadrina dehiscens (Chapman, Parr&Colli	127	CATAPSYDRACIDAE
Lagena hirtahalsensis Anderson	194	* Fig. 7r	Globoquadrina subdehiscens	128	*
Lagena hispida Reuss	32	*	Globoquadrina tripartita	477	*
Lagena meridionalis Weisner	290	*	Globorotaloides suteri	189	GLOBIGERINIDAE
Lagena nebulosa Cushman	560	* Fig. 7g	Globorotaloides testarugosus Jenkins	274	* Figs. 1r,s
Lagena scalariforme-sulcata	197	*	Globoturborotalia labiacrassata (Jenkins)	123	* Fig. 1j
Lagena semimarginata Reuss	169	*	Guembelitria triseriata (Terquem)	115	GUEMBELITRI. Fig. 1n
Lagena sp.2	363	*	Paragloborotalia kugleri	265	GLOBOROTALID. Fig. 2f
Lagena sp.3	520	*	Paragloborotalia opima nana (Bolli)	124	* Fig. 1q

APPENDIX B - SPECIES LIST

Lagena sp.4	524	*	Paragloborotalia opima opima	479	* Fig. 1m
Lagena stelligera Brady	592	*	Praetenuitella insolita (Jenkins)	129	CANDEINIDAE Fig. 1i
Lagena striata (d'Orbigny)	36	* Fig. 7s	Pseudohastigerina micra (Cole)	159	GLOBANOMAL. Figs.1d,e
Lagena substriata Williamson	34	* Fig. 7n	Subbotina angiporoides (Hornibrook)	110	CATAPSYDRAC. Fig. 1g
Lagena sulcata (Walker&Jacob)	280	* Fig. 7d	Subbotina linaperta (Finlay)	109	* Fig. 1f
Lagena sulcata var spicata	594	*	Tenuitella aculeata (Jenkins)	132	CANDEINIDAE Fig. 1e
Lagenasolenia largicostata	632	*	Tenuitella gemma (Jenkins)	130	* Fig. 1k
Lagenosolenia sp.	587	* Fig. 9w	Tenuitella munda (Jenkins)	131	* Fig. 1l
Lamarckina airensis Carter	469	CERATOBUL. Fig. 16i,j	Tenuitellinata juvenilis (Bolli)	275	* Fig. 2c
Lamarckina glencoensis Chapman&Crespin	104	* Fig. 16k,l	Turborotalia ampliapertura (Bolli)	119	GLOBIGERINIDAE
Latibolivina byramensis (Cushman)	45	BOLIVINIDAE	Turborotalia increbescens (Bandy)	133	GLOBOROTAL. Fig. 2m
Laticarinina altocamerata (Heron-Allen&Earland)	95	DISCORBINELL. Fig. 13a			
Laticarinina coronata (Heron-Allen&Earland)	94	* Fig. 13b,c			
sub-total	297				
	538	benthic total	planktonics	48	

PLATE 1 - PLANKTONIC FORAMINIFERA

a, b. *Cassigerinella winniana* (Howe) [13]; a. apertural view, b. side view; MB191, interval zone E, early Oligocene.
c. *Globigerinatheka index* (Finlay) [118]; apertural view; OB135, Int. B, late Eocene.
d, h. *Pseudohastigerina micra* (Cole) [159]; d. umbilical view, h. apertural view; OB122, Int. C.
e. *Tenuitella aculeata* (Jenkins) [132]; umbilical view; OB135.
f. *Subbotina linaperta* (Finlay) [109]; apertural view; OB135.
g. *Subbotina angiporoides* (Hornibrook) [110]; OB114, Int. D.
i. *Praetenuitella insolita* (Jenkins) [129]; umbilical view; OB135.
j. *Globoturborotalia labiacrassata* (Jenkins) [123]; OB91, Int. E.
k. *Tenuitella munda* (Jenkins) [131]; 2W112, Int. G.
l. *Tenuitella gemma* (Jenkins) [130]; umbilical view; OB53.
m. *Paragloborotalia opima opima* (Bolli) [479]; OB73, Int. E.
n. *Guembelitria triseriata* (Terquem) [115]; OB73.
o. *Chiloguembelina cubensis* (Palmer) var. *ototora* [114]; OB114.
p. *Chiloguembelina cubensis* s.s. (Palmer) [114]; OB114.
q. *Paragloborotalia opima nana* (Bolli) [124]; umbilical view; MF48, Int. D.
s, t. *Globorotaloides testarugosus* Jenkins [274]; s. side view, t. umbilical view; OB122.

(scale bar = 100μm)

PLATE 1

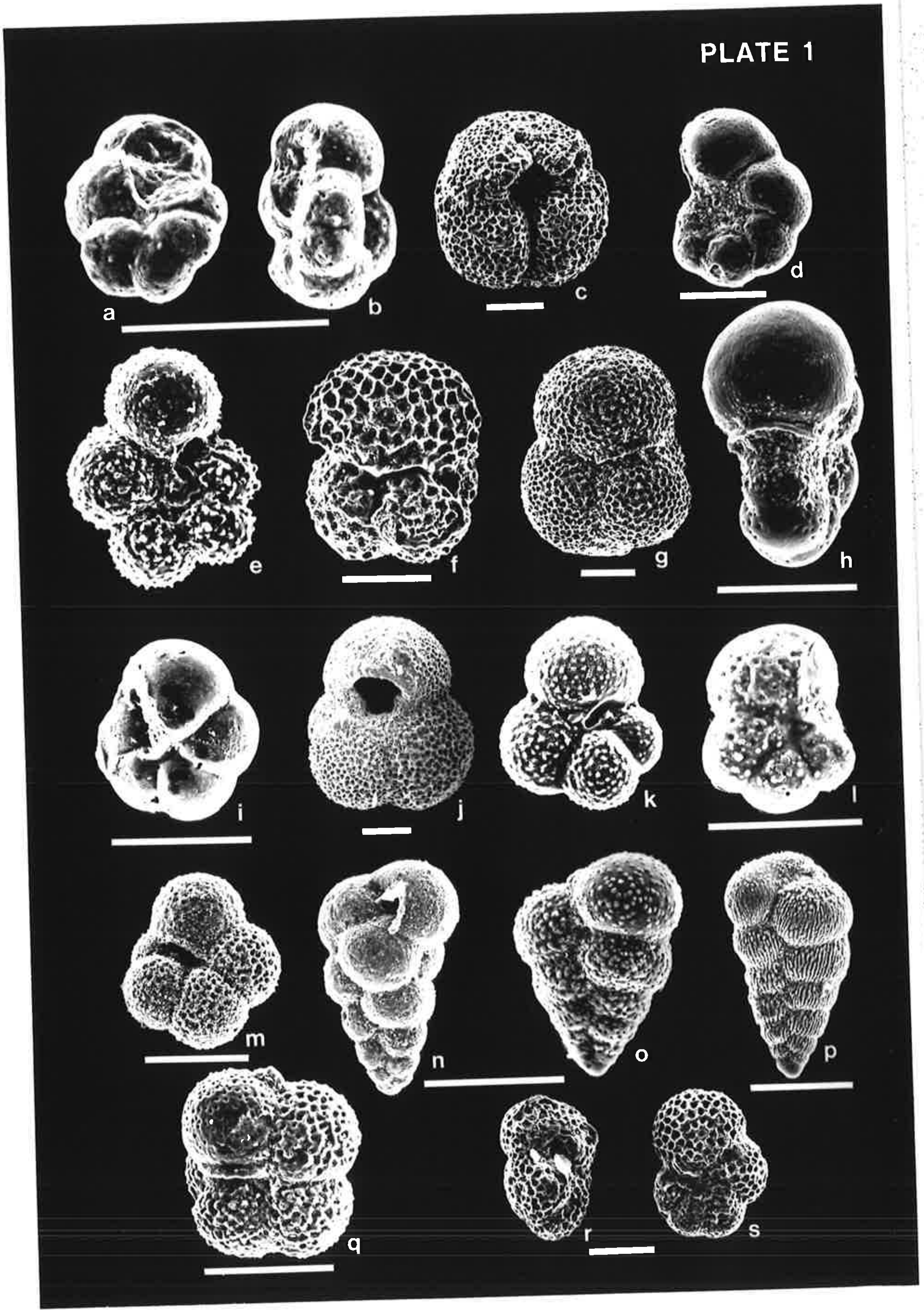


PLATE 2

a. *Globigerina ciperoensis* Bolli [121]; umbilical view; OB57, Int. F.
b. *Globigerina anguliofficinalis* Blow [261]; umbilical view; OB21, Int. H.
c. *Tenuitellinita juvenilis* (Bolli) [275]; umbilical view; OB35, Int. H.
d. *Globigerina angustiumbilicata* Bolli [518]; umbilical view; OB35.
e. *Globigerina angulisuturalis* Bolli [273]; umbilical view; OB51, Int. G.
f. *Paragloborotalia kugleri* (Bolli) [265]; umbilical view, sample MG52, Int. H.
g. *Catapsydrax dissimilis* (Cushman & Bermudez) [236]; OB114, Int. D.
h, i. *Globoquadrina dehiscens praedehiscens* Blow & Banner [478]; h. peripheral view, i. umbilical view; OB36.
j. *Globigerina apertura* Cushman [476]; OB21.
k, l. *Globigerina euapertura* Jenkins [122]; k. umbilical view, OB21; l. Umbilical view, OB36.
m. *Turborotalia increbescens* (Bandy); umbilical view; OB57, Int. F.
n, o, p. *Globigerinella obesa* (Bolli) [235]; n, o. OB36, p. OB57.
q, r. *Globigerina bulloides* d'Orbigny [120]; q. OB51, r. OB21.
s. *Globigerina woodi connecta* Jenkins [513]; OB21.
t. *Globigerina woodi* Jenkins [117]; 2W94.7, Int. I.

(scale bar = 100μm)

PLATE 2

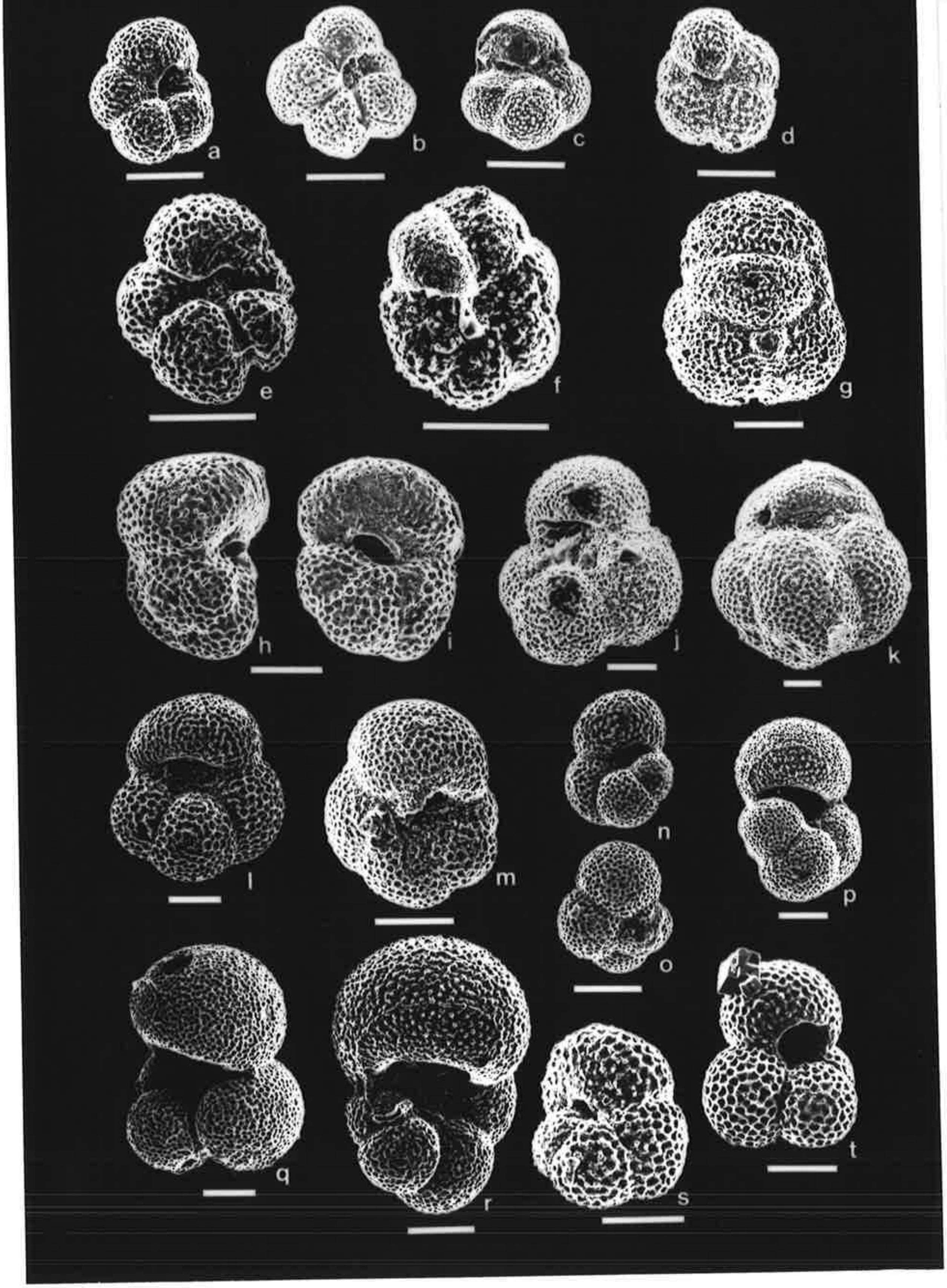


PLATE 3 - BENTHIC FORAMINIFERA

a. *Dorothia minima* (Karrer) [152] ; MB190, Int. E.
b. *Dorothia parri* [230] ; W120, Int. H/I.
c. *Siphotextularia gladizea* (Finlay) [49] ; WMC24, Int. D; Kingston.
d. *Siphotextularia concava* (Karrer) [272] ; WMC SE703, 44.65m, Int. C; Kingston.
e. *Bigenerina nodosaria* d'Orbigny [599] ; MB183, Int. F.
f. *Tritaxia victoriensis* (Cushman) [200] ; OB91, Int. D.
g. *Textularia colemani* Quilty [158]; RR121, Int. H; Mt Gambier.
h. *Gaudryina convexa* (Karrer) [569]; 2W121, Int. G.
i. *Textularia* sp.4 [661]; 2W121.
j. *Arenodsaria antipoda* (Stache) [254] ; W152, Int. F.
k. *Textularia semicarinata* Hornibrook [511] ; OB114.
l. *Gaudryina attenuata* Chapman [661] ; MG88, Miocene.
m. *Textularia magallanica* Todd & Kniker [389] ; OB36, Int. H.
n, o. *Textularia hayi* Karrer [662]; n. oblique peripheral view OB24, Int. H,. o. side view OB36.
p. *Gaudryina crespinae* Cushman [53] ; OB36.
q. *Spirillina medioscabra* Carter [635] ; OB91, Int. E.
r, s. *Spirillina grosseperforata* Zheng [218] ; r. peripheral view, RR66188, s. oblique side view, OB96, Int. D.
t. *Spirillina decorata* Brady [64] ; OB128, Int. C.
u. *Textularia jutsoni* Quilty [490] ; MB190, Int. E.

(scale bar = 100μm)

PLATE 3

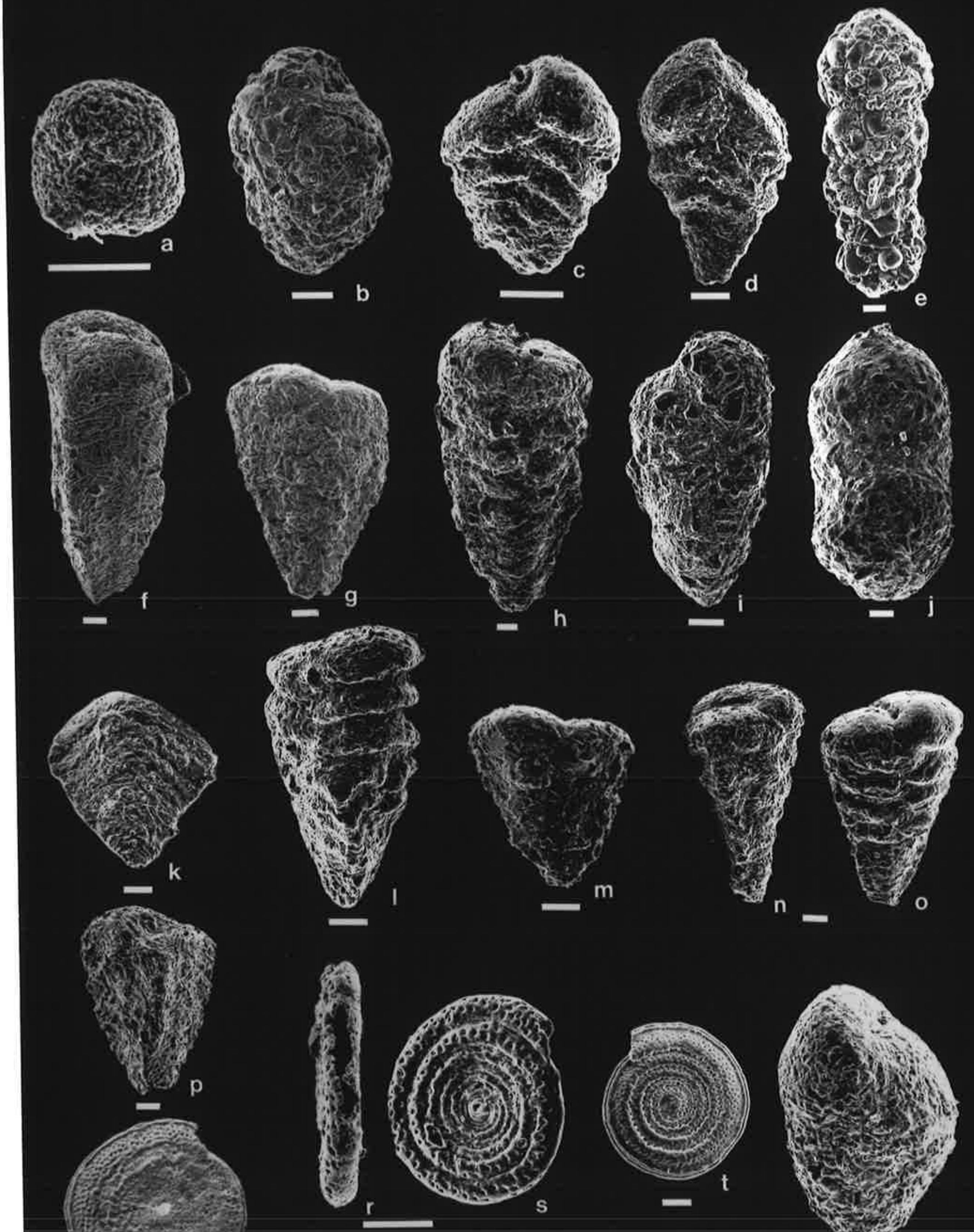


PLATE 4

a. *Spiroloculina* sp.1 [515]; OB114, Int. D.
b.*Quinqueloculina weaveri* Rau [3]; OB114.
c. *Quinqueloculina zealandica* Srinivasan [407]; OB122, Int. C.
d. *Quinqueloculina lamarckiana* d'Orbigny [412]; E&WS Croydon-2 Bore 312m, eastern St Vincent Basin.
e. *Massilina torquayensis* (Chapman) [150]; OB128, Int. C.
f. *Nummoloculina irregularis* (d'Orbigny) [481]; MF99, Int. B; Magrath Flat.
g. *Triloculina trigonula* (Lamarck); W150, Int. G.
h. *Sigmoilina obesa* Heron-Allen & Earland [435]; W152.
i. *Biloculina bulloides* d'Orbigny [481]; MB190, Int. E.
j. *Nummoloculina contraria* (d'Orbigny) [588]; SE703, early Oligocene; Kingston, Otway Basin.
k. *Ophthalmidium* sp. [406]; MF75, Int. D.
l. *Quinqueloculina crassicostata* Terquem [9]; OB35.
m. *Sigmoilina aspera* (d'Orbigny) [626]; 2W155, Int. F.
n. *Spiroloculina angulata* Cushman [517]; OB21, Int. H.
o. *Quinqueloculina intricata* Terquem var.[659]; 2W155.
p. *Austrotrillina howchini* (Schlumberger) [4]; W120.
q, u. *Victoriella conoidea* (Rutten) [145]; q. E160, late Oligocene; Kongorong region, Otway Basin, u. ? juvenile form OB91.
r. *Wadella globiformis* (Chapman) [154]; OB21.3.
s. *Operculina victoriensis* Chapman & Parr [79]; W140, Int. H.
t. *Amphistegina lessoni* d'Orbigny [42]; W138, Int. G.

(scale bar = 100µm)

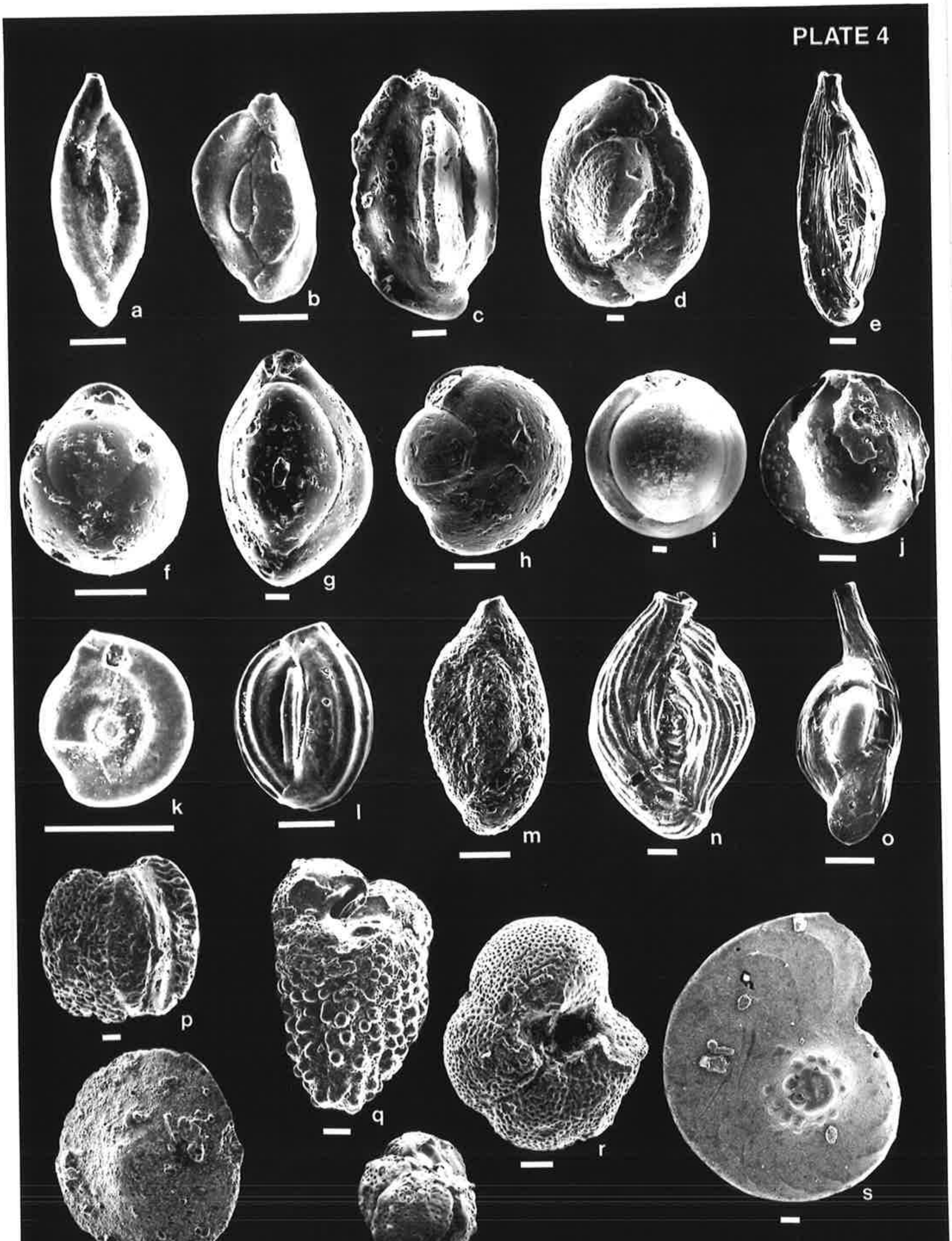


PLATE 4
a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t
u

PLATE 5

a. *Vaginulinopsis acanthonucleus* Carter [501]; OB114, Int. D.
b, c. *Nodosaria mutabilis* Costa [136]; OB36, Int. H.
d. *Amphicoryna pauciloculata* (Cushman) [302]; OB122.
e. *Amphicoryna* cf. *A.halkyardi* (Cushman) [279]; OB91, Int. D.
f. *Nodosaria mutabilis* Terquem var.[136]; OB36.
g. *Nodosarella* sp. [148]; OB88, Int. E.
h. *Vaginulina elegans* d'Orbigny [148]; OB114, Int. D, early Oligocene.
i. *Pleurostomella* sp.[376]; OB135, Int. B.
j. *Hemirobulina* sp. [552]; OB114.
k, l *Nodosaria vertebralis* var.[257]; k. l. OB12, Int. H?I.
m. *Nodosaria filiformis* d'Orbigny; RR111, Int. I, Miocene.
n. *Marginulinopsis hydropica* Hornibrook [97]; SE703 45.3m, early Oligocene; Kingston.
o. *Nodosaria* sp. 2 [50]; OB114, Int. D, early Oligocene.
p. *Dentalina* sp. 2 [506]; W182, Int. E, early Oligocene.
q. *Dentalina subsoluta* (Cushman) [420]; MB177, Int. F, late Oligocene.
r. *Lingulina* sp. [604]; OB135, Int. B, late Eocene.
s. *Marginulina* sp ; OB122, Int. C.
t. *Nodosaria* sp. ; OB96, Int. D.
u. *Pseudonodosaria coronata* (Grzybowski) [30]; OB96, Int. D.
v. *Marginulina* sp. [369]; OB135, Int. B.

(scale bar = 100µm)

PLATE 5

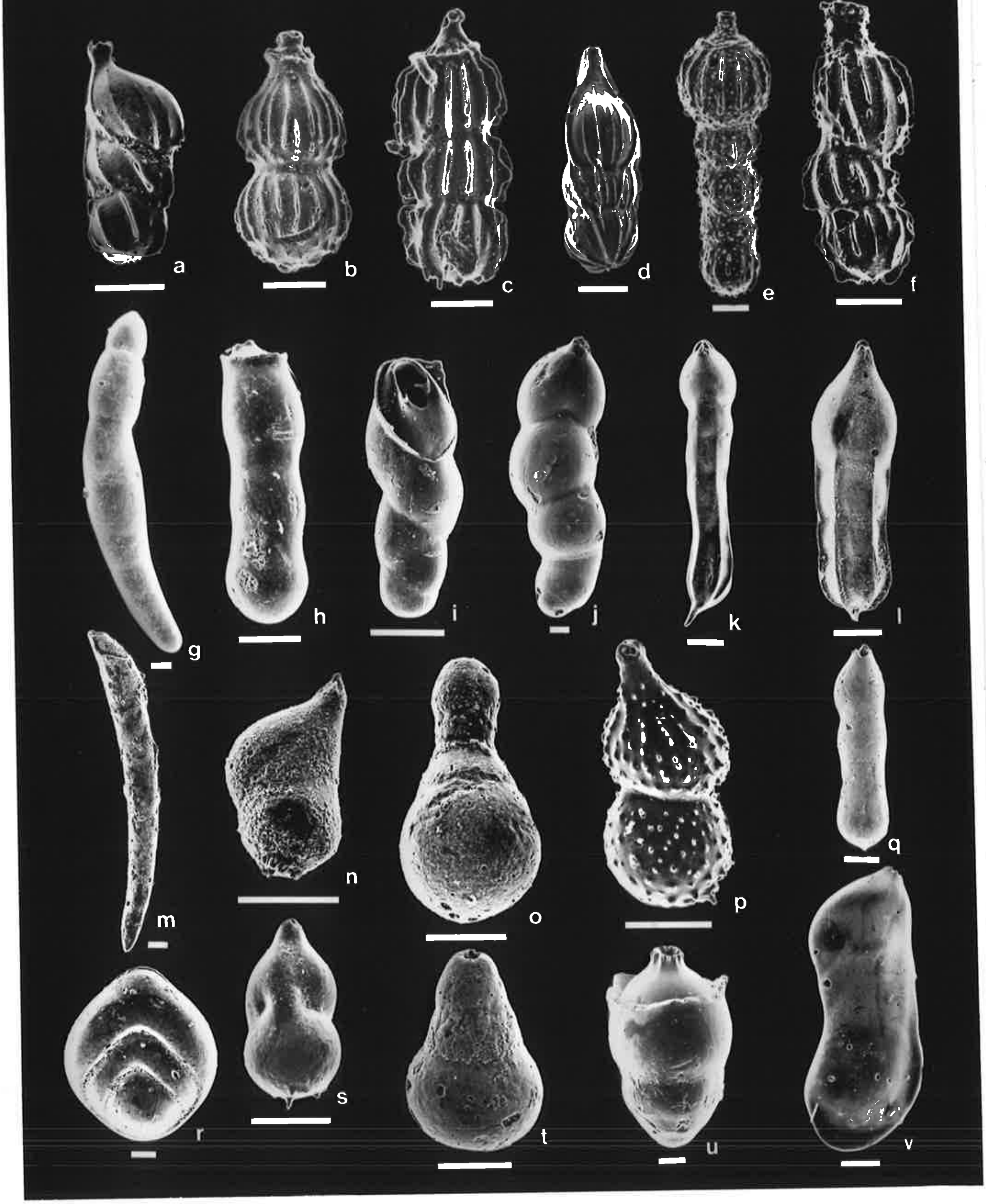


PLATE 6

a. *Lenticulina (Robulus) gyroscalprum* (Stache) [43]; 2W146, Int. F.
b. *Lenticulina foliata* (Stache) [244]; OB21, Int. H.
c. *Lenticulina gibba* (d'Orbigny) [245]; OB36, Int. H.
d. *Lenticulina (Robulus) pliocaenicus* (Silvestri) [166]; OB122, Int. C.
e. *Lenticulina* sp. [365]; 2W86, Int. I.
f. *Lenticulina* sp. 2 [432]; OB88, Int. E.
g. *Lenticulina convergens* (Bornemann) [351]; OB51, Int. G.
h. *Lenticulina* sp. cf. *L. gibba* (d'Orbigny) [245]; OB51, Int. G.
i. *Lenticulina thalmani* (Hessland) [216]; OB36.
j. *Lenticulina planula* (Galloway & Heminway) [428]; OB131, Int. C.
k. *Lenticulina* cf *L. nitida* (Reuss) [39]; OB24, Int. H.
l, m. *Astacolus* sp. [51]; OB36.
n. *Astacolus crepidulus* (Fitchel & Moll) [613]; OB24, Int. H.
o. *Saracenaria* cf. *S.obesa* Cushman & Todd [223];
p. *Marginulina duracina* Stache [211]; OB131, Int. C.
q. *Lenticulina peregrina* (Schwager) [662]; OB27, Int. H.
r. *Saracenaria arcuatula* (Stache) [557]; OB36.
s. *Amphicoryna scalaris* (Batsch) var. [240]; RR111, Int. H.
t. *Planularia australis* Chapman [215]; OB42, Int. G.
u.*Planularia* sp. 1 [433]; SE703, early Oligocene; Kingston, Otway Basin.
v.*Plectofrondicularia proparri* (Finlay) [221]; OB111, Int. D.

(scale bar = 100µm)

PLATE 6

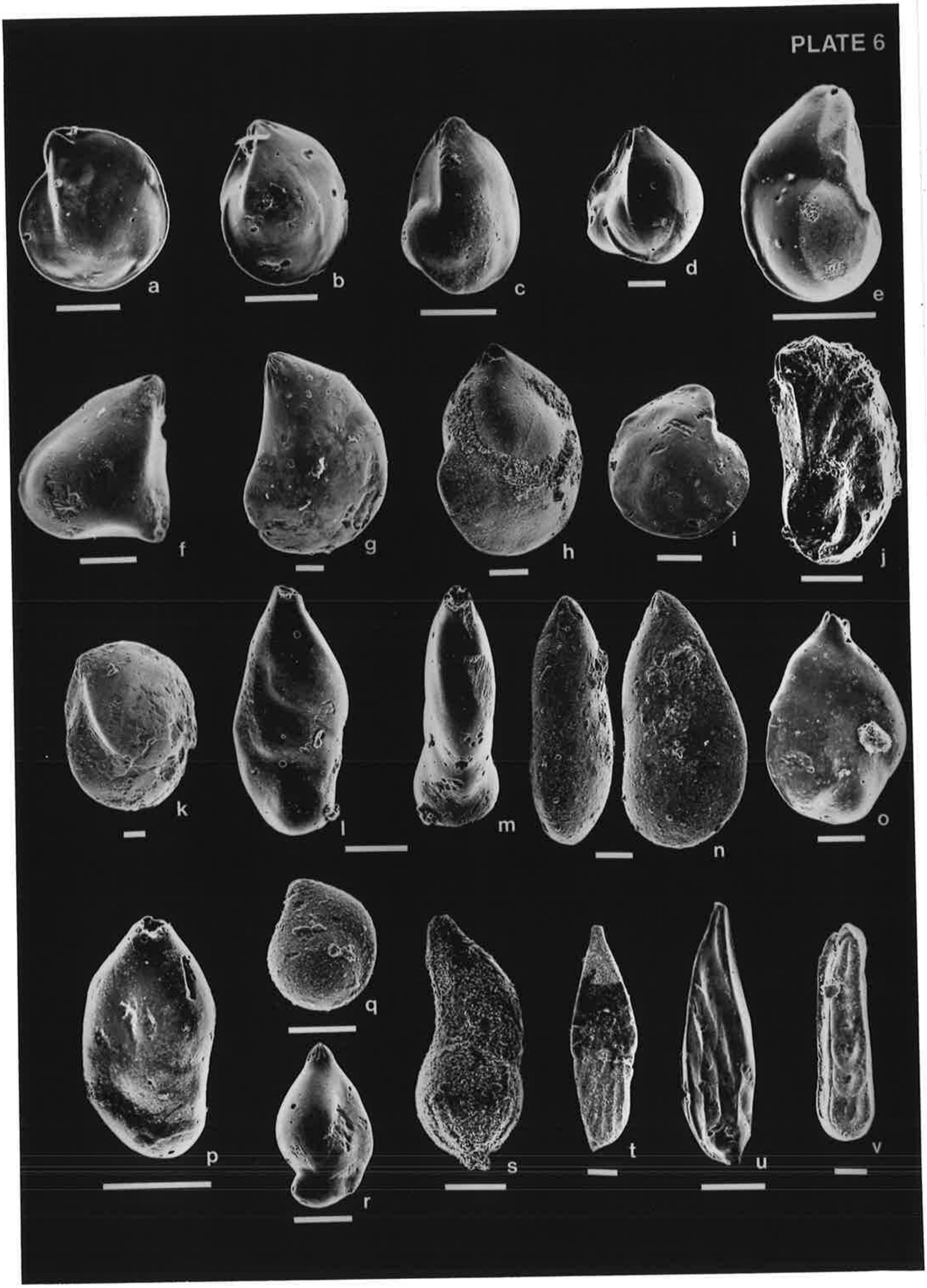


PLATE 7

a. *Oolina hexagona* (Williamson) [31]; A26, Int. C, early Oligocene; Pt Willunga Formation.
b. *Oolina melo* d'Orbigny [285]; OB42, Int. G.
c. *Favulina squamosa* (Montagu) [648]; W152, Int. F.
d. *Lagena sulcata* (Walker and Jacob) var. *spicata* Cushman & McCulloch [594]; RR111, Int. H.
e. *Procerolagena distoma* (Parker&Jones) [625]; MB181.9, Int. F.
f. *Palliolatella laevis* (Montagu) [199]; MF78, Int. D.
g. *Lagena nebulosa* Cushman [560]; MF51, Int. E.
h. *Lagena curvicostata* Heron-Allen&Earland; 2W86, Int. I.
i. *Procerolagena cylindrocostata* [636]; 2W86.9, Int. I.
j. *Lagena sulcata* Walker&Jacob var *spicata* Cushman&McCulloch [594]; OB42, Int. G.
k. *Lagena luciae* Parr) [530]; OB122, Int. C.
l. *Oolina* sp.var. (?= *Oolina globosa* (Montagu) var.*major* uhlig) [52]; W152, Int. F.
m. *Lagena* sp. 1 cf. *L. hexacostata* McCulloch [425]; 2W125, Int. F.
n. *Lagena substriata* Williamson [34]; OB114, Int. D.
o. *Pygmaeoseistron* sp. [654]; OB99. Int. D.
p. *Oolina confluenta* McCulloch [631]; 2W146, Int. F.
q. *Oolina collaripolygonata* Albani&Yassini [630]; 2W121, Int. H.
r. *Lagena hirtshalsenis* Anderson [32]; OB21, Int. H.
s *Lagena striata* (d'Orbigny) [36]; MF78, Int. D.
t, u. *Cushmanina plumigera* (Brady) [530]; t. OB85, Int. E; u. 2W146, Int. F, late Oligocene; Waikerie.
v. *Cushmanina tasmaniae* (Quilty); 2W121, Int. G.

(scale bar = 100µm)

PLATE 7

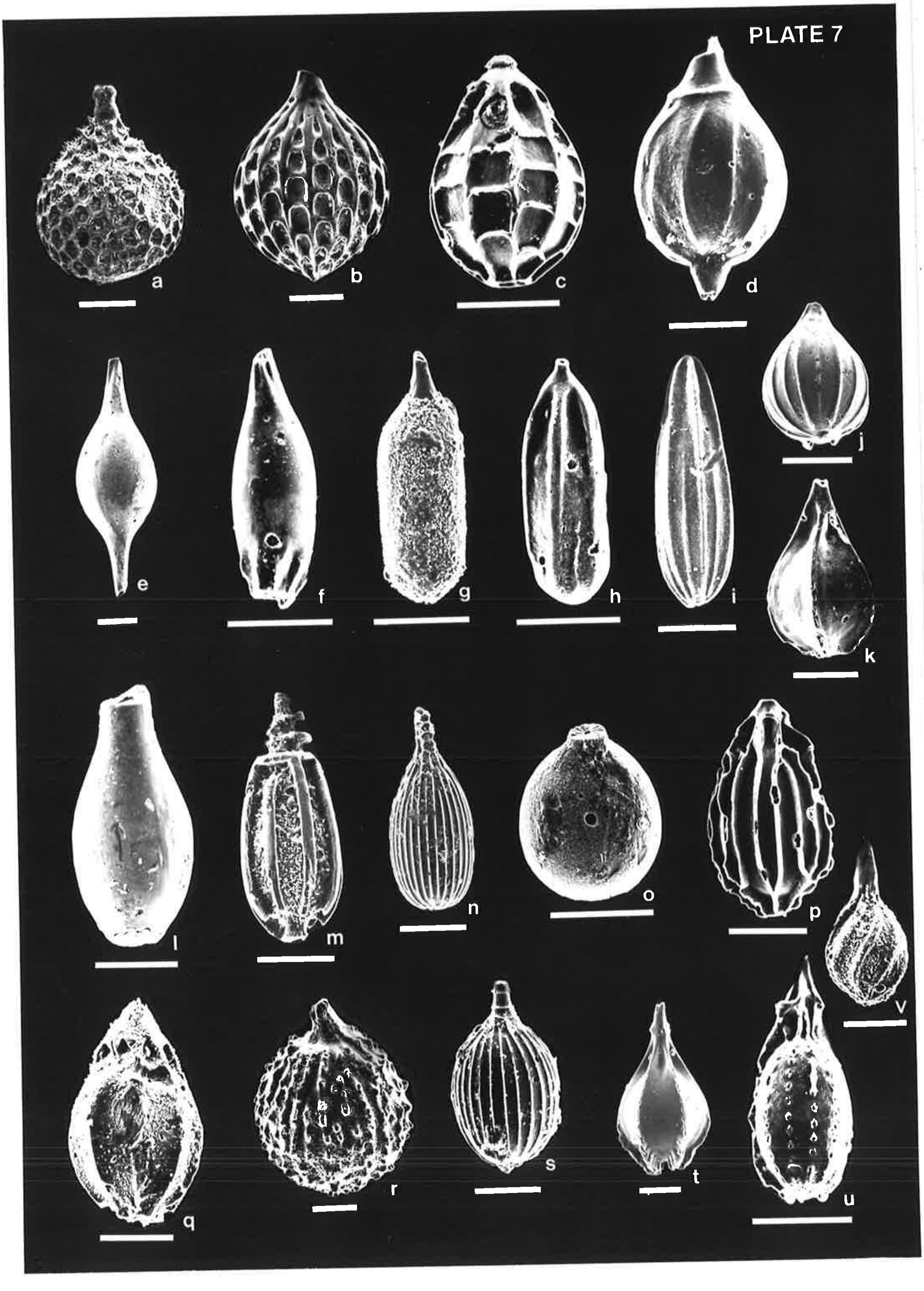


PLATE 8

a. *Guttulina communis* (d'Orbigny) [422]; OB114, Int. D.

b. *Guttulina regina* (Brady, Parker & Jones) [426]; OB114, Int. D.

c. *Guttulina problema* d'Orbigny [27]; OB119, Int. D.

d. *Guttulina communis* (d'Orbigny) var.[429]; Ruwarung Member, Pt Willunga Formation, Int. D, early Oligocene.

e. *Guttulina frankei* Cushman & Ozawa [353]; OB36, Int. H.

f. *Pyrulina gutta* d'Orbigny [24]; Ruwarung Member, Pt Willunga Formation, Int. D, early Oligocene.

g. *Guttulina yabei* Cushman&Ozawa [233]; OB53, Int. G.

h. *Sigmomorphina obesa* Hornibrook [435]; OB24, Int. H.

i. *Globulina inaequalis* Reuss [293]; W140, Int. G.

j. *Globulina* cf. *G . gibba* d'Orbigny [30]; OB36, Int. H.

k. *Glandulina symmetrica* (Stache) [51]; OB114, Int. D.

l. *Guttulina pacifica* (Cushman&Ozawa) [355]; SE703, early Oligocene; Otway Basin.

m.*Guttulina problema* d'Orbigny var. [27]; W140, Int. G.

n. *Sigmomorphina wynyardensis* Parr & Collins [167]; W152, Int. F.

o. *Guttulina communis* (d'Orbigny) var. [422]; OB51, Int. G.

p. *Sigmoidella bortonica* Finlay [380]; MF92, Int. C.

q. *Globocassidulina subglobosa* (Brady) [8]; OB114.

r. *Cassidulina cuneata* (Finlay) [135]; SE703, early Oligocene.

s. *Evolvocassidulina orientalis* (Cushman) [165]; R13, Ruwarung Formation, early Oligocene.

t. *Cassidulina laevigata* d'Orbi\gny [415]; OB36, late Oligocene.

u. *Globocassidulina pseudocrassa* (Hornibrook) [8]; OB51, Int. G.

v. *Globocassidulina crassa* d'Orbigny [15]; OB36, late Oligocene.

w, x. *Cassidulina carapitana* Hedberg [188]; OB24; OB51, late Oligocene.

(scale bar = 100μm)

PLATE 8

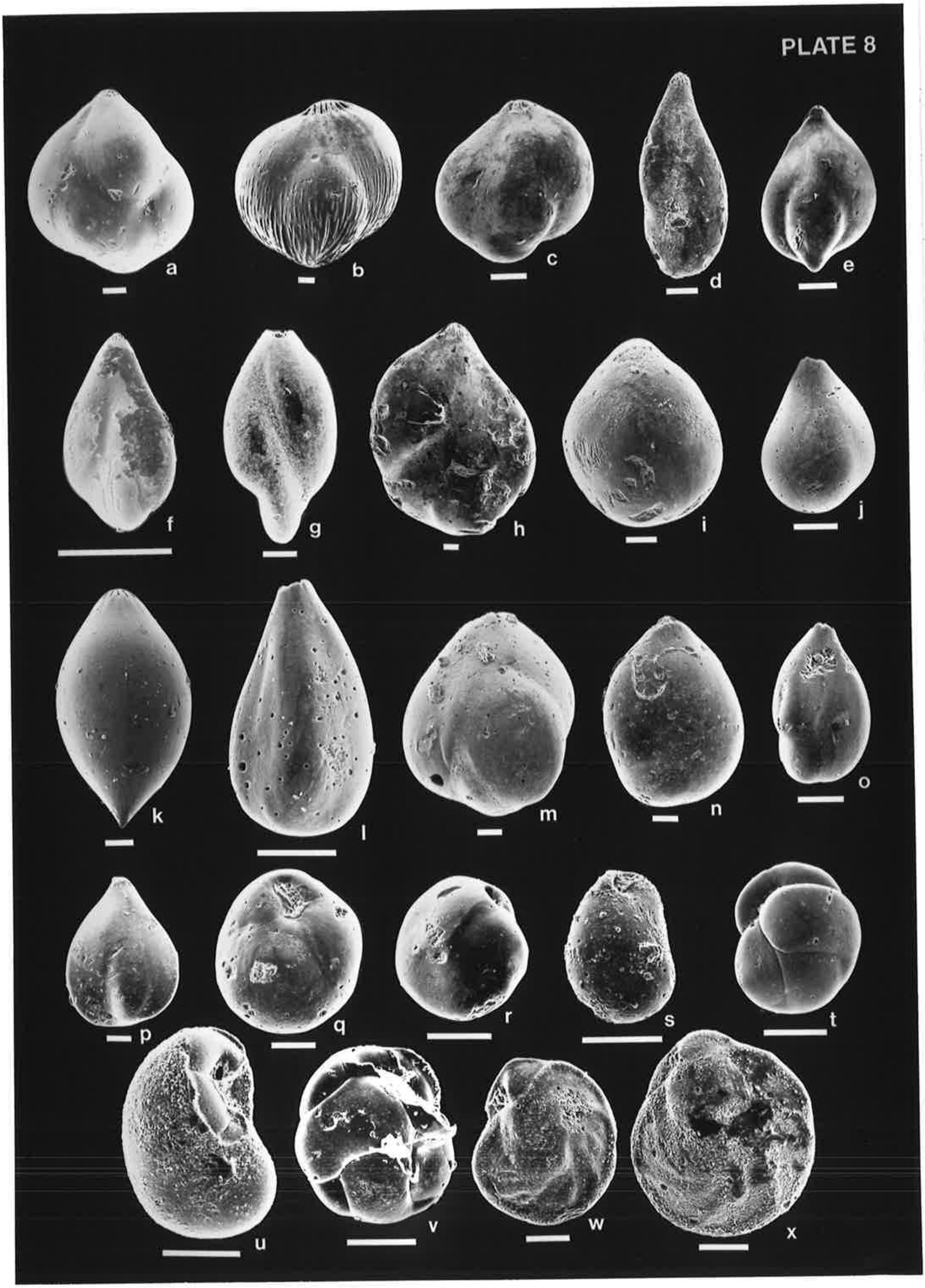


PLATE 9

a, b. *Fissurina aperta* Seguenza [14]; OB135, Int. B, late Eocene; Robe, Otway Basin.
c. *Palliolatella bradyiformis* (McCulloch) [640]; OB117, Int. D.
d.*Bucherina* sp. 1; OB135, Int. B.
e. *Bucherina* sp. 2 [651]; 2W139, Int. G; Murray Basin.
f. *Fissurina marginata* (Walker&Boys) var [149]; OB51, Int. G.
g. *Lagenasolenia* sp.[586]; 2W146, Int. F.
h. *Fissurina quadrata* (Williamson) [195]; OB51, Int. G.
i. *Palliolatella arborea* (Matthes) var. [610]; 2W147, Int. F.
j. *Fissurina quadrata* (Williamson) var.[196]; 2W128, Int. G.
k. *Palliolatella* cf. *L. pulcherrima* Cushman & Jarvis [551]; MF87, Int. C.
l. *Fissurina orbignyana* (Seguenza) var. *Flintii* Cushman [418]; OB122, Int. C.
m. *Fissurina orbignyana* (Seguenza) var.[418]; OB73, Int. E.
n. *Fissurina alveolata* (Brady) var. [628]; OB117, Int. D.
o. *Palliolatella semialata* (Balkwill&Millett) [271]; SE703, early Oligocene.
p. *Fissurina crassianulata* Collins [11]; W152, Int. B.
q. *Fissurina marginata* (Walker&Boys) [149]; MF99, Int. B.
r. *Fissurina* cf. *globosocaudata* Albani & Yassini [639]; OB135, Int. B.
s. *Fissurina quadrata* (Wiliamson) [195]; MF99.
t. *Parafissurina carinata* (Buchner) [581]; MF78, Int. D.
u. *Fissurina paralucida* Jones [508]; MF78, Int. D.
v. *Pseudofissurina muccullochae* Jones [516] ; OB36, Int. H.
w. *Lagenosolenia* sp. 2 [587] ; MF96, Int. B.
x. *Fissurina aperta* Seguenza var. [14]; OB36, Int. 36.

(scale bar = 100μm)

PLATE 9

PLATE 10

a, b. *Kolesnikovella australis* (Heron-Allen & Earland) [20]; A27, Int. C, early Oligocene; PWF, St Vincent Basin.

c. *Uvigerina rustica* Cushman & Edwards [402]; OB51, Int. G, late Oligocene; Robe, Otway Basin.

d. *Angulogerina tenuistrata* (Reuss) [58]; MB183, Int. F, late Oligocene; Wirha, Murray Basin.

e. *Trifarina bradyi* Cushman [22]; MB183.

f. *Trifarina tortuosa* (Hornibrook) [147];

g. *Siphouvigerina proboscidea* (Schwager) [21]; 2W128, late Oligocene; Waikerie, Murray Basin.

h. *Angulogerina camagüeyana* (Bermudez) [556]; W162, Int. F, late Oligocene.

i. *Bolivina jacksonesis* Cushman & Applin [10]; OB85, early Oligocene.

j. *Bolivina pontis* Finlay [210]; OB122, Int. C, early Oligocene.

k. *Latibolivina byramensis* [45]; W152, Int. F, late Oligocene.

l. *Bolivina lapsus* Finlay [19]; OB36, Int. H, late Oligocene.

m. *Bolivinella elegans* Parr [107]; OB36.

n. *Loxostomum lobatum* (Brady) [192]; MB188, Int. F, late Oligocene.

o. *Sigmavirgulina tortuosa* (Brady) [174]; 2W146, Int. F, late Oligocene; Waikerie, Murray Basin.

p. *Bolivina pseudoplicata* Heron-Allen & Earland [17]; MB185, Int. F, late Oligocene.

q. *Bolivina reticulata* Hantken [185]; OB36.

r. *Bolivinella folia* (Parker & Jones) [176]; MB185.

s. *Bolivinopsis* sp. [541]; OB122, Int. C, early Oligocene.

t. *Bolivinopsis cubensis* (Cushman & Bermudez) [5]; OB128, Int. C.

u. *Uvigerina spinulosa* Hadley [28]; OB131, Int. C, early Oligocene; Robe, Otway Basin.

v. *Buliminella browni* Finlay [282]; 2W112, Int. G, late Oligocene; Waikerie, Murray Basin.

w. *Uvigerina gallowayi* Cushman [100]; RR111, Int. I, Miocene; Mt Gambier, Otway Basin.

y. *Shaeroidina bulloides* d'Orbigny [410]; OB42, late Oligocene; Robe, Otway Basin.

z. *Buliminella seminuda* (Terquem) [414]; MB188.

(scale bar = 100µm)

PLATE 10

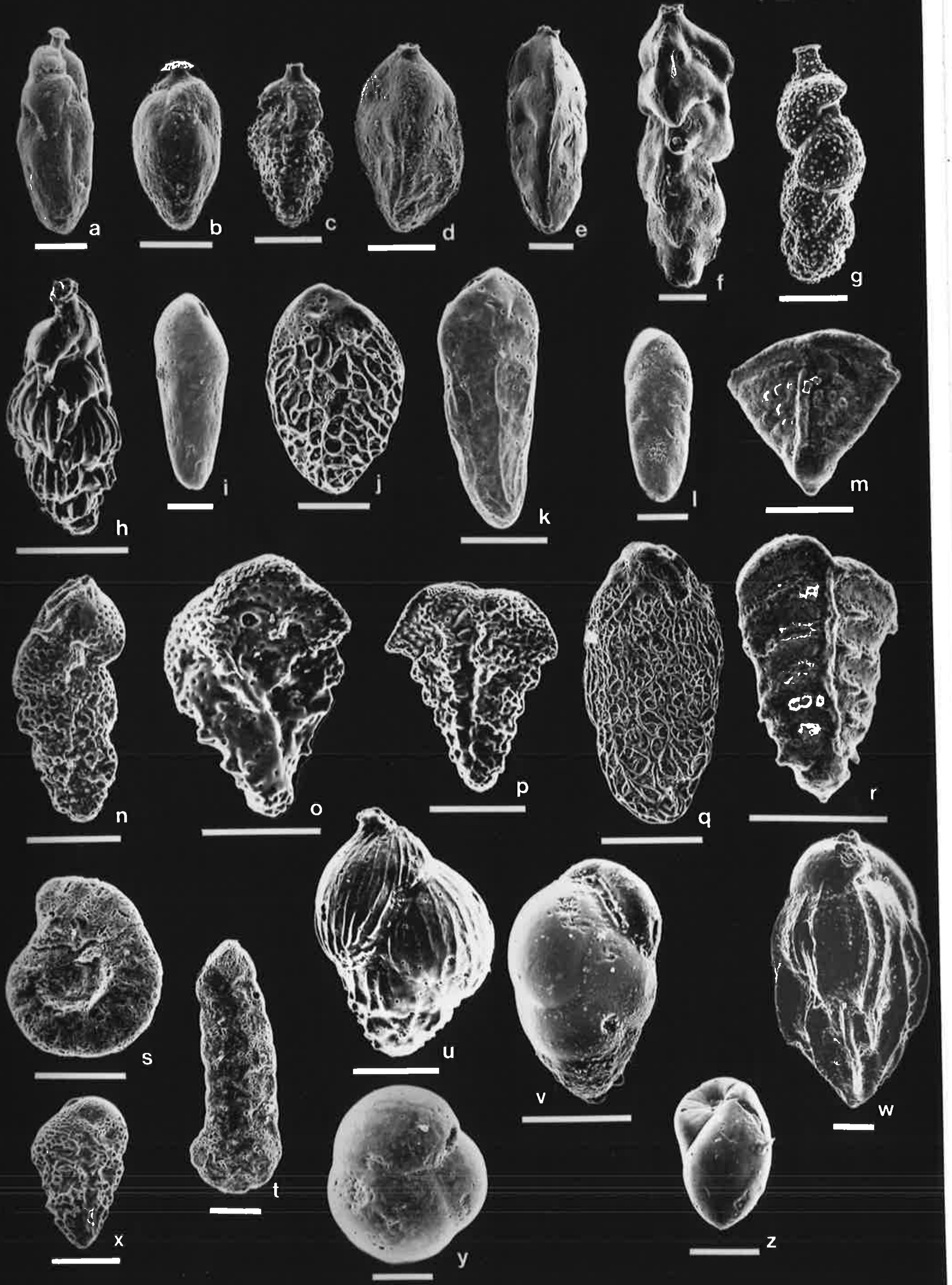


PLATE 11

a, b. *Anomalinoides nonionoides* (Fursenko & Fursenko) [198]; a. oblique side view, b. peripheral view sample OB42.
c, d. *Anomalinoides macralabra* (Finlay) [66]; a. side view sample A2, b. peripheral view sample W152.
e. *Anomalinoides granosa* (Hantken) [307]; side view sample OB122.
f. *Astrononion centroplax* Carter [86]; oblique side view sample RR117, late Oligocene, Mt Gambier - Otway Basin.
g. *Astrononion australe* Cushman & Edwards [276]; side view; OB53, late Oligocene.
h. *Astrononion stelligerum* (d'Orbigny) [68]; side view sample OB53.
i. *Anomalinoides procolligera* Carter [241]; oblique peripheral view, W142.
j, k. *Melonis obesum* (Carter); side view, oblique peripheral view sample SE703(48.8m), early Oligocene.
l. *Anomalinoides pinguinglabra* (Finlay) [67]; side view sample W182, early Oligocene.
m, n, o. *Gyroidinoides zelandica* (Finlay) [164]; m. involute side, n. peripheral view, o. oblique peripheral view; MF102, Int. B, late Eocene.
p, q. *Gyroidinoides allani* (Finlay) [59]; p. oblique peripheral view, q. peripheral view ; RR111,.Int. I, Miocene.
r. *Gyroidinoides* sp. [633]; peripheral view; E159, late Oligocene.
s, t. *Pullenia quinqueloba* (Reuss) [82]; s. oblique side view t. oblique side view OB91.
u. *Pullenia bulloides* (d'Orbigny) [81] - side view sample OB91.

(scale bar = 100μm)

PLATE 11

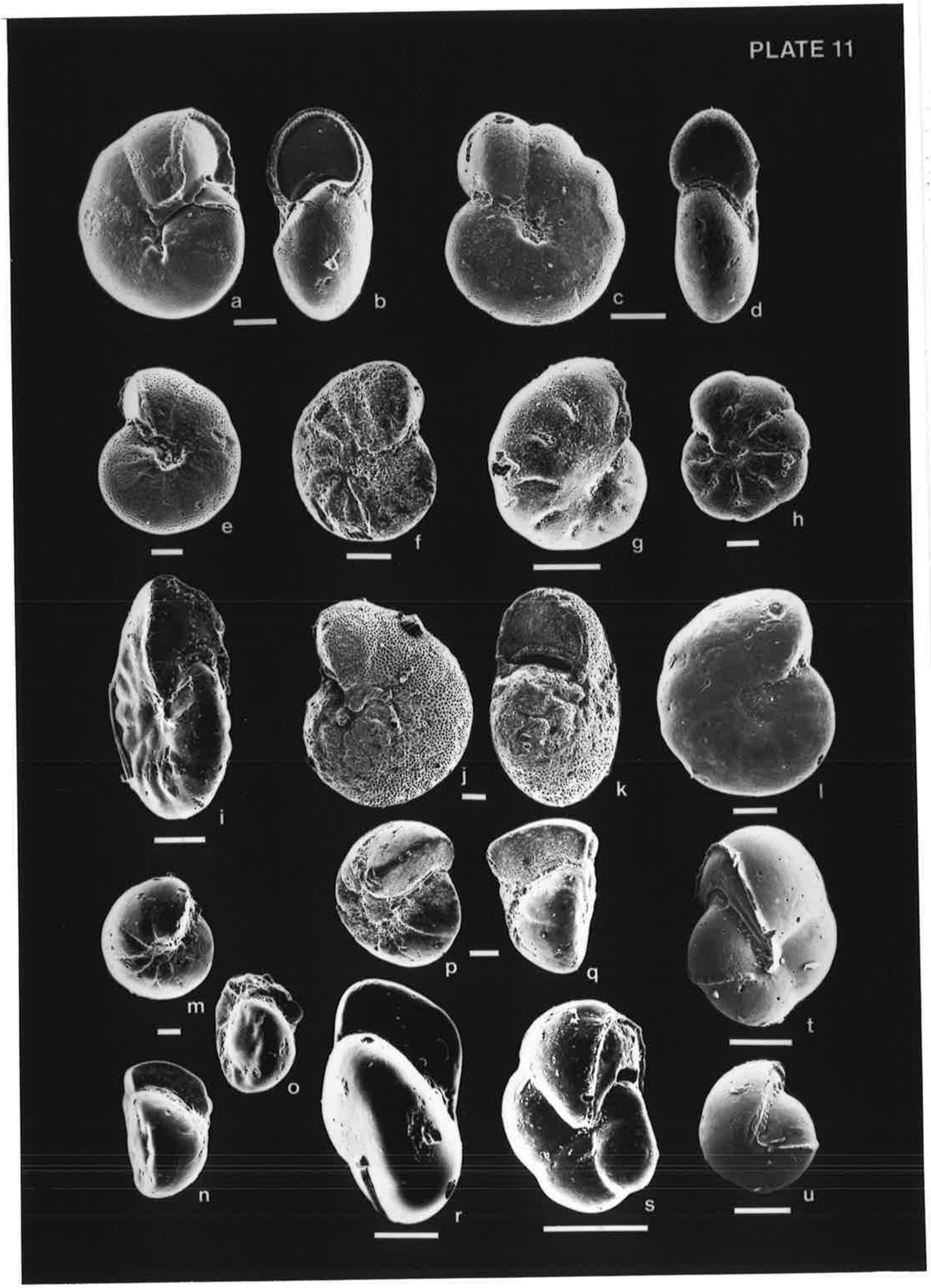


PLATE 12

a, b *Cibicides subhaidingeri* Parr [179]; OB36, Int. H, late Oligocene; Robe, Otway Basin.

c, d, e. *Cibicides pseudolobatulus* Perelis&Reiss [72]; 2W146, c. ventral view, d. peripheral view, e. dorsal view OB36.

f, g, h. *Heterolepa subhaidingeri* (Parr) [179]; f. OB36, g, h. OB131

i, j. *Cibicidoides brevoralis* (Carter) [69] - a. involute view, sample OB36, peripheral view OB128; Int. C, early Oligocene; Robe, Otway Basin.

k, l, m. *Cibicides westi* Howe [529]; OB36 k. involute side, l. oblique peripheral view, m. spiral side.

n, o. *Cibicides perforatus* (Karrer) [70]; W140, Int. G, late Oligocene; Waikerie, Murray Basin.

p, q. *Cibicidoides* sp. 1 [323]; p. ventral side, q. dorsal side, OB73, Int. E, early Oligocene.

r, s. *Cibicides lobatulus* (Walker & Jacob) [73]; r. oblique ventral view, OB91, Int. D; s. dorsal side, SE703, early Oligocene.

t. *Cibicides mediocris* Finlay [78] - dorsal side; OB128, Int. C, late Oligocene.

u,v. *Cibicidoides karreriformis* (Hornibrook) [249] - u. involute view, spiral view sample OB9.1.

w. *Dyocibicides byserialis* Cushman & Valentine [80] - involute side, 2W121, Int. G, late Oligocene.

(scale bar = 100μm)

PLATE 12

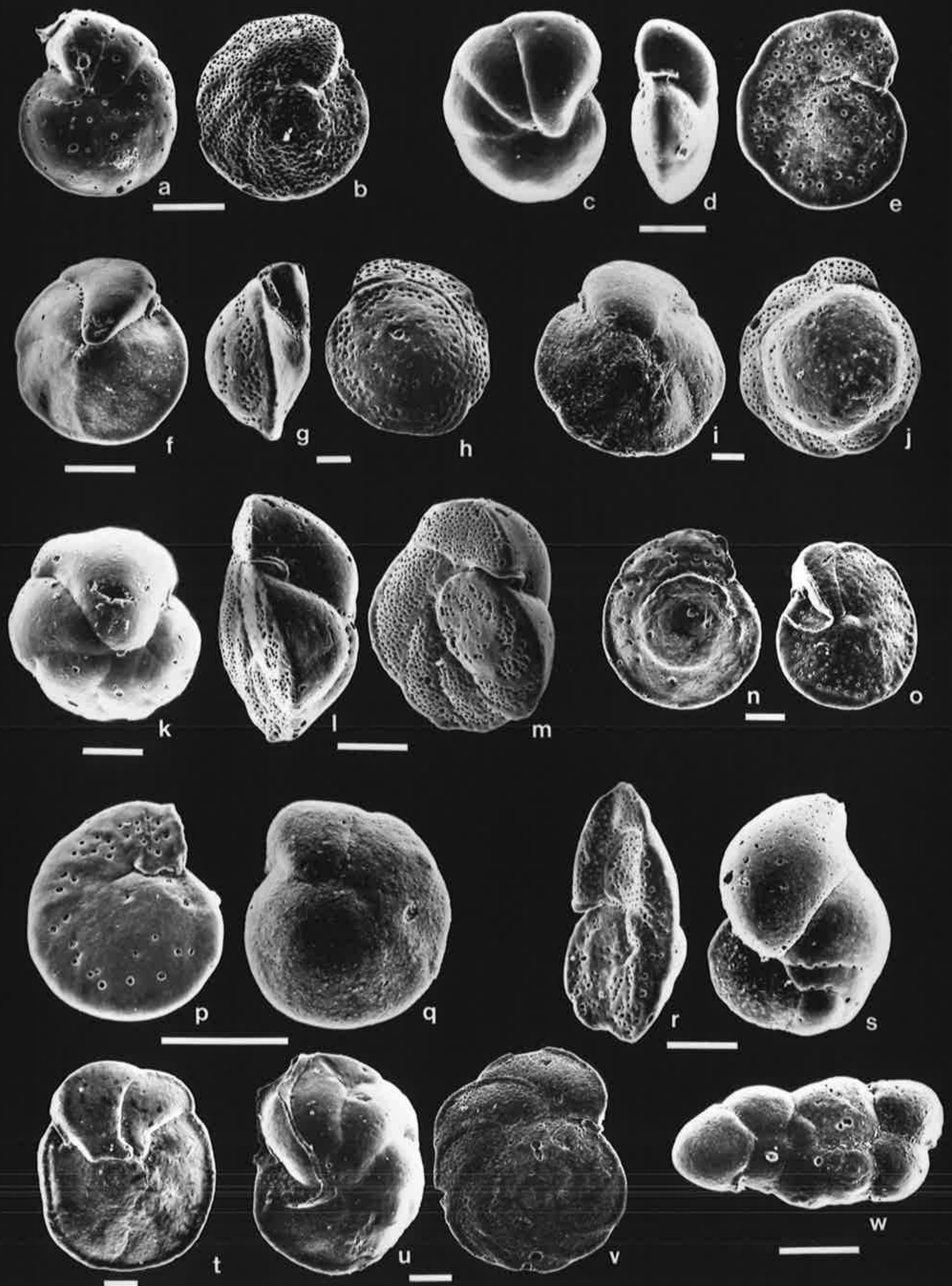


PLATE 13

a. *Laticarinina altocamerata* (Heron-Allen & Earland) [95]; Pt Willunga Formation, Int. C.

b, c. *Laticarinina coronata* (Heron-Allen & Earland) [94]; W152, Int. F; Waikerie.

d, e. *Discorbinella biconcava* (Jones & Parker) [203]; d. dorsal view, e. peripheral view, SE703, early Oligocene; Kingston, Otway Basin.

f, g, h. *Colonimilesia* sp. [570]; f. oblique view, g. dorsal view, h. ventral view; MB183, Int. F.

i. *Patellina corrugata* Williamson [250]; OB53, Int. G.

j. *Rosalina* cf *bradyi* (Cushman); OB121, Int. C.

k. *Discorbinella rarescens* (Brady) [277]; dorsal view; OB114, Int. D.

l, m *Discorbis pseudodiscoides* van Bellen, [57]; l. dorsal view, m. ventral view, Ruwarung Member.

n, o *Glabratellina sigali* Seiglie & Bermudez [289]; peripheral view, ventral view, OB94.7, Int. D.

p. *Planorbulinella roseanna* Lindsay [450]; RR121, Int. H; Mt Gambier.

q. *Sherbonina atkinsoni* Chapman [637]; R22 Ruwarung Member.

r. *Planorbulina* sp. [374]; W120, late Oligocene-Miocene; Waikerie.

s. *Sherbonina cuneimarginata* Wade [634]; R13, Ruwarung Member.

(scale bar = 100µm)

PLATE 13

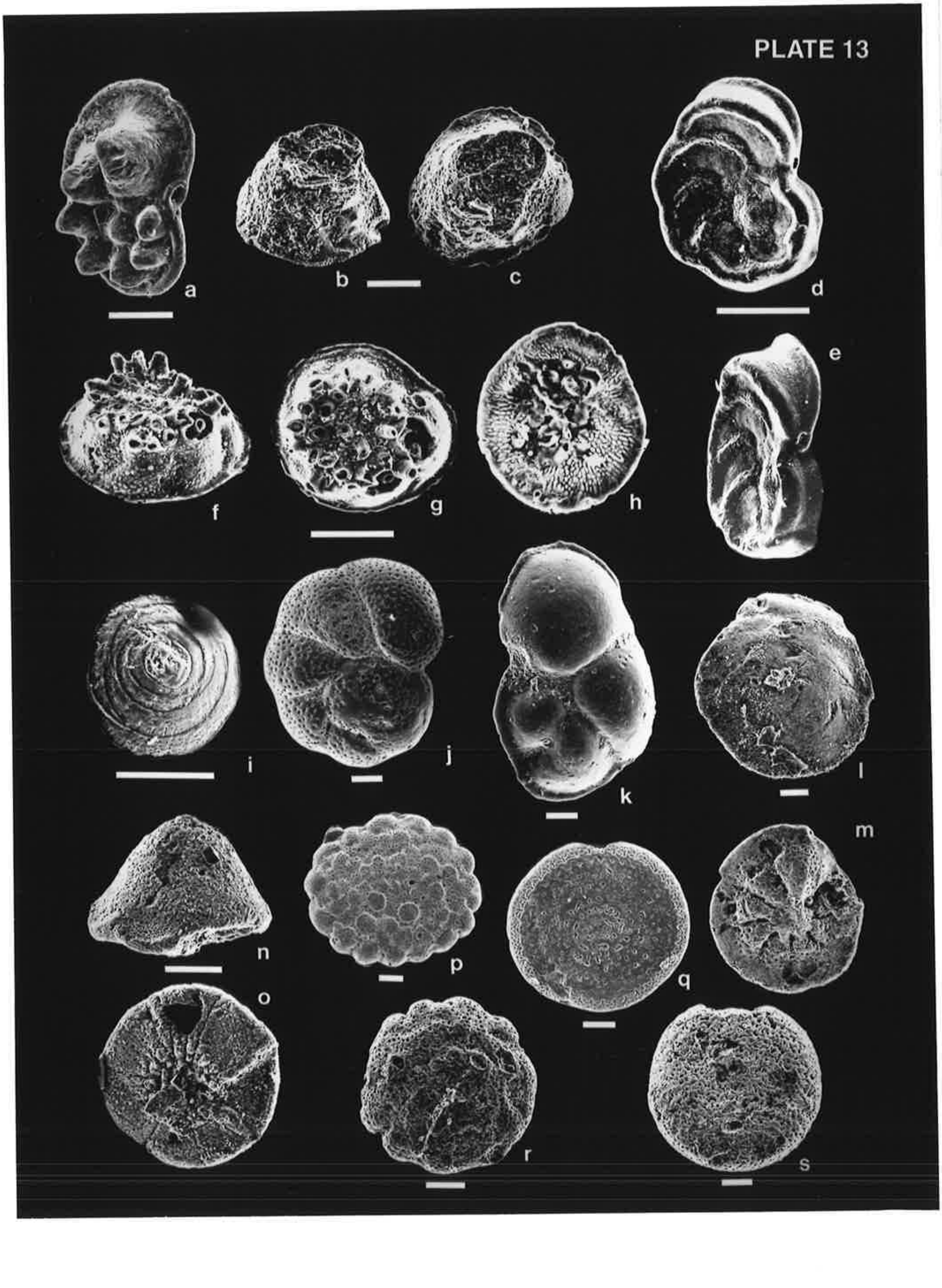


PLATE 14

a, b, c. *Alabamina tenuimarginata* (Chapman, Parr & Collins) [63]; a. dorsal view, b. peripheral view, c. ventral view; OB21, Int. H.

d. *Alabamina tenuimarginata* (Chapman, Parr & Collins) [63]; ventral view; W140, Int. G.

e. *Ammonia beccarii* (Linné) [65]; oblique spiral view; OB52; late Oligocene.

f, g. *Cancris laevinflatus* Hornibrook [264]; f. dorsal view, g. ventral view ; W148; late Oligocene.

h, i. *Buccella lotella* Hornibrook [234]; h. ventral view OB122, i. dorsal view OB128, early Oligocene; Robe, Otway Basin.

j. *Ceratobulimina* sp. [466]; involute side A2, early Oligocene; Aldinga Member, St Vincent Basin.

k, l. *Eponides lornensis* [61]; k. dorsal view, l. peripheral view; OB51, late Oligocene.

m, n. *Eponides repandus* (Fitchel&Moll) [62]; m. dorsal view W152; n. peripheral view W142, late Oligocene.

o, p. *Heronallenia lingulata* (Burrows&Holland) [90]; o. peripheral view, p. dorsal view; OB122, early Oligocene.

q. *Heronallenia parri* Carter [89]; ventral view; OB53, late Oligocene.

r, s. *Valvulineria kalimnenensis* (Parr) [620]; peripheral view, s. side view; MB182, late Oligocene.

t. *Crespinella parri* Quilty [539]; oblique side view; W140, late Oligocene.

u. *Siphonina australis* Cushman [139]; W152.

v. *Stomatorbina concentrica* (Parker&Jones) var. *torrei* (Cushman&Bermudez) [600]; dorsal view; A29, early Oligocene.

w, x. *Stomatorbina concentrica* (Parker&Jones) [108]; ventral view, dorsal view OB88, early Oligocene.

(scale bar = 100µm)

PLATE 14

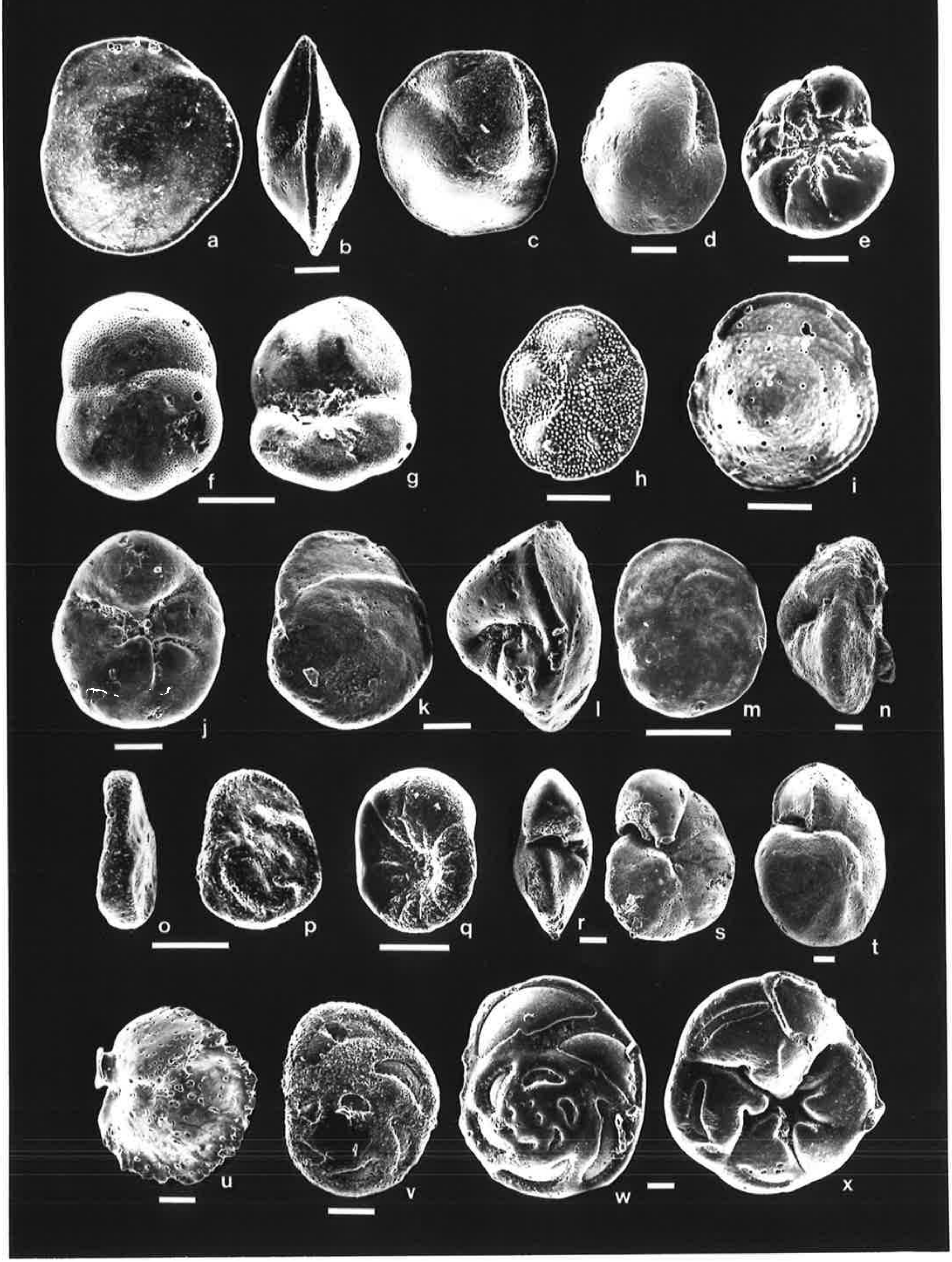


PLATE 15

a. *Elphidium pseudonodosum* Cushman (202); OB122, Int. C, early Oligocene; Robe, Otway Basin.

b. *Elphidium subrotatum* Hornibrook [454]; OB122.

c. *Elphidium* cf. nigarense Cushman ; W140, Int. G, late Oligocene; Dunstan Rd., Waikerie - Murray Basin.

d, e. *Elphidiella* sp. [453]; OB60, d. side view, e. apertural view Int. F, late Oligocene; Robe, Otway Basin.

f. *Notorotalia clathrata* (Brady) [247]; ventral side OB36, Int. H, late Oligocene; Robe, Otway Basin.

g, h. *Notorotalia howchini* (Chapman, Parr &Collins) [247]; g. ventral side, h. dorsal side; OB36.

i. *Porosorotalia crassimura* (Carter) [92]; A2, Int. C, early Oligocene; Pt Willunga Formation, Willunga Embayment.

j. *Discorotalia tenuissima* (Karrer) [256]; OB91, Int. E, early Oligocene; Robe, Otway Basin.

k. *Discorotalia* cf. *D. tenuissima* (Karrer) [256]; OB79, early Oligocene; Robe, Otway Basin.

l. *Parrellina centrifugalis* Carter [463]; OB73, early Oligocene.

m, n. *Parrellina crespinae* (Cushman) [85]; OB27, Int. H, late Oligocene; oblique peripheral view OB67, Int. F, late Oligocene; Robe, Otway Basin.

o, p. *Pararotalia verriculata* (Howchin & Parr) [83]; side view, oblique view; W120, Int. I, late Oligocene-Miocene; Waikerie, Murray Basin.

q, r. *Elphidium* cf. *E. crassatum* Cushman [601] - oblique, apertural view, sample W142, late Oligocene.

s, t. *Porosorotalia* sp. [660]; dorsal side, ventral side; MF48, Int. E, early Oligocene.

u. *Calcarina calcar* d'Orbigny [183]; ventral view; MB185, Int. F, late Oligocene; Wirha Murray Basin.

v. *Calcarina mackayi* (Karrer) [48]; ventral view; OB39, Int. G, late Oligocene; Robe, Otway Basin.

(scale bar = 100µm)

PLATE 15

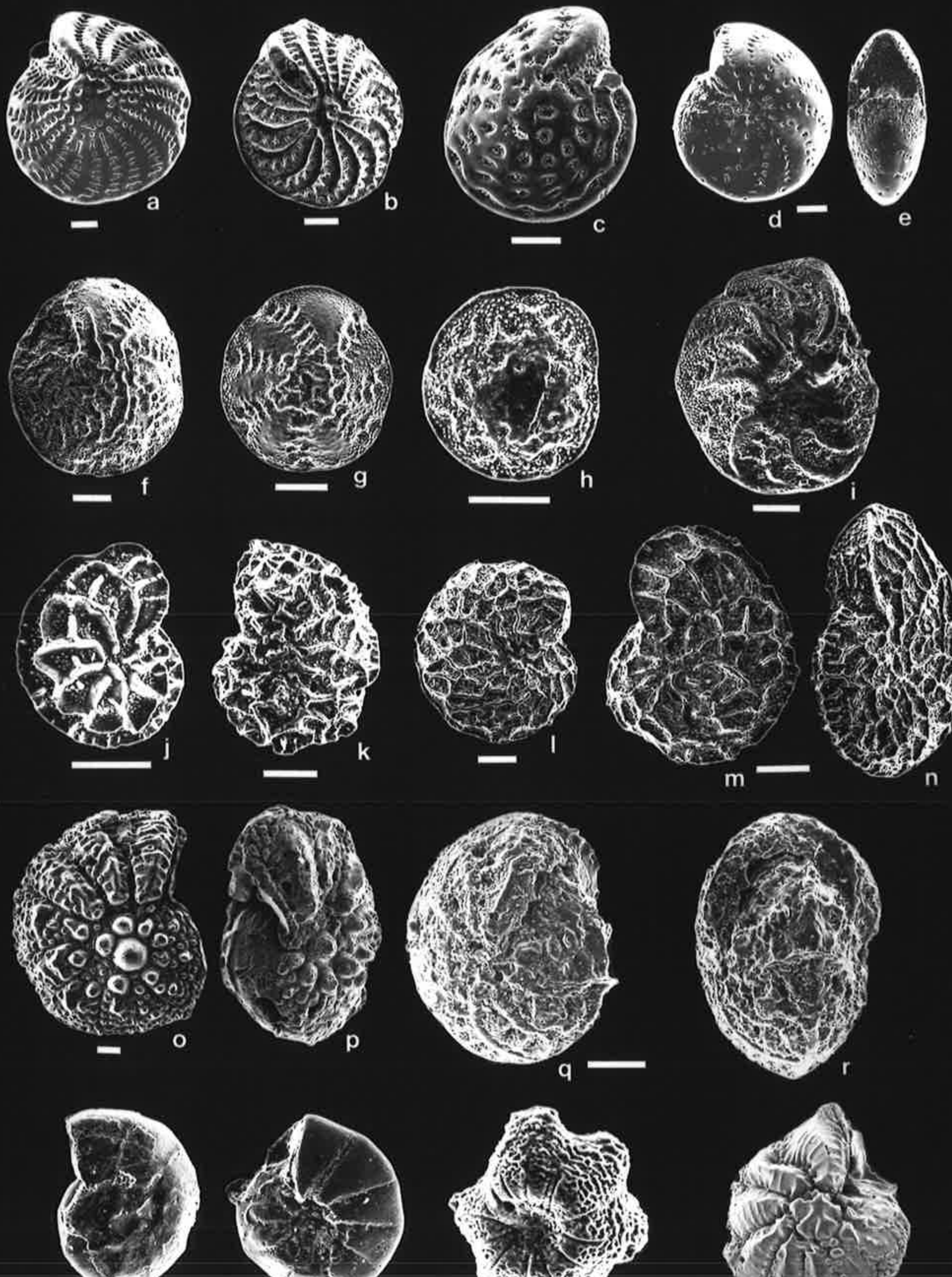


PLATE 16

a, b. *Karreria pseudoconvexa* (Parr) [98]; a. dorsal view, b. ventral view; OB122, Int. C.

c. *Karreria maoria* (Finlay) [71]; RR125, Int. G; Mt Gambier.

d. *Glabratella crassa* Dorreen [60]; W150; Int. F.

e. *Stomatorbina* sp. [600]; OB122.

f. *Hoeglundina elegans* (d'Orbigny) [156]; OB128, Int. C.

g, h. *Hanzawaia scopos* (Finlay) [242]; g. ventral side, h. dorsal side; SE703, early Oligocene; Kingston, Otway Basin.

i, j. *Lamarckina airensis* Carter [469]; i. peripheral view, j. dorsal view; OB128.

k, l. *Lamarckina glencoensis* Chapman&Crespin [104]; k. dorsal view, l. ventral view; OB128.

m. *Zeaflorilus victoriense* (Cushman) [268]; MB184, Int. F, late Oligocene; Wirha, Murray Basin.

n. *Planulina evoluta* [44]; OB36, Int. H, late Oligocene.

o, p. *Cerobertina kakahoica* Finlay [105]; o. dorsal view, p. ventral view; OB122.

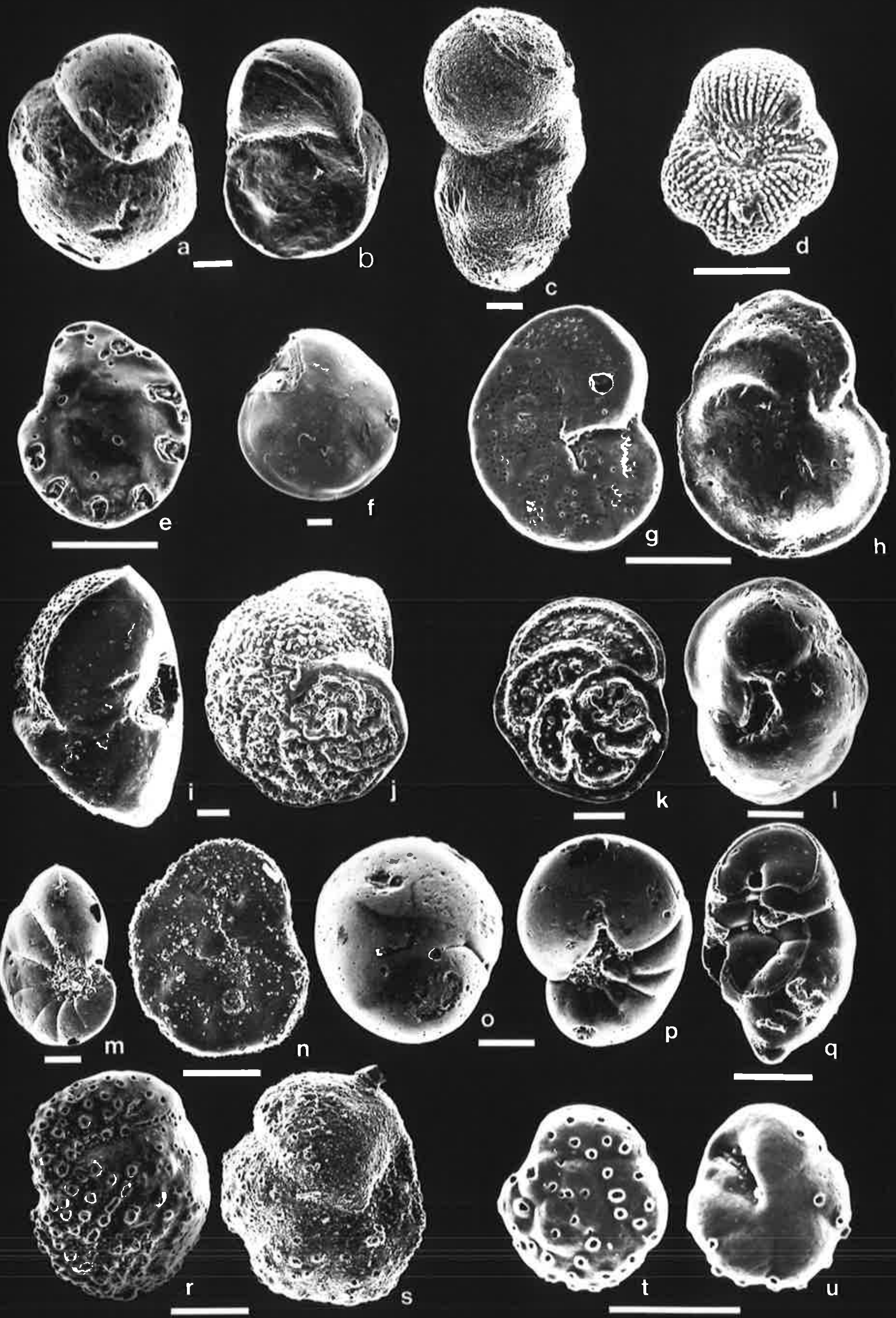
q. *Robertina lornensis* Finlay [102]; MF99, Int. B, late Eocene; Magrath Flat, Murray Basin.

r, s. *Svratkina* sp. [386]; r. dorsal view, s. ventral view; OB36, Int. H.

t, u. *Svratkina australiensis* (Chapman, Parr&Collins) [270]; t. dorsal view, u. ventral view; 2W146, Int. F, late Oligocene; Waikerie, Murray Basin.

(scale bar = 100µm)

PLATE 16



Appendices C to F

All data not included in appendices C -F are available on floppy disk from the author.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
1	APPENDIX C11	BC-1	BC4	BC5	BC6	BC7	BC8	BC9	BC10	BC11	BC12	BC13	BC14	BC15	BC16	BC17	BC18	BC19	BC20	BC21	BC22	BC23	BC24	BC25	BC26	BC27	BC28	BC29	BC40	BC41	BC42	BC43	BC44	BC45	BC46	BC47	BC48	BC49	BC50	BC51	BC52	1971/20	1971/21	BC34
2	CLADEDEPTH IN M	-0.06	0.6	1.2	2	2.6	3.2	3.8	4.4	5	5.6	6.2	6.8	7.6	8.2	8.8	9.3	9.9	10.5	11.1	11.7	12.2	12.8	13.4	14	14.6	15.2	15.8	16.4	17	17.6	18.4	19.1	19.8	20.4	21	21.6	22.4	23	23.6	24.2	25.2	26.7	27.2
3	Agglutinated	39	100	0	44	40	56	37	58	24	36	27	20	28	15	46	17	45	59	16	24	5	21	17	13	5	6	29	8	1	22	20	19	17	37	27	4	52	34	22	30	49	45	64
4	Miliolidae	0	0	0	5	8	4	0	2	2	3	2	2	0	0	5	13	66	136	77	201	153	148	79	10	51	58	5	1	3	63	100	16	47	58	19	0	0	6	34	138	98	41	2
5	Nodosariidae	18	7	0	30	23	30	21	25	9	36	32	33	17	10	28	61	54	55	49	41	56	60	38	13	35	44	89	30	21	58	46	36	40	45	59	33	49	75	41	109	114	98	67
6	*Polymorphina*	20	13	0	16	26	25	15	37	16	11	34	19	11	6	15	21	23	32	21	34	41	47	12	18	18	45	70	9	9	34	17	17	22	19	47	23	25	44	31	74	66	98	55
7	*Fissurina/Lagena*		40	1	74	95	137	50	66	24	49	53	42	33	30	56	43	77	93	66	113	84	115	87	93	76	168	324	64	25	137	106	110	100	98	155	69	96	271	112	252	174	152	90
8	Bolivinidae	9	5	0	27	38	17	13	4	2	5	10	3	4	10	31	19	30	24	12	19	15	22	13	31	9	7	37	2	8	5	14	9	16	8	5	12	18	16	29	26	29	6	41
9	*Sphaeroidina*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	0	0	0	3	126	55	117	84	102	102
10	Uvigerinidae	671	546	27	973	1107	850	343	505	434	979	390	443	507	158	354	486	594	172	83	526	500	648	215	72	107	148	278	176	175	140	288	272	412	407	422	406	450	341	56	136	135	168	236
11	*Cibicides*	1424	1176	46	1080	1312	1293	446	737	314	538	648	423	208	135	329	475	637	771	733	629	789	339	160	167	200	279	564	219	178	319	284	232	303	274	416	745	373	502	433	691	543	337	639
12	*Cassidulina*	240	97	5	254	362	496	261	345	116	408	587	295	298	56	507	806	797	876	1180	1056	1095	590	455	498	296	618	1263	417	333	445	355	471	423	469	816	1513	529	681	635	953	556	575	1208
13	*Gyroidinoides*	37	3	0	20	16	3	3	28	4	17	15	7	23	10	50	37	19	27	34	9	19	12	21	26	19	39	106	23	15	39	36	33	31	23	34	77	14	53	37	85	57	45	42
14	*Anomalinoides*	80	66	2	96	127	95	56	135	45	111	100	72	48	19	41	61	106	76	70	45	62	27	35	23	20	75	114	16	20	22	22	17	26	28	29	36	28	35	25	59	35	29	40
15	*Karreria*	6	15	0	32	127	37	4	3	10	17	11	15	3	0	2	1	8	9	17	40	48	37	8	10	3	47	37	3	5	14	21	8	3	7	7	14	2	30	25	131	61	85	44
16	Discorbids	2	5	3	22	47	20	15	7	3	7	7	5	4	9	76	65	62	51	139	173	69	56	32	40	76	123	319	62	61	115	83	78	98	54	29	52	55	84	126	142	115	91	66
17	Elphidiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	2	3	7	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	3	0	0	0
18	*Pullenia*	35	9	0	24	32	36	22	5	9	18	8	17	6	9	92	36	35	46	23	21	12	15	14	24	18	39	31	14	14	29	21	5	16	7	11	20	13	16	12	25	13	19	47
19	*Robertina*	0	1	0	3	0	1	11	4	11	19	16	15	4	3	2	2	0	0	0	0	0	1	2	0	0	1	0	6	3	6	1	0	0	1	0	0	0	0	0	0	0	4	0
20	*Cerobertina*	3	0	2	23	62	69	31	27	25	105	33	24	16	13	18	22	30	34	33	45	46	29	18	5	12	70	55	3	2	0	4	7	11	11	12	73	9	40	23	51	29	48	55
21	*Hoeglundina*	30	65	64	11	7	22	9	24	8	8	35	59	4	38	61	112	142	117	77	50	173	9	9	8	9	105	131	4	3	3	0	24	51	36	26	18	1	4	0	13	18	4	44
22	*Lamarckina*	12	1	3	0	0	2	0	1	0	0	0	0	5	0	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
23	Others	101	60	26	76	196	128	86	135	761	147	137	78	65	71	158	153	182	156	178	323	191	191	119	53	76	119	222	59	34	112	197	70	124	122	137	178	123	248	124	266	199	188	171
24	Planktonics	126	206	6	271	560	350	353	398	237	322	292	257	359	139	783	533	638	667	482	802	958	803	577	526	396	951	1614	502	439	1110	852	711	1077	894	1328	1827	1020	1601	808	1781	2222	1490	859
25	Total	2923	2415	185	3081	4185	3671	1776	2546	2054	2836	2437	1829	1643	731	2659	2970	3547	3404	3297	4151	4316	3170	1931	1630	1426	2942	5288	1618	1349	2674	2467	2136	2822	2598	3579	5100	2860	4207	2630	5082	4595	3625	3872
26	benthic tot.	2727	2209	179	2810	3625	3321	1423	2148	1817	2514	2145	1572	1284	592	1876	2437	2909	2737	2815	3349	3358	2367	1354	1104	1030	1991	3674	1116	910	1564	1615	1425	1745	1704	2251	3273	1840	2606	1822	3301	2373	2135	3013
27	CLADEDEPTH IN M	-0.06	0.6	1.2	2	2.6	3.2	3.8	4.4	5	5.6	6.2	6.8	7.6	8.2	8.8	9.3	9.9	10.5	11.1	11.7	12.2	12.8	13.4	14	14.6	15.2	15.8	16.4	17	17.6	18.4	19.1	19.8	20.4	21	21.6	22.4	23	23.6	24.2	25.2	26.7	27.2
28	Agglutinated	1.4%	4.5%	0.0%	1.6%	1.1%	1.7%	2.6%	2.7%	1.3%	1.4%	1.3%	1.3%	2.2%	2.5%	2.5%	0.7%	1.5%	2.2%	0.6%	0.7%	0.1%	0.9%	1.3%	1.2%	0.5%	0.3%	0.8%	0.7%	0.1%	1.4%	1.2%	1.3%	1.0%	2.2%	1.2%	0.1%	2.8%	1.3%	1.2%	0.9%	2.1%	2.1%	2.1%
29	Miliolidae	0.0%	0.0%	0.0%	0.2%	0.2%	0.1%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.3%	0.5%	2.3%	5.0%	2.7%	6.0%	4.6%	6.3%	5.8%	0.9%	5.0%	2.9%	0.1%	0.1%	0.3%	4.0%	6.2%	1.1%	2.7%	3.4%	0.8%	0.0%	0.0%	0.2%	1.9%	4.2%	4.1%	1.9%	0.1%
30	Nodosariidae	0.7%	0.3%	0.0%	1.1%	0.6%	0.9%	1.5%	1.2%	0.5%	1.4%	1.5%	2.1%	1.3%	1.7%	1.5%	2.5%	1.9%	2.0%	1.7%	1.2%	1.7%	2.5%	2.8%	1.2%	3.4%	2.2%	2.4%	2.7%	2.3%	3.7%	2.8%	2.5%	2.3%	2.6%	2.6%	1.0%	2.7%	2.9%	2.3%	3.3%	4.8%	4.6%	2.2%
31	*Polymorphina*	0.7%	0.6%	0.0%	0.6%	0.7%	0.8%	1.1%	1.7%	0.9%	0.4%	1.6%	1.2%	0.9%	1.0%	0.8%	0.9%	0.8%	1.2%	0.7%	1.0%	1.2%	2.0%	0.9%	1.6%	1.7%	2.3%	1.9%	0.8%	1.0%	2.2%	1.1%	1.2%	1.3%	1.1%	2.1%	0.7%	1.4%	1.7%	1.7%	2.2%	2.7%	4.6%	1.8%
32	*Fissurina/Lagena*	0.0%	1.8%	0.6%	2.6%	2.6%	4.1%	3.5%	3.1%	1.3%	1.9%	2.5%	2.7%	2.6%	5.1%	3.0%	1.8%	2.6%	3.4%	2.3%	3.4%	2.5%	4.9%	6.4%	8.4%	7.4%	8.4%	8.8%	5.7%	2.7%	8.8%	6.6%	7.7%	5.7%	5.8%	6.9%	2.1%	5.2%	10.4%	6.1%	7.6%	7.3%	7.1%	3.0%
33	Bolivinidae	0.3%	0.2%	0.0%	1.0%	1.0%	0.5%	0.9%	0.2%	0.1%	0.2%	0.5%	0.2%	0.3%	1.7%	1.7%	0.8%	1.0%	0.9%	0.4%	0.6%	0.4%	0.9%	1.0%	2.8%	0.9%	0.4%	1.0%	0.2%	0.9%	0.3%	0.9%	0.6%	0.9%	0.5%	0.2%	0.4%	1.0%	0.6%	1.6%	0.8%	1.2%	0.3%	1.4%
34	*Sphaeroidina*	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.2%	4.8%	3.0%	3.5%	3.5%	4.8%	3.4%
35	Uvigerinidae	24.6%	24.7%	15.1%	34.6%	30.5%	25.6%	24.1%	23.5%	23.9%	38.9%	18.2%	28.2%	39.5%	26.7%	18.9%	19.9%	20.4%	6.3%	2.9%	15.7%	14.9%	27.4%	15.9%	6.5%	10.4%	7.4%	7.6%	15.8%	19.2%	9.0%	17.8%	19.1%	23.6%	23.9%	18.7%	12.4%	24.5%	13.1%	3.1%	4.1%	5.7%	7.9%	7.8%
36	*Cibicides*	52.2%	53.2%	25.7%	38.4%	36.2%	38.9%	31.3%	34.3%	17.3%	21.4%	30.2%	26.9%	16.2%	22.8%	17.5%	19.5%	21.9%	28.2%	26.0%	18.8%	23.5%	14.3%	11.8%	15.1%	19.4%	14.0%	15.4%	19.6%	19.6%	20.4%	17.6%	16.3%	17.4%	16.1%	18.5%	22.8%	20.3%	19.3%	23.8%	20.9%	22.9%	15.8%	21.2%
37	*Cassidulina*	8.8%	4.4%	2.8%	9.0%	10.0%	14.9%	18.3%	16.1%	6.4%	16.2%	27.4%	18.8%	23.2%	9.5%	27.0%	33.1%	27.4%	32.0%	41.9%	31.5%	32.6%	24.9%	33.6%	45.1%	28.7%	31.0%	34.4%	37.4%	36.6%	28.5%	22.0%	33.1%	24.2%	27.5%	36.3%	46.2%	28.8%	26.1%	34.9%	28.9%	23.4%	26.9%	40.1%
38	*Gyroidinoides*	1.4%	0.1%	0.0%	0.7%	0.4%	0.1%	0.2%	1.3%	0.2%	0.7%	0.7%	0.4%	1.8%	1.7%	2.7%	1.5%	0.7%	1.0%	1.2%	0.3%	0.6%	0.5%	1.6%	2.4%	1.8%	2.0%	2.9%	2.1%	1.6%	2.5%	2.2%	2.3%	1.8%	1.3%	1.5%	2.4%	0.8%	2.0%	2.0%	2.6%	2.4%	2.1%	1.4%
39	*Anomalinoides*	2.9%	3.0%	1.1%	3.4%	3.5%	2.9%	3.9%	6.3%	2.5%	4.4%	4.7%	4.6%	3.7%	3.2%	2.2%	2.5%	3.6%	2.8%	2.5%	1.3%	1.8%	1.1%	4.1%	2.1%	1.9%	3.8%	3.1%	1.4%	2.2%	1.4%	1.4%	1.2%	1.5%	1.6%	1.3%	1.1%	1.5%	1.3%	1.4%	1.8%	1.5%	1.4%	1.3%
40	*Karreria*	0.2%	0.7%	0.0%	1.1%	3.5%	1.1%	0.3%	0.1%	0.6%	0.7%	0.5%	1.0%	0.2%	0.0%	0.1%	0.0%	0.3%	0.3%	0.6%	1.2%	1.4%	1.6%	0.6%	0.9%	0.3%	2.4%	1.0%	0.3%	0.5%	0.9%	1.3%	0.6%	0.2%	0.4%	0.3%	0.4%	0.1%	1.2%	1.4%	4.0%	2.6%	4.0%	1.5%
41	Discorbids	0.1%	0.2%	1.7%	0.8%	1.3%	0.6%	1.1%	0.3%	0.2%	0.3%	0.3%	0.3%	0.3%	1.5%	4.1%	2.7%	2.1%	1.9%	4.9%	5.2%	2.1%	2.4%	2.4%	3.6%	7.4%	6.2%	8.7%	5.6%	6.7%	7.4%	5.1%	5.5%	5.6%	3.2%	1.3%	1.6%	3.0%	3.2%	6.9%	4.3%	4.8%	4.3%	2.2%
42	Elphidiidae	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%
43	*Pullenia*	1.3%	0.4%	0.0%	0.9%	0.9%	1.1%	1.5%	0.2%	0.5%	0.7%	0.4%	1.1%	0.5%	1.5%	4.9%	1.5%	1.2%	1.7%	0.8%	0.6%	0.4%	0.6%	1.0%	2.2%	1.7%	2.0%	0.8%	1.3%	1.5%	1.9%	1.3%	0.4%	0.9%	0.4%	0.5%	0.6%	0.7%	0.6%	0.7%	0.8%	0.5%	0.9%	1.6%
44	*Robertina*	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.8%	0.2%	0.6%	0.8%	0.7%	1.0%	0.3%	0.5%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.5%	0.3%	0.4%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%
45	*Cerobertina*	0.1%	0.0%	1.1%	0.8%	1.7%	2.1%	2.2%	1.3%	1.4%	4.2%	1.5%	1.5%	1.2%	2.2%	1.0%	0.9%	1.0%	1.2%	1.2%	1.3%	1.4%	1.2%	1.3%	0.5%	1.2%	3.5%	1.5%	0.3%	0.2%	0.0%	0.2%	0.5%	0.6%	0.6%	0.5%	2.2%	0.5%	1.5%	1.3%	1.5%	1.2%	2.2%	1.8%
46	*Hoeglundina*	1.1%	2.9%	35.8%	0.4%	0.2%	0.7%	0.6%	1.1%	0.4%	0.3%	1.6%	3.8%	0.3%	6.4%	3.3%	4.6%	4.9%	4.3%	2.7%	1.5%	5.2%	0.4%	0.7%	0.7%	0.9%	5.3%	3.6%	0.4%	0.3%	0.2%	0.0%	1.7%	2.9%	2.1%	1.2%	0.5%	0.1%	0.2%	0.0%	0.4%	0.8%	0.2%	1.5%
47	*Lamarckina*	0.4%	0.0%	1.7%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
48	Others	3.7%	2.7%	14.5%	2.7%	5.4%	3.9%	6.0%	6.3%	41.9%	5.8%	6.4%	5.0%	5.1%	12.0%	8.4%	6.3%	6.3%	5.7%	6.3%	9.6%	5.7%	8.1%	8.8%	4.8%	7.4%	6.0%	6.0%	5.3%	3.7%	7.2%	12.2%	4.9%	7.1%	7.2%	6.1%	5.4%	6.7%	9.5%	6.8%	8.1%	8.4%	8.8%	5.7%
49	Planktonics	4.3%	8.5%	3.2%	8.8%	13.4%	9.5%	19.9%	15.6%	11.5%	11.4%	12.0%	14.1%	21.9%	19.0%	29.4%	17.9%	18.0%	19.6%	14.6%	19.3%	22.2%	25.3%	29.9%	32.3%	27.8%	32.3%	30.5%	31.0%	32.5%	41.5%	34.5%	33.3%	38.2%	34.4%	37.1%	35.8%	35.7%	38.1%	30.7%	35.0%	48.4%	41.1%	22.2%
50																																												
51	infauna&cylindrical	1003	769	97	1393	1664	1588	719	974	602	1503	1115	892	869	311	1133	1564	1731	1386	1497	1826	1935	1459	831	739	550	1129	2153	707	579	818	830	928	1061	1070	1494	2071	1159	1530	942	1634	1123	1124	1835
52	epifauna	1549	1265	51	1255	1637	1452	524	912	378	693	783	524	286	173	503	652	898	1070	1070	1097	1140	619	355	276	369	621	1145	324	282	572	546	384	508	444	534	924	472	710	680	1246	909	628	833
53	IE ratio	0.648	0.608	1.902	1.110	1.016	1.094	1.372	1.068	1.593	2.169	1.424	1.702	3.038	1.798	2.252	2.399	1.928	1.295	1.399	1.665	1.697	2.357	2.341	2.678	1.491	1.818	1.880	2.182	2.053	1.430	1.520	2.417	2.089	2.410	2.798	2.241	2.456	2.155	1.385	1.311	1.235	1.790	2.203

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	APPENDIX C	SADME bore RR65 - MT GAMBIER, GAMBIER BASIN																		
2	SAMPLE	RR235.2	RR234.2	RR226.5	RR225.5	RR209.2	RR194.5	RR192.5	RR127.5	RR123.5	RR120.5	RR119.5	RR118.5	RR117.5	RR116.5	RR115.5	RR114.5	RR112.5	RR111.5	RR110.5
3	CLADE\DEPTH IN M	235.2	234.2	226.5	225.5	209.2	194.5	192.5	127.5	123.5	120.5	119.5	118.5	117.5	116.5	115.5	114.5	112.5	111.5	110.5
4	*Cibicides&Cibicidoides*	26	184	118	378	255	289	248	231	133	88	142	108	108	120	155	68	70	92	17
5	*Bolivina*	25	29	9	4	27	28	18	74	4	20	44	31	11	31	23	27	19	44	34
6	miliolids	0	1	0	1	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0
7	discorbids	5	19	10	38	99	87	89	104	20	57	94	69	40	48	58	31	22	14	0
8	Elphidiidae	0	6	1	6	5	22	28	66	27	9	3	13	20	30	5	20	4	2	0
9	*Uvigerina*	6	19	24	33	31	56	59	6	1	13	26	39	2	6	18	9	13	10	26
10	*Lagena&Dentalina*	17	14	7	5	24	15	14	6	16	10	21	26	8	8	20	9	8	41	3
11	agglutinated	3	4	1	3	47	5	4	1	32	24	5	3	28	4	6	2	2	8	4
12	*Anomalina*	2	18	2	26	28	5	17	6	6	11	15	16	21	21	12	12	17	12	13
13	*Siphonina*	0	0	0	0	0	0	0	0	6	0	15	10	1	30	15	6	6	0	0
14	*Stomatorbina*	1	0	0	0	0	0	6	7	1	0	7	5	3	1	6	1	2	0	0
15	*Gyroidina*	0	5	2	11	8	2	4	24		6	4	4	8	14	18	4	5	10	4
16	*Cassidulina*	16	122	53	179	32	147	82	53	42	35	79	54	26	47	62	18	74	20	18
17	globigerinids	205	28	27	34	114	215	295	303	43	103	332	438	103	253	258	147	96	562	504
18	rotalids	33	232	133	459	395	405	386	431	186	171	258	210	197	233	248	135	118	130	34
19	sum=	329	449	254	718	670	871	864	881	331	376	787	817	379	613	658	354	338	815	623
20	benthic total=	115	421	227	684	556	656	569	578	288	273	455	379	276	360	400	207	242	253	119
21	planktonic to benthic ratio	1.783	0.067	0.119	0.050	0.205	0.328	0.518	0.524	0.149	0.377	0.730	1.156	0.373	0.703	0.645	0.710	0.397	2.221	4.235
22	mean =	22	32	18	51	48	62	62	63	25	27	56	58	27	44	47	25	24	58	45
23	max=	205	184	118	378	255	289	295	303	133	103	332	438	108	253	258	147	96	562	504
24	*Pullenia*	14																		
25	CLADE\DEPTH IN M	235.2	234.2	226.5	225.5	209.2	194.5	192.5	127.5	123.5	120.5	119.5	118.5	117.5	116.5	115.5	115.5	112.5	111.5	110.5
26	*Cibicides&Cibicidoides*	22.6%	43.7%	52.0%	55.3%	45.9%	44.1%	43.6%	40.0%	46.2%	32.2%	31.2%	28.5%	39.1%	33.3%	38.8%	32.9%	28.9%	36.4%	14.3%
27	*Bolivina*	21.7%	6.9%	4.0%	0.6%	4.9%	4.3%	3.2%	12.8%	1.4%	7.3%	9.7%	8.2%	4.0%	8.6%	5.8%	13.0%	7.9%	17.4%	28.6%
28	miliolids	0.0%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%
29	discorbids	4.3%	4.5%	4.4%	5.6%	17.8%	13.3%	15.6%	18.0%	6.9%	20.9%	20.7%	18.2%	14.5%	13.3%	14.5%	15.0%	9.1%	5.5%	0.0%
30	Elphidiidae	0.0%	1.4%	0.4%	0.9%	0.9%	3.4%	4.9%	11.4%	9.4%	3.3%	0.7%	3.4%	7.2%	8.3%	1.3%	9.7%	1.7%	0.8%	0.0%
31	*Uvigerina*	5.2%	4.5%	10.6%	4.8%	5.6%	8.5%	10.4%	1.0%	0.3%	4.8%	5.7%	10.3%	0.7%	1.7%	4.5%	4.3%	5.4%	4.0%	21.8%
32	*Lagena&Dentalina*	14.8%	3.3%	3.1%	0.7%	4.3%	2.3%	2.5%	1.0%	5.6%	3.7%	4.6%	6.9%	2.9%	2.2%	5.0%	4.3%	3.3%	16.2%	2.5%
33	agglutinated	2.6%	1.0%	0.4%	0.4%	8.5%	0.8%	0.7%	0.2%	11.1%	8.8%	1.1%	0.8%	10.1%	1.1%	1.5%	1.0%	0.8%	3.2%	3.4%
34	*Anomalina*	1.7%	4.3%	0.9%	3.8%	5.0%	0.8%	3.0%	1.0%	2.1%	4.0%	3.3%	4.2%	7.6%	5.8%	3.0%	5.8%	7.0%	4.7%	10.9%
35	*Siphonina*	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.1%	0.0%	3.3%	2.6%	0.4%	8.3%	3.8%	2.9%	2.5%	0.0%	0.0%
36	*Stomatorbina*	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	1.2%	0.3%	0.0%	1.5%	1.3%	1.1%	0.3%	1.5%	0.5%	0.8%	0.0%	0.0%
37	*Gyroidina*	0.0%	1.2%	0.9%	1.6%	1.4%	0.3%	0.7%	4.2%	0.0%	2.2%	0.9%	1.1%	2.9%	3.9%	4.5%	1.9%	2.1%	4.0%	3.4%
38	*Cassidulina*	13.9%	29.0%	23.3%	26.2%	5.8%	22.4%	14.4%	9.2%	14.6%	12.8%	17.4%	14.2%	9.4%	13.1%	15.5%	8.7%	30.6%	7.9%	15.1%
39	globigerinids	62.3%	6.2%	10.6%	4.7%	17.0%	24.7%	34.1%	34.4%	13.0%	27.4%	42.2%	53.6%	27.2%	41.3%	39.2%	41.5%	28.4%	69.0%	80.9%
40	rotalids	28.7%	55.1%	58.6%	67.1%	71.0%	61.7%	67.8%	74.6%	64.6%	62.6%	56.7%	55.4%	71.4%	64.7%	62.0%	65.2%	48.8%	51.4%	28.6%
41	mean benthos=	11.9%	10.8%	11.3%	11.5%	12.5%	12.4%	13.5%	13.9%	11.8%	12.7%	13.3%	13.9%	13.2%	13.7%	13.4%	13.8%	11.8%	14.7%	14.0%
42	overall max=	71.0%	71.0%	71.0%	71.0%	74.6%	74.6%	80.9%	80.9%	80.9%	80.9%	80.9%	80.9%	80.9%	80.9%	80.9%	80.9%	80.9%	69.0%	80.9%
43	stand.dev=	0.16928	0.12724	0.14262	0.15319	0.1221	0.13087	0.13563	0.1305	0.121	0.10486	0.13044	0.14663	0.11304	0.1243	0.13107	0.12468	0.11262	0.19137	0.2163
44																				
45	infauna+cylindrical:epifauna	2.690	0.913	0.770	0.546	0.409	0.905	0.731	0.765	0.616	0.829	0.945	1.132	0.475	0.656	0.615	0.912	1.180	1.026	2.382

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
1	APPENDIX E2	PORT WILLUNGA FORMATION - ALDINGA BAY, ST VINCENT BASIN																																
2	SAMPLE	PW3	PW4	PW5	PW6	PW7	PW8	PW9	PW10	PW11	PW12	PW13	PW17	PW18	PW20	PW21	PW22	PW23	PW24	PW25	PW26	PW27	PW28	PW29	PW30	PW31	PW32	PW33	PW34	PW35	PW36	R16	R16a	R17
3	M ABOVE CGF	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4	6.0	6.4	7.4	8.0	8.9	9.5	10.1	10.7	11.3	11.9	12.5	13.1	13.7	14.3	14.9	15.4	16.0	16.6	17.2	17.8	18.4	19.0	19.5	20.0
4	Agglutinated	3	3	2	7	2	15	1	12	1	32	31	9	12	5	16	5	49	14	6	7	2	3	1	1	9	13	17	18	37	20	15	22	29
5	Nodosariidae	1	0	1	0	0	1	2	1	0	4	4	3	3	1	5	4	1	0	5	5	8	7	3	5	9	8	6	1	2	8	12	17	7
6	*Polymorphina*	0	4	2	3	1	10	2	2	0	2	3	4	5	0	3	0	4	3	5	3	4	6	3	4	6	10	5	1	4	2	7	10	11
7	*Fiss./Lagena*	1	5	7	4	2	3	0	2	1	4	2	3	9	0	6	2	6	3	13	11	17	6	10	18	19	23	10	11	9	4	19	22	21
8	Bolivinidae	2	0	0	10	2	1	2	7	0	15	23	16	10	2	29	10	2	3	5	13	17	10	22	12	15	25	3	1	5	2	21	12	28
9	*Anomalina*	2	2	3	9	1	5	3	9	1	2	13	9	19	1	10	6	19	10	45	34	30	26	27	21	44	30	12	17	16	20	65	36	125
10	Discorbididae	4	13	9	35	13	18	7	34	2	23	33	67	53	5	19	28	16	8	36	20	38	37	21	37	87	86	18	59	38	52	89	90	184
11	Elphidiidae	1	2	4	12	7	4	3	7	3	0	0	0	2	0	0	4	2	1	13	9	17	10	14	8	14	9	10	34	14	14	8	20	13
12	Eponidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	21	9
13	Glabratellidae	0	0	0	0	0	0	0	2	2	1	2	0	0	0	0	0	0	0	7	7	3	0	0	0	0	1	11	1	1	2	11	7	12
14	Nonionidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	7	4
15	*Planorbulina*	0	0	0	2	2	1	3	1	0	3	3	2	1	0	0	0	4	0	2	2	3	0	0	0	2	1	0	1	1	3	0	0	0
16	*Sphaeroidina*	4	6	11	13	22	15	6	14	4	5	9	26	14	1	4	1	7	3	44	22	2		8	5	19	4	7	2	5	6	11	16	2
17	*Sherbornina*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	8
18	Uvigerinidae	4	12	7	25	14	8	6	34	1	32	42	66	42	7	37	19	21	5	81	80	55	29	53	57	69	65	22	9	18	17	91	73	125
19	Cibicididae	37	83	107	108	68	41	20	173	16	338	349	231	277	44	149	120	75	41	556	548	348	269	265	251	464	470	547	455	581	613	1009	599	603
20	*Cassidulina*	4	6	11	13	22	15	6	14	4	5	9	26	14	1	4	1	7	3	44	22	2	5	8	5	19	10	7	2	5	6	74	23	43
21	*Gyroidinoides*	4	6	11	13	22	15	6	14	4	5	9	26	14	1	4	1	7	3	44	22	2	5	8	5	19	10	7	2	5	6	5	0	0
22	Other Benths.	9	23	22	74	10	38	10	67	7	32	29	67	42	4	32	29	32	9	67	88	50	61	48	43	84	89	29	47	52	63	21	30	34
23	Planktonics	0	0	0	4	0	0	0	12	0	3	6	5	1	0	3	1	6	2	1	7	6	4	3	9	5	10	1	1	2	4	0	0	0
24	Total R/Data	76	165	197	332	188	190	77	405	46	506	567	560	518	72	321	231	258	108	974	900	604	478	494	481	884	864	712	662	795	842	1502	1005	1258
25	total benthics	76	165	197	328	188	190	77	393	46	503	561	555	517	72	318	230	252	106	973	893	598	474	491	472	879	854	711	661	793	838	1502	1005	1258
26	Agglutinated	3.9%	1.8%	1.0%	2.1%	1.1%	7.9%	1.3%	3.1%	2.2%	6.4%	5.5%	1.6%	2.3%	6.9%	5.0%	2.2%	19.4%	13.2%	0.6%	0.8%	0.3%	0.6%	0.2%	0.2%	1.0%	1.5%	2.4%	2.7%	4.7%	2.4%	1.0%	2.2%	2.3%
27	Nodosariidae	1.3%	0.0%	0.5%	0.0%	0.0%	0.5%	2.6%	0.3%	0.0%	0.8%	0.7%	0.5%	0.6%	1.4%	1.6%	1.7%	0.4%	0.0%	0.5%	0.6%	1.3%	1.5%	0.6%	1.1%	1.0%	0.9%	0.8%	0.2%	0.3%	1.0%	0.8%	1.7%	0.6%
28	*Polymorphina*	0.0%	2.4%	1.0%	0.9%	0.5%	5.3%	2.6%	0.5%	0.0%	0.4%	0.5%	0.7%	1.0%	0.0%	0.9%	0.0%	1.6%	2.8%	0.5%	0.3%	0.7%	1.3%	0.6%	0.8%	0.7%	1.2%	0.7%	0.2%	0.5%	0.2%	0.5%	1.0%	0.9%
29	*Fiss./Lagena*	1.3%	3.0%	3.6%	1.2%	1.1%	1.6%	0.0%	0.5%	2.2%	0.8%	0.4%	0.5%	1.7%	0.0%	1.9%	0.9%	2.4%	2.8%	1.3%	1.2%	2.8%	1.3%	2.0%	3.8%	2.2%	2.7%	1.4%	1.7%	1.1%	0.5%	1.3%	2.2%	1.7%
30	Bolivinidae	2.6%	0.0%	0.0%	3.0%	1.1%	0.5%	2.6%	1.8%	0.0%	3.0%	4.1%	2.9%	1.9%	2.8%	9.1%	4.3%	0.8%	2.8%	0.5%	1.5%	2.8%	2.1%	4.5%	2.5%	1.7%	2.9%	0.4%	0.2%	0.6%	0.2%	1.4%	1.2%	2.2%
31	*Anomalina*	2.6%	1.2%	1.5%	2.7%	0.5%	2.6%	3.9%	2.3%	2.2%	0.4%	2.3%	1.6%	3.7%	1.4%	3.1%	2.6%	7.5%	9.4%	4.6%	3.8%	5.0%	5.5%	5.5%	4.4%	5.0%	3.5%	1.7%	2.6%	2.0%	2.4%	4.3%	3.6%	9.9%
32	Discorbididae	5.3%	7.9%	4.6%	10.7%	6.9%	9.5%	9.1%	8.7%	4.3%	4.6%	5.9%	12.1%	10.3%	6.9%	6.0%	12.2%	6.3%	7.5%	3.7%	2.2%	6.4%	7.8%	4.3%	7.8%	9.9%	10.1%	2.5%	8.9%	4.8%	6.2%	5.9%	9.0%	14.6%
33	Elphidiidae	1.3%	1.2%	2.0%	3.7%	3.7%	2.1%	3.9%	1.8%	6.5%	0.0%	0.0%	0.0%	0.4%	0.0%	0.0%	1.7%	0.8%	0.9%	1.3%	1.0%	2.8%	2.1%	2.9%	1.7%	1.6%	1.1%	1.4%	5.1%	1.8%	1.7%	0.5%	2.0%	1.0%
34	Eponidae	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.7%	2.1%	0.7%
35	Glabratellidae	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	4.3%	0.2%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.8%	0.5%	0.0%	0.0%	0.0%	0.0%	0.1%	1.5%	0.2%	0.1%	0.2%	0.7%	0.7%	1.0%
36	Nonionidae	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.7%	0.3%
37	*Planorbulina*	0.0%	0.0%	0.0%	0.6%	1.1%	0.5%	3.9%	0.3%	0.0%	0.6%	0.5%	0.4%	0.2%	0.0%	0.0%	0.0%	1.6%	0.0%	0.2%	0.2%	0.5%	0.0%	0.0%	0.0%	0.2%	0.1%	0.0%	0.2%	0.1%	0.4%	0.0%	0.0%	0.0%
38	*Sphaeroidina*	5.3%	3.6%	5.6%	4.0%	11.7%	7.9%	7.8%	3.6%	8.7%	1.0%	1.6%	4.7%	2.7%	1.4%	1.3%	0.4%	2.8%	2.8%	4.5%	2.5%	0.3%	0.0%	1.6%	1.1%	2.2%	0.5%	1.0%	0.3%	0.6%	0.7%	0.7%	1.6%	0.2%
39	*Sherbornina*	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%	0.0%	0.6%
40	Uvigerinidae	5.3%	7.3%	3.6%	7.6%	7.4%	4.2%	7.8%	8.7%	2.2%	6.4%	7.5%	11.9%	8.1%	9.7%	11.6%	8.3%	8.3%	4.7%	8.3%	9.0%	9.2%	6.1%	10.8%	12.1%	7.8%	7.6%	3.1%	1.4%	2.3%	2.0%	6.1%	7.3%	9.9%
41	Cibicididae	48.7%	50.3%	54.3%	32.9%	36.2%	21.6%	26.0%	44.0%	34.8%	67.2%	62.2%	41.6%	53.6%	61.1%	46.9%	52.2%	29.8%	38.7%	57.1%	61.4%	58.2%	56.8%	54.0%	53.2%	52.8%	55.0%	76.9%	68.8%	73.3%	73.2%	67.2%	59.6%	47.9%
42	*Cassidulina*	5.3%	3.6%	5.6%	4.0%	11.7%	7.9%	7.8%	3.6%	8.7%	1.0%	1.6%	4.7%	2.7%	1.4%	1.3%	0.4%	2.8%	2.8%	4.5%	2.5%	0.3%	1.1%	1.6%	1.1%	2.2%	1.2%	1.0%	0.3%	0.6%	0.7%	4.9%	2.3%	3.4%
43	*Gyroidinoides*	5.3%	3.6%	5.6%	4.0%	11.7%	7.9%	7.8%	3.6%	8.7%	1.0%	1.6%	4.7%	2.7%	1.4%	1.3%	0.4%	2.8%	2.8%	4.5%	2.5%	0.3%	1.1%	1.6%	1.1%	2.2%	1.2%	1.0%	0.3%	0.6%	0.7%	0.3%	0.0%	0.0%
44	%other benthics	11.8%	13.9%	11.2%	22.6%	5.3%	20.0%	13.0%	17.0%	15.2%	6.4%	5.2%	12.1%	8.1%	5.6%	10.1%	12.6%	12.7%	8.5%	6.9%	9.9%	8.4%	12.9%	9.8%	9.1%	9.6%	10.4%	4.1%	7.1%	6.6%	7.5%	1.4%	3.0%	2.7%
45	PB ratio	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.031	0.000	0.006	0.011	0.009	0.002	0.000	0.009	0.004	0.024	0.019	0.001	0.008	0.010	0.008	0.006	0.019	0.006	0.012	0.001	0.002	0.003	0.005	0.000	0.000	0.000
46	infauna	13	25	30	64	47	32	19	65	9	60	80	114	80	11	81	40	39	15	161	140	116	67	110	105	145	140	58	58	53	51	230	174	241
47	epifauna	47	104	130	165	104	79	36	230	23	368	404	333	363	51	182	155	117	62	681	624	418	337	321	314	614	596	584	533	640	691	1193	746	921
48	[I+C]/E	0.277	0.240	0.231	0.388	0.452	0.405	0.528	0.283	0.391	0.163	0.198	0.342	0.220	0.216	0.445	0.258	0.333	0.242	0.236	0.224	0.278	0.199	0.343	0.334	0.236	0.235	0.099	0.109	0.083	0.074	0.193	0.233	0.262
49																																		
50																																		

	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS
1											
2	R17a	R18	R18a	R18b	R19	R24	R25	R26a	R26b	R22	R23
3	20.5	21.0	21.5	22.0	22.6	22.8	23.3	24.5	25.0	26.0	26.4
4	11	25	18	2	4	8	6	5	0	2	5
5	5	14	9	37	6	6	7	25	32	5	6
6	16	8	11	0	10	12	3	1	2	0	1
7	29	31	20	19	9	13	12	14	9	13	6
8	12	29	9	12	14	13	14	24	30	23	27
9	24	59	24	40	25	41	41	23	24	33	40
10	120	149	133	163	39	71	79	97	175	110	136
11	17	23	19	2	34	18	17	13	4	11	27
12	15	29	10	7	3	44	18	10	23	4	18
13	6	4	10	43	4	0	2	13	15	1	5
14	7	9	10	2	11	7	7	15	33	3	8
15	0	3	0	0	1	0	0	0	0	0	0
16	3	12	7	10	4	0	0	3	0	0	0
17	0	11	14	12	10	6	7	0	0	1	6
18	49	167	38	39	32	27	27	32	71	51	83
19	510	760	504	1160	1348	1243	1406	848	803	253	687
20	10	59	9	25	30	10	14	2	6	19	14
21	2	2	2	8	4	1	1	7	5	0	0
22	56	47	45	25	23	19	8	12	7	15	15
23	0	0	0	0	0	0	0	0	0	0	0
24	892	1441	892	1606	1611	1539	1669	1144	1239	544	1084
25	892	1441	892	1606	1611	1539	1669	1144	1239	544	1084
26	1.2%	1.7%	2.0%	0.1%	0.2%	0.5%	0.4%	0.4%	0.0%	0.4%	0.5%
27	0.6%	1.0%	1.0%	2.3%	0.4%	0.4%	0.4%	2.2%	2.6%	0.9%	0.6%
28	1.8%	0.6%	1.2%	0.0%	0.6%	0.8%	0.2%	0.1%	0.2%	0.0%	0.1%
29	3.3%	2.2%	2.2%	1.2%	0.6%	0.8%	0.7%	1.2%	0.7%	2.4%	0.6%
30	1.3%	2.0%	1.0%	0.7%	0.9%	0.8%	0.8%	2.1%	2.4%	4.2%	2.5%
31	2.7%	4.1%	2.7%	2.5%	1.6%	2.7%	2.5%	2.0%	1.9%	6.1%	3.7%
32	13.5%	10.3%	14.9%	10.1%	2.4%	4.6%	4.7%	8.5%	14.1%	20.2%	12.5%
33	1.9%	1.6%	2.1%	0.1%	2.1%	1.2%	1.0%	1.1%	0.3%	2.0%	2.5%
34	1.7%	2.0%	1.1%	0.4%	0.2%	2.9%	1.1%	0.9%	1.9%	0.7%	1.7%
35	0.7%	0.3%	1.1%	2.7%	0.2%	0.0%	0.1%	1.1%	1.2%	0.2%	0.5%
36	0.8%	0.6%	1.1%	0.1%	0.7%	0.5%	0.4%	1.3%	2.7%	0.6%	0.7%
37	0.0%	0.2%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
38	0.3%	0.8%	0.8%	0.6%	0.2%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%
39	0.0%	0.8%	1.6%	0.7%	0.6%	0.4%	0.4%	0.0%	0.0%	0.2%	0.6%
40	5.5%	11.6%	4.3%	2.4%	2.0%	1.8%	1.6%	2.8%	5.7%	9.4%	7.7%
41	57.2%	52.7%	56.5%	72.2%	83.7%	80.8%	84.2%	74.1%	64.8%	46.5%	63.4%
42	1.1%	4.1%	1.0%	1.6%	1.9%	0.6%	0.8%	0.2%	0.5%	3.5%	1.3%
43	0.2%	0.1%	0.2%	0.5%	0.2%	0.1%	0.1%	0.6%	0.4%	0.0%	0.0%
44	6.3%	3.3%	5.0%	1.6%	1.4%	1.2%	0.5%	1.0%	0.6%	2.8%	1.4%
45	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
46	129	332	114	136	136	94	98	125	185	125	171
47	671	999	673	1378	1419	1400	1545	985	1030	400	881
48	0.192	0.332	0.169	0.099	0.096	0.067	0.063	0.127	0.180	0.313	0.194
49											
50											

Pt Willunga

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
1	APPENDIX C8	SADME bore ROS10 'OB2', ROBE - GAMBIER BASIN																											
2	SAMPLE	OB131.3	OB130.1	OB125.8	OB122.5	OB117.3	OB114.3	OB111.2	OB108.2	OB105.1	OB101.8	OB99.1	OB96	OB91.4	OB88.4	OB85.3	OB82.3	OB77.2	OB73.1	OB70.1	OB60.9	OB57.9	OB53.3	OB45.7	OB36.6	OB30.5	OB15.2	OB9.1	
3	CLADE\DEPTH IN M	131.36	130.15	125.88	122.5	117.34	114.3	111.25	108.24	105.15	101.8	99.06	96.01	91.44	88.39	85.34	82.29	77.24	73.15	70.10	60.96	57.91	53.34	45.72	36.58	30.48	15.24	9.14	
4	*Cibicides&Cibicidoides*	251	319	112	158	451	551	779	482	403	459	276	466	423	309	233	293	104	281	345	364	87	129	312	100	220	179	16	
5	*Bolivina*	19	8	8	61	78	159	21	68	19	28	29	10	28	22	24	19	10	116	24	34	67	15	45	119	49	65	8	
6	miliolids	11	45	1	11	12	20	0	1	0	2	0	0	0	0	5	0	0	0	1	0	1	0	1	4	0	0	13	
7	Discorbidae	22	48	19	13	1	17	7	15	7	25	53	50	46	67	44	47	19	33	36	116	33	35	59	26	77	106	7	
8	Elphidiidae	2	0	0	0	2	2	2	0	1	4	2	4	1	8	16	19	37	93	72	98	80	41	92	35	116	71	18	
9	*Uvigerina*	29	16	43	4	37	49	83	102	53	56	55	20	45	25	34	52	13	12	13	42	14	15	43	12	24	37	6	
10	*Lag./Dent./Amphicoryna*	33	42	3	21	35	40	38	36	40	21	23	24	32	27	15	18	7	13	22	38	18	10	133	25	95	45	8	
11	agglutinated	1	3	1	1	4	0	38	12	27	17	42	19	8	10	9	6	8	5	9	14	6	1	14	16	32	30	4	
12	*Anomalina*	58	29	11	29	11	5	12	11	7	12	13	5	6	4	12	17	9	15	16	23	7	10	32	8	17	14	6	
13	*Hoeglundina*	14	10	2	1	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
14	*Gyroidina*	7	5	7	9	14	13	33	6	3	13	10	7	6	5	6	5	5	31	22	8	3	3	14	1	3	26	1	
15	*Pullenia*	21	14	4	10	25	13	8	3	3	4	2	6	8	1	6	8	4	3	5	1	0	1	6	6	10	1	1	
16	*Cassidulina*	242	250	95	23	103	340	194	208	232	145	42	57	123	141	118	107	101	97	158	57	29	30	134	90	180	76	13	
17	globigerinids	225	161	39	23	174	96	117	159	91	71	139	37	75	41	74	45	14	12	14	42	23	12	119	109	353	246	171	
18	*Guembelitria*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0			0							
19	robertinids	0	0	1	8	0	0	0	0	0	0	0	0	0	32	7	29	1	4	5	7	1	1	6	5	8	11	0	
20	rotalids	338	401	149	209	477	586	831	514	420	509	352	528	481	385	295	362	137	360	419	511	130	177	417	135	317	325	30	
21	sum=	935	950	346	372	951	1306	1332	1103	886	857	686	705	801	693	604	666	332	715	742	844	369	303	1010	556	1184	907	272	
22	benthic total=	710	789	306	341	777	1210	1215	944	795	786	547	668	726	619	522	591	317	699	723	795	345	290	885	442	823	650	101	mean PB to 70.2
23	P/B ratio=	0.317	0.204	0.127	0.067	0.224	0.079	0.096	0.168	0.114	0.090	0.254	0.055	0.103	0.066	0.142	0.076	0.044	0.017	0.019	0.053	0.067	0.041	0.134	0.247	0.429	0.378	1.693	0.119
24	mean =	66.786	67.857	24.643	26.000	67.929	93.286	95.143	78.786	63.286	61.214	49.000	50.357	57.214	47.143	42.571	45.429	23.643	50.786	52.643	59.786	26.286	21.571	71.714	39.357	84.000	64.000	19.429	
25	max=	251	319	112	158	451	551	779	482	403	459	276	466	423	309	233	293	104	281	345	364	87	129	312	119	353	246	171	
26	mean total=	770																											
27	mean benthos=	675																											
28	CLADE\DEPTH IN M	131.36	130.15	125.88	122.5	117.34	114.3	111.25	108.24	105.15	101.8	99.06	96.01	91.44	88.39	85.34	82.9	77.24	73.17	70.1	60.96	57.91	53.34	45.72	36.58	30.48	15.24	9.14	
29	*Cibicides&Cibicidoides*	35.4%	40.4%	36.6%	46.3%	58.0%	45.5%	64.1%	51.1%	50.7%	58.4%	50.5%	69.8%	58.3%	49.9%	44.6%	49.6%	32.8%	40.2%	47.7%	45.8%	25.2%	44.5%	35.3%	22.6%	26.7%	27.5%	15.8%	
30	*Bolivina*	2.7%	1.0%	2.6%	17.9%	10.0%	13.1%	1.7%	7.2%	2.4%	3.6%	5.3%	1.5%	3.9%	3.6%	4.6%	3.2%	3.2%	16.6%	3.3%	4.3%	19.4%	5.2%	5.1%	26.9%	6.0%	10.0%	7.9%	
31	miliolids	1.5%	5.7%	0.3%	3.2%	1.5%	1.7%	0.0%	0.1%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.3%	0.0%	0.1%	0.9%	0.0%	0.0%	12.9%	
32	Discorbidae	3.1%	6.1%	6.2%	3.8%	0.1%	1.4%	0.6%	1.6%	0.9%	3.2%	9.7%	7.5%	6.3%	10.8%	8.4%	8.0%	6.0%	4.7%	5.0%	14.6%	9.6%	12.1%	6.7%	5.9%	9.4%	16.3%	6.9%	
33	Elphidiidae	0.3%	0.0%	0.0%	0.0%	0.3%	0.2%	0.2%	0.0%	0.1%	0.5%	0.4%	0.6%	0.1%	1.3%	3.1%	3.2%	11.7%	13.3%	10.0%	12.3%	23.2%	14.1%	10.4%	7.9%	14.1%	10.9%	17.8%	
34	*Uvigerina*	4.1%	2.0%	14.1%	1.2%	4.8%	4.0%	6.8%	10.8%	6.7%	7.1%	10.1%	3.0%	6.2%	4.0%	6.5%	8.8%	4.1%	1.7%	1.8%	5.3%	4.1%	5.2%	4.9%	2.7%	2.9%	5.7%	5.9%	
35	*Lag./Dent./Amphicoryna*	4.6%	5.3%	1.0%	6.2%	4.5%	3.3%	3.1%	3.8%	5.0%	2.7%	4.2%	3.6%	4.4%	4.4%	2.9%	3.0%	2.2%	1.9%	3.0%	4.8%	5.2%	3.4%	15.0%	5.7%	11.5%	6.9%	7.9%	
36	agglutinated	0.1%	0.4%	0.3%	0.3%	0.5%	0.0%	3.1%	1.3%	3.4%	2.2%	7.7%	2.8%	1.1%	1.6%	1.7%	1.0%	2.5%	0.7%	1.2%	1.8%	1.7%	0.3%	1.6%	3.6%	3.9%	4.6%	4.0%	
37	*Anomalina*	8.2%	3.7%	3.6%	8.5%	1.4%	0.4%	1.0%	1.2%	0.9%	1.5%	2.4%	0.7%	0.8%	0.6%	2.3%	2.9%	2.8%	2.1%	2.2%	2.9%	2.0%	3.4%	3.6%	1.8%	2.1%	2.2%	5.9%	
38	*Hoeglundina*	2.0%	1.3%	0.7%	0.3%	0.5%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
39	*Gyroidina*	1.0%	0.6%	2.3%	2.6%	1.8%	1.1%	2.7%	0.6%	0.4%	1.7%	1.8%	1.0%	0.8%	0.8%	1.1%	0.8%	1.6%	4.4%	3.0%	1.0%	0.9%	1.0%	1.6%	0.2%	0.4%	4.0%	1.0%	
40	*Pullenia*	3.0%	1.8%	1.3%	2.9%	3.2%	1.1%	0.7%	0.3%	0.4%	0.5%	0.4%	0.9%	1.1%	0.2%	1.1%	1.4%	1.3%	0.4%	0.7%	0.1%	0.0%	0.3%	0.7%	1.4%	1.2%	0.2%	1.0%	
41	*Cassidulina*	34.1%	31.7%	31.0%	6.7%	13.3%	28.1%	16.0%	22.0%	29.2%	18.4%	7.7%	8.5%	16.9%	22.8%	22.6%	18.1%	31.9%	13.9%	21.9%	7.2%	8.4%	10.3%	15.1%	20.4%	21.9%	11.7%	12.9%	
42	globigerinids	24.1%	16.9%	11.3%	6.2%	18.3%	7.4%	8.8%	14.4%	10.3%	8.3%	20.3%	5.2%	9.4%	5.9%	12.3%	6.8%	4.2%	1.7%	1.9%	5.0%	6.2%	4.0%	11.8%	19.6%	29.8%	27.1%	62.9%	
43	*Guembelitria*	47.6%	50.8%	48.7%	61.3%	50.2%	44.9%	62.4%	46.6%	47.4%	59.4%	51.3%	74.9%	60.0%	55.6%	48.8%	54.4%	41.3%	50.3%	56.5%	60.5%	35.2%	58.4%	41.3%	24.3%	26.8%	35.8%	11.0%	
44	robertinids	11.44%	11.18%	10.66%	11.16%	8.45%	7.67%	7.77%	8.17%	7.88%	7.73%	8.59%	7.52%	7.81%	7.57%	8.02%	7.63%	7.44%	7.26%	7.28%	7.50%	7.59%	7.43%	7.98%	8.54%	9.27%	9.08%		
45	rotalids	74.89%																											
46	I+C/E	1.032	0.762	1.033	0.545	0.581	0.997	0.416	0.810	0.829	0.505	0.435	0.229	0.493	0.582	0.710	0.616	1.255	0.928	0.700	0.528	1.588	0.633	1.084	2.065	1.495	0.908	1.256	
47	EPIFAUNA	349	446	150	220	489	606	831	515	420	511	352	528	481	385	300	362	137	360	420	511	131	177	418	139	317	325	43	
48	INFAUNA	360	340	155	120	284	604	346	417	348	258	153	121	237	224	213	223	172	334	294	270	208	112	453	287	474	295	54	
49	SUM	709	786	305	340	773	1210	1177	932	768	769	505	649	718	609	513	585	309	694	714	781	339	289	871	426	791	620	97	
50	%INFAUNA	50.8%	43.3%	50.8%	35.3%	36.7%	49.9%	29.4%	44.7%	45.3%	33.6%	30.3%	18.6%	33.0%	36.8%	41.5%	38.1%	55.7%	48.1%	41.2%	34.6%	61.4%	38.8%	52.0%	67.4%	59.9%	47.6%	55.7%	
51	%EPIFAUNA	49.2%	56.7%	49.2%	64.7%	63.3%	50.1%	70.6%	55.3%	54.7%	66.4%	69.7%	81.4%	67.0%	63.2%	58.5%	61.9%	44.3%	51.9%	58.8%	65.4%	38.6%	61.2%	48.0%	32.6%	40.1%	52.4%	44.3%	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	APPENDIX C																									
2	SAMPLE	WMC37.5	WMC36.9	WMC36.4	WMC36	WMC35.6	WMC35	WMC34.4	WMC33.9	WMC33.4	WMC32.7	WMC32.1	WMC31.4	WMC30.6	WMC29.6	WMC29	WMC28.3	WMC27.5	WMC26.9	WMC26.3	WMC25.3	WMC24.8	WMC24.3	WMC23.8	WMC23.4	WMC22.8
3	CLADE\DEPTH IN M	37.5	36.9	36.4	36.0	35.6	35.0	34.4	33.9	33.4	32.7	32.1	31.4	30.6	29.6	29.0	28.3	27.5	26.9	26.3	25.3	24.8	24.3	23.8	23.4	22.8
4	agglutinated	1	16	46	105	90	63	71	89	123	108	77	16	31	38	2	55	36	74	83	64	70	108	119	135	55
5	miliolids		11	20	56	59	73	5	3	5	3															
6	Nodosariidae	1	6	4	18	30	49	4	15	10	9	10	2	3	3		8	10	14	12	2	10	35	10	14	14
7	Polymorphinids	3	3	10	20	34	72	10	7	12	13	11	6	7	24	1	6	9	16	14	7	9	27	23	30	7
8	*Fissurina/Lagena*	7	11	5	25	46	62	7	18	20	16	13	3	5	14		5	5	16	17	14	22	16	26	12	10
9	Bolivinidae	1	7	2	7	40	105	15	28	65	18	10	9	21	30	1	7	22	6	50	65	21	9	16	8	5
10	*Spaeroidina*	9	7	10	51	93	148	13	14	15	21	1	13	2	21		15	9	7	20	7	9	13	12	15	14
11	Uvigerinidae	28	106	52	424	620	712	157	226	176	195	135	69	96	155	6	66	99	67	192	152	128	61	105	71	48
12	*Discorbis*	2	27	14	39	52	53	24	69	55	64	38	22	23	24	1	19	10	6	9	22	20	8	26	6	6
13	Elphidiidae										1	1					3	23	89	30	21	37	218	105	138	35
14	*Cibicides&Cibicidoides*	60	160	239	531	835	862	227	332	374	432	384	250	236	807	57	294	273	304	367	284	290	982	780	757	524
15	*Cassidulina*	38	55	71	185	404	369	98	115	200	195	117	92	96	245	51	133	144	147	129	91	91	500	285	389	266
16	*Pullenia*	1	7	10	20	24	20	12	22	19	20	9	2	7	16	2	5	6	8	11	5	11	12	19	16	4
17	*Gyroidina*		6	5	32	67	19	36	36	29	50	34	43	11	52	14	34	55	36	13	6	8	147	51	93	44
18	*Anomalina*	6	11	9	52	149	206	32	52	39	52	29	15	23	27		14	10	13	11	14	11	13	17	14	5
19	*Karreria*	2		3	2		5																			
20	*Ceratobulimina*													1												
21	*Hoeglundina*	1	3	11	80	132	176																			
22	Robertinids	1		3	6	4	4																			
23	*Cerobertina*	4		4	5	46	147																			
24	other benthics	18	35	50	87	83	89	66	100	96	97	80	48	57	65	14	48	57	53	82	75	37	129	94	119	80
25	total benthics	183	471	568	1745	2808	3234	777	1126	1238	1294	949	590	619	1521	149	712	768	856	1040	829	774	2278	1688	1817	1117
26	planktonics	26	115	32	299	633	1292	80	171	364	158	118	100	77	131	0	59	140	80	395	302	279	62	175	97	81
27	planktonic:benthic	0.142	0.244	0.056	0.171	0.225	0.400	0.103	0.152	0.294	0.122	0.124	0.169	0.124	0.086	0.000	0.083	0.182	0.093	0.380	0.364	0.360	0.027	0.104	0.053	0.073
28	*S.linaperta*		15	13	60	165	264	20	37	60	16	22	11	5	5											
29	*S.angiporoides*	6	30	12	94	284	545	45	80	142	56	33	26	8	31		17	21	10	15	53	24	11	15	7	9
30	*G.index*			1	5	3	3																			
31	*Ten.munda,gemma,insol*		8		1	7	14	6		26	4	11	10	5	18		2	28	5	26	39	24	10	12	6	6
32	*Chiloguembelina*						3			1	1	1	4		2	1	1	3	1	4		3			1	
33	*G.triseriata*														1			8	1	3	13	4	1		1	1
34	*G.praebulloides gp.*	13	77	21	196	286	651	29	70	118	60	105	75	42	96	1	46	100	52	257	206	282	60	156	107	65
35	%*S.linaperta*	0.0%	13.0%	40.6%	20.1%	26.1%	20.4%	25.0%	21.6%	16.5%	10.1%	18.6%	11.0%	6.5%	3.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
36	%*S.angiporoides*	23.1%	26.1%	37.5%	31.4%	44.9%	42.2%	56.3%	46.8%	39.0%	35.4%	28.0%	26.0%	10.4%	23.7%	0.0%	28.8%	15.0%	12.5%	3.8%	17.5%	8.6%	17.7%	8.6%	7.2%	11.1%
37	%*G.index*	0.0%	0.0%	3.1%	1.7%	0.5%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
38	%*Tenuitella*	0.0%	7.0%	0.0%	0.3%	1.1%	1.1%	7.5%	0.0%	7.1%	2.5%	9.3%	10.0%	6.5%	13.7%	0.0%	3.4%	20.0%	6.3%	6.6%	12.9%	8.6%	16.1%	6.9%	6.2%	7.4%
39	%*Chiloguebelina*	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.3%	0.6%	0.8%	4.0%	0.0%	1.5%	0.0%	1.7%	2.1%	1.3%	1.0%	0.0%	1.1%	0.0%	0.0%	1.0%	0.0%
40	%*G. triseriata*	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	5.7%	1.3%	0.8%	4.3%	1.4%	1.6%	0.0%	1.0%	1.2%
41	%*G.praebulloides*	50.0%	67.0%	65.6%	65.6%	45.2%	50.4%	36.3%	40.9%	32.4%	38.0%	89.0%	75.0%	54.5%	73.3%	0.0%	78.0%	71.4%	65.0%	65.1%	68.2%	101.1%	96.8%	89.1%	110.3%	80.2%
42	%agglutinated	0.5%	3.4%	8.1%	6.0%	3.2%	1.9%	9.1%	7.9%	9.9%	8.3%	8.1%	2.7%	5.0%	2.5%	1.3%	7.7%	4.7%	8.6%	8.0%	7.7%	9.0%	4.7%	7.0%	7.4%	4.9%
43	%miloilids	0.0%	2.3%	3.5%	3.2%	2.1%	2.3%	0.6%	0.3%	0.4%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
44	%Nodosariidae	0.5%	1.3%	0.7%	1.0%	1.1%	1.5%	0.5%	1.3%	0.8%	0.7%	1.1%	0.3%	0.5%	0.2%	0.0%	1.1%	1.3%	1.6%	1.2%	0.2%	1.3%	1.5%	0.6%	0.8%	1.3%
45	%Polymorphina	1.6%	0.6%	1.8%	1.1%	1.2%	2.2%	1.3%	0.6%	1.0%	1.0%	1.2%	1.0%	1.1%	1.6%	0.7%	0.8%	1.2%	1.9%	1.3%	0.8%	1.2%	1.2%	1.4%	1.7%	0.6%
46	%Fiss./lag.	3.8%	2.3%	0.9%	1.4%	1.6%	1.9%	0.9%	1.6%	1.6%	1.2%	1.4%	0.5%	0.8%	0.9%	0.0%	0.7%	0.7%	1.9%	1.6%	1.7%	2.8%	0.7%	1.5%	0.7%	0.9%
47	%Bolivinidae	0.5%	1.5%	0.4%	0.4%	1.4%	3.2%	1.9%	2.5%	5.3%	1.4%	1.1%	1.5%	3.4%	2.0%	0.7%	1.0%	2.9%	0.7%	4.8%	7.8%	2.7%	0.4%	0.9%	0.4%	0.4%
48	%Sphaeroidina	4.9%	1.5%	1.8%	2.9%	3.3%	4.6%	1.7%	1.2%	1.2%	1.6%	0.1%	2.2%	0.3%	1.4%	0.0%	2.1%	1.2%	0.8%	1.9%	0.8%	1.2%	0.6%	0.7%	0.8%	1.3%
49	%Uvigigerinidae	15.3%	22.5%	9.2%	24.3%	22.1%	22.0%	20.2%	20.1%	14.2%	15.1%	14.2%	11.7%	15.5%	10.2%	4.0%	9.3%	12.9%	7.8%	18.5%	18.3%	16.5%	2.7%	6.2%	3.9%	4.3%
50	%Discorbis	1.1%	5.7%	2.5%	2.2%	1.9%	1.6%	3.1%	6.1%	4.4%	4.9%	4.0%	3.7%	3.7%	1.6%	0.7%	2.7%	1.3%	0.7%	0.9%	2.7%	2.6%	0.4%	1.5%	0.3%	0.5%
51	%Elphidiidae	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.4%	3.0%	10.4%	2.9%	2.5%	4.8%	9.6%	6.2%	7.6%	3.1%
52	%Cibicides&Cibicidoid	32.8%	34.0%	42.1%	30.4%	29.7%	26.7%	29.2%	29.5%	30.2%	33.4%	40.5%	42.4%	38.1%	53.1%	38.3%	41.3%	35.5%	35.5%	35.3%	34.3%	37.5%	43.1%	46.2%	41.7%	46.9%
53	%Cassidulina	20.8%	11.7%	12.5%	10.6%	14.4%	11.4%	12.6%	10.2%	16.2%	15.1%	12.3%	15.6%	15.5%	16.1%	34.2%	18.7%	18.8%	17.2%	12.4%	11.0%	11.8%	21.9%	16.9%	21.4%	23.8%
54	%Pullenia	0.5%	1.5%	1.8%	1.1%	0.9%	0.6%	1.5%	2.0%	1.5%	1.5%	0.9%	0.3%	1.1%	1.1%	1.3%	0.7%	0.8%	0.9%	1.1%	0.6%	1.4%	0.5%	1.1%	0.9%	0.4%
55	%Gyroidina	0.0%	1.3%	0.9%	1.8%	2.4%	0.6%	4.6%	3.2%	2.3%	3.9%	3.6%	7.3%	1.8%	3.4%	9.4%	4.8%	7.2%	4.2%	1.3%	0.7%	1.0%	6.5%	3.0%	5.1%	3.9%
56	%Anomalina	3.3%	2.3%	1.6%	3.0%	5.3%	6.4%	4.1%	4.6%	3.2%	4.0%	3.1%	2.5%	3.7%	1.8%	0.0%	2.0%	1.3%	1.5%	1.1%	1.7%	1.4%	0.6%	1.0%	0.8%	0.4%
57	%Karreria	1.1%	0.0%	0.5%	0.1%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
58	%Ceratobulimina	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
59	%Hoeglundina	0.5%	0.6%	1.9%	4.6%	4.7%	5.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
60	%Robertinids	0.5%	0.0%	0.5%	0.3%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
61	%Cerobertina	2.2%	0.0%	0.7%	0.3%	1.6%	4.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
62	%others	9.8%	7.4%	8.8%	5.0%	3.0%	2.8%	8.5%	8.9%	7.8%	7.5%	8.4%	8.1%	9.2%	4.3%	9.4%	6.7%	7.4%	6.2%	7.9%	9.0%	4.8%	5.7%	5.6%	6.5%	7.2%
63	%plankton	12.4%	19.6%	5.3%	14.6%	18.4%	28.5%	9.3%	13.2%	22.7%	10.9%	11.1%	14.5%	11.1%	7.9%	0.0%	7.7%	15.4%	8.5%	27.5%	26.7%	26.5%	2.6%	9.4%	5.1%	6.8%
64	WMC507	37.5	36.9	36.4	36.0	35.6	35.0	34.4	33.9	33.4	32.7	32.1	31.4	30.6	29.6	29.0	28.3	27.5	26.9	26.3	25.3	24.8	24.3	23.8	23.4	22.8

	A	B	C	D	E	F	G	H	I	J	K	L
1	APPENDIX E3	SADME bore '2W' - WAIKERIE, MURRAY BASIN										
2	SAMPLE	2W155.4	2W147.8	2W137.2	2W125	2W117.3	2W110	2W109.2	2W103.6	2W94.8	2W88.7	2W85.3
3	CLADE\DEPTH IN M	155.45	147.83	137.16	125.00	117.35	110.00	109.12	103.63	94.79	88.70	85.34
4	*Cibicides&Cibicidoides*	109	153	141	186	166	168	137	111	114	116	124
5	*Cass/Uvig.*	53	84	37	10	14	29	22	16	4	1	24
6	Bolivinidae	7	26	32	23	9	20	9	4	18	29	10
7	miliolida	8	2	1	0	0	0	3	0	0	0	0
8	*Discorbis*	9	25	54	32	49	50	55	29	51	26	51
9	Elphidiidae	0	5	13	18	50	23	61	120	49	56	17
10	*Uvigerina*	34	71	12	2	2	2	1	2	2	0	6
11	Nodosaridae	2	3	6	5	3	8	3	12	2	10	3
12	agglutinated	2	0	0	1	0	0	0	0	1	2	4
13	*Anomalina*	5	19	23	26	26	48	27	41	35	27	17
14	*Siphonina*	0	2	6	0	2	4	0	12	18	4	2
15	*Gyroidina*	0	2	1	0	0	0	0	0	0	1	0
16	*Pullenia*	3	2	0	2	1	2	3	1	4	2	1
17	*Cassidulina*	19	13	25	8	12	27	21	14	2	1	18
18	globigerinids	1	15	7	12	3	7	3	4	10	29	5
19	robertinids	2	0	0	0	0	0	0	0	0	0	0
20	rotalids	123	199	219	244	241	266	219	181	200	170	192
21	sum=	201	338	321	315	323	359	323	350	306	303	258
22	benthic total=	200	323	314	303	320	352	320	346	296	274	253
23	P/B ratio=	0.005	0.046	0.022	0.040	0.009	0.020	0.009	0.012	0.034	0.106	0.020
24	mean =	17	28	24	22	22	26	23	24	21	20	19
25	max=	109	153	141	186	166	168	137	120	114	116	124
26	CLADE\DEPTH IN M	155.45	147.83	137.16	125.00	117.35	110.00	109.12	103.63	94.79	88.70	85.34
27	*Cibicides&Cibicidoides*	54.5%	47.4%	44.9%	61.4%	51.9%	47.7%	42.8%	32.1%	38.5%	42.3%	49.0%
28	*Cass/Uvig.*	26.5%	26.0%	11.8%	3.3%	4.4%	8.2%	6.9%	4.6%	1.4%	0.4%	9.5%
29	Bolivinidae	3.5%	8.0%	10.2%	7.6%	2.8%	5.7%	2.8%	1.2%	6.1%	10.6%	4.0%
30	miliolida	4.0%	0.6%	0.3%	0.0%	0.0%	0.0%	0.9%	0.0%	0.0%	0.0%	0.0%
31	*Discorbis*	4.5%	7.7%	17.2%	10.6%	15.3%	14.2%	17.2%	8.4%	17.2%	9.5%	20.2%
32	Elphidiidae	0.0%	1.5%	4.1%	5.9%	15.6%	6.5%	19.1%	34.7%	16.6%	20.4%	6.7%
33	*Uvigerina*	17.0%	22.0%	3.8%	0.7%	0.6%	0.6%	0.3%	0.6%	0.7%	0.0%	2.4%
34	Nodosaridae	1.0%	0.9%	1.9%	1.7%	0.9%	2.3%	0.9%	3.5%	0.7%	3.6%	1.2%
35	agglutinated	1.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.3%	0.7%	1.6%
36	*Anomalina*	2.5%	5.9%	7.3%	8.6%	8.1%	13.6%	8.4%	11.8%	11.8%	9.9%	6.7%
37	*Siphonina*	0.0%	0.6%	1.9%	0.0%	0.6%	1.1%	0.0%	3.5%	6.1%	1.5%	0.8%
38	*Gyroidina*	0.0%	0.6%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%
39	*Pullenia*	1.5%	0.6%	0.0%	0.7%	0.3%	0.6%	0.9%	0.3%	1.4%	0.7%	0.4%
40	*Cassidulina*	9.5%	4.0%	8.0%	2.6%	3.8%	7.7%	6.6%	4.0%	0.7%	0.4%	7.1%
41	globigerinids	0.5%	4.4%	2.2%	3.8%	0.9%	1.9%	0.9%	1.1%	3.3%	9.6%	1.9%
42	robertinids	61.5%	61.6%	69.7%	80.5%	75.3%	75.6%	68.4%	52.3%	67.6%	62.0%	75.9%
43	rotalids	11.7%	12.0%	11.5%	11.7%	11.3%	11.6%	11.0%	9.9%	10.8%	10.7%	11.7%
44	overall max=	0.005	0.04644	0.02229	0.0396	0.00938	0.01989	0.00938	0.01156	0.03378	0.10584	
45												
46	Clade	**155.45**	**149.35**	**137.16**	**125.00**	**117.35**	**110.00**	**109.12**	**103.63**	**94.79**	**88.70**	**85.34**
47	infauna+cylindrical	65	115	75	40	27	59	37	33	28	42	38
48	epifauna	131	206	238	262	293	293	283	313	267	229	211
49	I+C/E	0.496	0.558	0.315	0.153	0.092	0.201	0.131	0.105	0.105	0.183	0.180

2W Waikerie

APPENDIX D: SADME '2W' WAK-1 (6829-00442), Walkerie, Murray Basin

	core reference/sample interval	2W155.4	2W149.3	2W147.8	2W146.3	2W143.9	2W139.6	2W137.2	2W134.1	2W131.1	2W128	2W125	2W121.9	2W117.3	2W114.3	2W112.8	2W110	2W109.1	2W106.9	2W103.6	2W94.8	2W88.7	2W86.9	2W85.3
T.C	TAXON\DEPTH IN M.	155.4	149.3	147.8	146.3	143.9	139.6	137.2	134.1	131.1	128.0	125.0	121.9	117.3	114.3	112.8	110.0	109.1	106.9	103.6	94.8	88.7	86.9	85.3
42	Amphestigina lessoni	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0
303	Amphicoryna separans	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
305	Angulogerina elliptica	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	Angulogerina esuriens *	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
58	Angulogerina tenuistriata *	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	Anomalinoides macralabra *	1	0	1	0	0	1	1	0	0	0	1	0	0	1	1	1	1	0	1	1	1	1	1
67	Anomalinoides pinguinglabra *	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	1
241	Anomalinoides procolligera	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	1
448	Arenodosaria sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
590	Astacolus neolatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
137	Astacolus sp ?judyae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
613	Astacolus sp.1 crepidulus	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
608	Astigerina lornensis	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
276	Astrononion australe	1	1	0	1	0	1	0	0	0	1	0	0	0	1	1	1	1	0	0	1	0	1	1
86	Astrononion centroplax	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Austrotrillina howchini	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
611	Bolivina decussata	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
19	Bolivina lapsus (cf mahoenuica Hornibro	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1
248	Bolivina nitida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
151	Bolivina osloni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210	Bolivina pontis	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	Bolivina pseudoplicata	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
185	Bolivina reticulata	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1	0	1
13	Bolivina targetensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107	Bolivinella elegans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
176	Bolivinella folia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
5	Bolivinopsis cubensis *	0	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
201	Brizalina spathulata	0	0	1	0	0	0	1	1	0	0	0	0	1	1	1	1	1	0	0	1	1	1	1
234	Buccella lotella	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
170	Bulimina pupula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
282	Buliminella cf browni	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
183	Calcarina cf. calcar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
264	Cancris laevinflatus *	0	0	1	1	1	0	1	1	0	1	1	1	0	0	1	1	1	0	1	0	1	1	0
154	Carpentaria globiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
284	Cassidulina cf margareta	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
135	Cassidulina cuneata	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
415	Cassidulina laevigata *	0	1	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	1	0	0	0	1
138	Chrysalogonium verticale *	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69	Cibicides brevoralis *	1	0	0	0	1	1	1	0	0	0	1	0	1	1	1	0	0	0	1	1	1	0	0
206	Cibicides cygnorum	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
73	Cibicides lobatulus	1	0	1	0	0	0	0	0	0	1	1	1	1	1	1	0	1	0	1	0	0	1	0
78	Cibicides mediocris	1	0	1	0	0	0	1	0	0	0	0	1	1	1	1	0	0	1	1	1	1	1	0
162	Cibicides molestus	0	0	0	0	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	1	0	0
74	Cibicides praecipuus *	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
278	Cibicides refulgens	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1
179	Cibicides subhaidingeri	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
77	Cibicides vortex *	0	0	1	1	1	1	1	0	1	1	1	1	1	0	0	0	0	0	0	1	0	1	0
249	Cibicidoides karreriformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
249	Cibicidoides Karreriformis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
70	Cibicidoides perforatus *	0	1	1	0	1	1	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
570	Colonimilesia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
539	Crespinella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
621	Cribrogoesella robusta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
33	Cushmanina tasminiae *	1	0	1	0	1	1	1	0	0	1	1	1	0	0	1	1	1	0	0	0	0	1	0
530	Cushmanina plumigera	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1
657	Cushmanina sp.1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
46	Cyclammina incisa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
47	Cyclogyra involvens	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Dentalina soluta *	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0
203	Discorbinella biconcava	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1	0	0	0	1	1	0	1	1
232	Discorbinella complanata	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0	1	1
251	Discorbinella galera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
277	Discorbinella rarescens	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	1	0
459	Discorbinella sp	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0
55	Discorbis sp.	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1	1	1	0	0	0	0	0	0
256	Discorotalia tenuissima	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
152	Dorothia minima	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1
230	Dorothia parri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
80	Dyocibicides primitiva	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
258	Elphidium craticulatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
214	Elphidium crispum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
202	Elphidium pseudonodosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	Eponides lornensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
62	Eponides repandus *	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	1
165	Evolocassidulina orientalis	0	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0
648	Favulina squamosa	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
628	Fissurina alveolata var	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
177	Fissurina annectens	1	1	1	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
14	Fissurina aperta *	1	1	1	0	1	1	1	0	0	0	1	0	0	1	1	0	0	0	0	0	1	1	1
190	Fissurina bifida	0	0	0	1	0	1	1	1	0	0	0	1	0	0	1	1	0	0	0	0	0	1	0
617	Fissurina cf fimbriata	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	Fissurina crassiannulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
38	Fissurina furcata *	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
224	Fissurina orbignyana var. flintii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
586	Fissurina lagenoides	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
149	Fissurina marginata	0	0	1	1	0	1	1	1	0	1	1	0	0	0	0	1	1	0	0	0	0	0	1
418	Fissurina orbigyana	0	0	1	0	0	1	1	0	0	1	1	1	0	0	1	1	0	0	0	1	1	1	0
195	Fissurina quadrata	0	0	0	1	0	1	1	0	0	1	1	0	0	0	1	1	1	0	0	1	0	1	0
196	Fissurina quadrata var carinata	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	1	1	0	0	0	1	0	0
656	Fissurina radiato-marginata	0	0	1	1	0	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	1	1	0
208	Fissurina seminarginata	1	1	0	1	1	1	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
536	Fissurina sequenziana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
554	Fissurina sequenziana var	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
193	Fissurina sp.1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
651	Bucherina sp. 2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
191	Fissurina submarginata	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	0	0	1	1
646	Fissurina trigono-ornata	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
269	Florilus stachei	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0
268	Florilus victoriense	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0
53	Gaudryina crespinae	1	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	1	0	0	0	0	1	0
569	Gaudryina sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	Glabratella crassa	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
289	Glabratellina sigali (?P.patelliformis pl.8	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
51	Glandulina symmetrica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
15	Globocassidulina crassa	1	0	0	0	0	0	1	1	0	0	0	1	1	0	0	1	1	1	0	0	0	0	1
8	Globocassidulina subglobosa *	1	0	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1
422	Guttulina communis	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
421	Guttulina irregularis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
27	Guttulina problema	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	1
426	Guttulina regina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
164	Gyroidina zealandica	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
59	Gyroidinoides allani *	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
242	Hanzawaia scopos	0	0	0	0	1	0	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1
90	Heronallenia lingulata *	0	0	1	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
89	Heronallenia parri *	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
237	Heteromorphina calomorpha	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
156	Hoeglundina elegans *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	Homalohedra acuticosta	1	0	1	0	0	1	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
20	Kolesnikovella australis	1	0	0	1	0	0	0	0	1	0	0	0	1	1	1	1	1	0	1	1	0	1	0
636	Lagena curvicostata	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
625	Lagena distoma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
294	Lagena gracilis	0	0	1	0	0	0	0	1	0	1	1	0	0	1	1	1	1	0	0	0	0	1	0
168	Lagena gracillima	0	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
32	Lagena hispida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
194	Lagena hirtshalsensis	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	1
290	Lagena meridionalis	1	0	0	1	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
560	Lagena nebulosa	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
425	Lagena sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
584	Lagena spiralis	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
592	Lagena stelligera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
36	Lagena striata	0	0	1	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0
34	Lagena substriata *	1	0	1	0	1	1	0	1	0	1	1	1	0	1	1	0	0	0	0	0	0	1	0
280	Lagena sulcata *	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
594	Lagena sulcata var spicata	0	1	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
632	Lagenasolenia largicostata	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95	Laticarinina altocamerata	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94	Laticarinina coronata	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
571	Leibusella soldanii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
629	Lenticulina (Robulus) coloratus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
43	Lenticulina (Robulus) gyroscalprus *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
166	Lenticulina (Robulus) pliocaenicus	1	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0
528	Lenticulina cf loculosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
245	Lenticulina gibba	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
532	Lenticulina lucida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
564	Lenticulina sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
609	Lingulina sp.2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
192	Loxostomum lobatum	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0
30	Marginulina coronata	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
211	Marginulina duracina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
97	Marginulopsis hydropica	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
150	Massalina torquayensis	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
267	Miliolinella oblonga	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
246	Nodosaria simplex (cf. N.pyrula)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
268	Nonionella sp.?=Nonion victoriense	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
173	Notorotalia cf. clathrata	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	1	0	0	1

	TAXON\DEPTH IN M.	192.4	191.8	191.1	190.7	190.1	189.5	189	188.34	187.1	186.5	185.9	185.2	184.6	184	183.2	182.6	182	181.4	180.8	180.2	179.5	178.9	178.3	177.7	177.1	176.5	175.9	175.3	174.7
215	Planularia sp 2	1	1	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
44	Planulina evoluta	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	1	0	1	0	1	0	1	1	0	1
50	Polymorphina sp	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
92	Porosorotalia crassimura *	1	1	1	1	0	0	1	1	1	0	1	1	0	1	1	1	0	0	1	1	1	0	1	1	1	0	1	1	0
438	Pseudopolymorphina sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
81	Pullenia bulloides	0	1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
82	Pullenia quinqueloba	0	0	0	1	1	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
653	Pyrgo lucernula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	Pyrulina gutta	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
405	Q.weaveri cf. Q.vulgaris	0	0	0	0	1	0	1	0	1	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
1	Quinqueloculina laevigata	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
407	Quinqueloculina zealandica	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
102	Robertina lomensis	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
174	Sigmavirgulina tortuosa	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
231	Sigmoidella elegantissima	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
626	Sigmoilina asperta	0	0	1	0	1	0	0	1	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
167	Sigmomorhina wynyardensis	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
139	Siphonina australis	0	1	0	0	0	1	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0
410	Sphaeroidina bulloides	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0	1	0	0	0	0	1
226	Sphaeroidina variabilis ??	0	1	1	1	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
64	Spirillina decorata	0	0	1	0	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
515	Spiriloculina sp	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
509	Spiriloculina sp.2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
108	Stomatorbina concentrica	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
270	Svratkina australiensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0
49	Textularia gladizea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
490	Textularia jutsoni	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
491	Textularia sp.1	0	0	0	1	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	Trifarina bradyi	0	0	0	0	0	0	1	1	1	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0
370	Trifarina parva	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1
175	Triloculina brochita	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
409	Triloculina cf carinata ?affinis	0	0	0	0	0	0	0	1	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
479	Turborotalia opima	0	0	1	0	1	0	0	0	0	1	1	0	1	1	1	0	0	0	0	0	1	1	1	1	1	0	1	0	0
213	Uvigerina multistriata	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	Uvigerina proboscidae	0	1	1	1	0	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1
305	Uvigerina sp ? A.elliptica	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
563	Vaginulina americana	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
501	Vaginulinopsis acanthonucleu	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
620	Valvinulinaria kalimnensis	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
111	Cassigerinella chipolensis	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
113	Cassigerinella winniana	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
114	Chiloguembelina cubensis	0	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
119	Globigerina ampliapertura	1	0	0	1	0	0	0	0	0	1	0	0	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
125	Globigerina brazieri	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120	Globigerina bulloides *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
122	Globigerina euapertura	0	0	0	1	0	0	0	0	0	1	1	0	0	1	1	1	0	1	0	0	0	0	0	0	1	1	0	0	1
275	Tenuitellinita juvenilis	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
123	Globigerina labiacrassata	0	1	1	1	1	1	0	1	0	0	0	1	0	0	1	1	0	1	0	0	0	1	0	1	1	0	0	0	0
126	Globigerina officinalis	1	0	0	1	0	0	1	0	0	0	1	0	0	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0
116	Globigerina praebulloides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
121	Globigerina sp.cf G.ciperoensi	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0
274	Globorotaloides testarugosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115	Guembelitria triseriata	0	0	1	1	1	0	1	0	0	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
129	Praetenuitella insolita	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
159	Pseudohastigerina micra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
110	Subbotina angiporoides	0	0	1	1	1	1	0	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
109	Subbotina linaperta	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
132	Tenuitella aculeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	Tenuitella gemma	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131	Tenuitella munda	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0	0	0	0	0	0	1	0	1	1	0	1
133	Turborotalia increbescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	simple diversity=	215.4	224.8	231.1	254.7	230.1	238.5	243	245.34	229.1	258.5	242.9	244.2	249.6	260	253.2	245.6	208	211.4	201.8	193.2	200.5	207.9	205.3	217.7	207.1	192.5	200.9	187.3	191.7
	benthic diversity=	212.4	220.8	223.1	243.7	221.1	234.5	238	242.34	227.1	251.5	237.9	240.2	246.6	253	244.2	236.6	205	208.4	201.8	193.2	199.5	206.9	205.3	211.7	205.1	190.5	199.9	187.3	189.7
	planktonic diversity=	3	4	8	11	9	4	5	3	2	7	5	4	3	7	9	9	3	3	0	0	1	1	0	6	2	2	1	0	2

636	Lagena curvicostata	0	1	0	0	0	0	0	0	0	1	0	1	0	3
168	Lagena gracillima (Seguenza)	0	0	1	0	0	0	1	1	0	1	0	0	0	4
194	Lagena hirtahalsensis	0	0	1	1	1	1	1	0	0	1	1	1	0	8
290	Lagena meridionalis	0	0	0	0	0	0	0	1	0	0	0	0	0	1
560	Lagena nebulosa	0	0	0	0	0	0	0	0	0	0	0	1	0	1
584	Lagena spiralis (Brady)	0	0	0	0	0	0	1	1	0	0	0	0	0	2
36	Lagena striata	1	1	1	0	0	0	0	0	0	0	0	0	0	3
34	Lagena substriata *	1	0	0	1	1	1	1	1	1	0	1	1	1	10
280	Lagena sulcata *	1	0	1	1	0	1	1	1	1	1	1	1	1	11
594	Lagena sulcata var spicata	0	1	1	0	0	0	0	0	0	0	0	0	0	2
469	Lamarckina sirensis	1	0	0	0	0	0	0	0	0	0	0	0	0	1
104	Lamarckina glencoensis	1	0	0	0	0	0	0	0	0	0	0	0	0	1
43	Lenticulina (R.) gyroscalprus *	1	1	0	1	1	1	1	1	1	1	0	1	0	10
166	Lenticulina (R.) pliocaenicus	0	0	0	0	0	0	0	1	0	0	0	0	0	1
521	Lenticulina (Robulus) cultrata	1	0	0	0	0	0	0	0	0	0	0	0	0	1
528	Lenticulina ?loculosa	0	0	0	0	0	0	0	1	0	0	0	0	0	1
41	Lenticulina erratica	0	0	0	0	0	1	0	0	0	0	0	1	0	2
245	Lenticulina gibba	0	1	0	0	0	0	0	0	0	1	1	0	0	3
97	Marginulopsis hydropica *	0	0	0	1	0	0	1	1	0	1	0	0	0	4
150	Massilina torquayensis	0	0	0	0	1	1	1	0	1	0	0	0	0	4
267	Miliolinella oblonga	1	0	1	0	0	0	0	0	0	0	0	0	0	2
148	Nodosarella sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	1
497	Nodosaria longiscata	0	0	0	0	1	1	0	0	0	1	0	0	0	3
257	Nodosaria vertebralis var	0	0	0	1	0	0	0	1	0	0	1	0	0	3
247	Notorotalia cf. Howchini	0	0	0	1	0	1	1	1	1	1	1	1	0	8
87	Notorotalia spinosa	0	0	0	0	0	0	0	0	0	0	1	0	0	1
588	Nummoloculina contraria	0	0	0	0	0	0	1	0	0	0	0	0	0	1
655	Nummoloculina irregularis	1	1	1	0	0	0	0	0	0	0	0	0	0	3
31	Oolina hexagona *	0	0	0	1	1	1	1	1	1	1	1	1	0	9
52	Oolina sp. *	0	0	0	1	1	1	1	0	0	1	1	1	0	7
406	Ophthalmidium sp.	0	1	1	0	0	0	0	0	1	0	0	0	0	3
271	Palliolatella semialata	0	0	1	0	0	0	1	1	0	1	0	0	0	4
581	Parafissurina carinata	0	0	0	0	0	0	0	1	0	0	0	0	0	1
85	Parrellina crispinae	0	0	0	0	0	0	1	0	0	1	1	0	0	3
95	Parvicarinina altocamerata	0	0	0	0	1	0	0	0	1	0	1	0	0	3
94	Parvicarinina coronata	0	0	0	0	0	0	0	1	0	0	0	0	0	1
250	Patellina corrugata *	0	1	1	1	0	1	1	0	0	0	1	0	0	6
440	Patellina sp	1	0	0	0	0	0	0	0	0	0	0	0	0	1
498	Peneroplis cf. pertusis	0	0	0	0	0	0	0	1	0	0	0	0	0	1
433	Planularia sp 2* ?Vaginulina te	0	0	0	1	0	0	0	1	0	0	0	0	0	2
44	Planulina evoluta	1	0	0	1	1	1	1	0	1	0	0	1	0	7
430	Planulina halophora	0	0	0	0	1	0	0	0	0	0	0	0	0	1
50	Polymorphina sp	0	0	0	0	1	1	0	0	0	1	1	0	0	4
92	Porosorotalia crassimura	0	0	0	1	0	1	1	1	1	0	1	1	0	7
660	Porosorotalia sp	0	0	0	0	0	0	0	0	0	0	0	0	1	1
656	Pseudofissurina obscurocostata	0	0	0	0	1	0	0	0	1	0	0	1	1	4
81	Pullenia bulloides *	1	1	1	1	1	1	1	1	1	1	0	1	0	11
82	Pullenia quinqueloba *	1	1	1	1	1	1	1	1	0	0	0	0	0	8
228	Pyrgo elongata	1	0	0	0	0	0	0	0	0	0	0	0	0	1
207	Pyrulina fusiformis	0	0	0	0	0	1	0	0	0	0	0	1	0	2
9	Quinqueloculina imperialis	0	1	0	0	0	0	1	0	0	0	0	0	0	2
1	Quinqueloculina laevigata *	0	0	0	1	1	1	0	0	1	1	1	1	0	7
405	Quinqueloculina weaveri *	0	0	0	1	1	1	1	0	1	0	1	1	0	7
243	Rectoglandulina rotunda	0	0	0	0	0	0	0	0	0	0	1	0	0	1
102	Robertina sp. ?lornensis	0	0	1	1	1	1	0	1	0	0	0	0	0	5
458	Rosalina augur *	0	0	0	1	0	0	0	0	1	0	1	1	0	4
174	Sigmavirgulina tortuosa	0	0	0	0	0	0	1	0	0	0	0	1	0	2
231	Sigmoidella elegantissima	1	0	0	0	0	0	0	0	0	0	0	0	0	1
626	Sigmoilina asperta	0	0	1	0	0	0	1	0	0	0	0	0	0	2
139	Siphonina australis *	0	0	1	1	1	0	1	0	1	1	1	1	0	8
153	Siphotextularia awamoana	0	0	0	1	0	1	1	0	0	0	0	1	0	4
21	Siphouvigerina proboscidae *	0	0	1	1	0	1	1	1	1	1	1	1	0	9
410	Sphaeroidina bulloides *	1	1	1	1	1	1	1	1	1	1	1	1	0	12
226	Sphaeroidina variabilis *	0	1	0	1	0	0	0	0	0	0	0	0	0	2
64	Spirillina decorata	1	0	0	0	0	0	1	0	0	0	0	0	0	2
446	Spirillina striatogranulosa	0	0	0	0	1	0	0	0	0	0	0	0	0	1
509	Spiroloculina sp. 2	0	0	0	1	0	0	1	0	0	1	0	0	0	3
515	Spiroloculina sp.1	0	0	0	1	0	0	1	1	1	0	0	0	0	4
493	Stilostomella verneuilii	0	0	0	0	0	1	0	0	0	0	0	1	0	2
108	Stomatorbina concentrica *	0	0	0	1	0	1	1	0	0	1	1	0	0	5
158	Textularia colemani	0	0	0	0	1	1	1	1	1	0	1	0	0	6
49	Textularia gladizea	0	0	0	0	0	0	0	0	0	0	0	1	0	1
22	Trifarina bradyi	1	1	1	1	0	1	1	1	1	1	1	1	1	12
219	Trifarina costornata	0	0	0	0	0	0	0	0	0	0	0	1	0	1
175	Triloculina brochita	1	0	0	0	0	0	0	0	0	0	0	0	0	1
409	Triloculina carinata	1	0	0	0	0	0	0	0	0	1	0	0	0	2
538	Triloculina trigonula	1	0	0	0	0	0	0	0	1	0	0	0	0	2
213	Uvigerina multistriata	0	0	1	0	0	0	0	0	0	0	0	1	0	2
489	Vaginulina awamoana	0	0	0	0	0	0	1	1	0	1	0	0	0	3
620	Valvinulinaria kalimnensis	1	0	0	0	0	0	0	0	0	0	0	0	0	1
114	Chiloguembelina cubensis *	0	1	1	1	1	1	1	1	1	1	0	1	0	10
119	Globigerina ampliapertura	1	1	1	1	1	0	0	0	0	0	0	1	0	6
125	Globigerina brazieri	0	0	0	0	0	0	1	1	0	0	0	0	0	2
120	Globigerina bulloides *	0	0	0	0	0	0	1	0	1	0	1	1	0	4
121	Globigerina cf. G.ciperoensis c	0	0	1	0	0	0	0	0	0	0	0	1	0	2
122	Globigerina euapertura	0	0	0	0	0	0	1	0	0	0	0	1	0	2
123	Globigerina labiacrassata	0	1	1	1	1	0	0	1	0	0	0	1	0	6
126	Globigerina woodi connecta	0	0	0	0	0	0	0	0	0	0	0	0	1	1
118	Globigerinatheka index	1	1	0	0	0	0	0	0	0	0	0	0	0	2
115	Guembelitria triseriata	0	0	0	0	1	0	1	0	1	1	1	1	0	6
110	Subbotina angiporoides *	0	1	1	1	1	0	1	0	0	1	0	0	0	6
109	Subbotina linaperta *	1	0	1	0	1	0	0	0	0	0	0	0	0	3
132	Tenuitella aculeata	1	1	1	0	0	0	0	0	0	0	0	0	0	3
130	Tenuitella gemma	1	1	1	0	0	0	1	1	0	1	0	0	0	6
131	Tenuitella munda	1	1	1	0	0	0	1	0	0	1	1	1	0	7
275	Tenuitellinata juvenilis	1	0	1	0	0	0	1	0	0	1	0	1	0	5
133	Turborotalia increbescens	0	0	0	0	1	1	0	0	0	0	0	0	0	2
479	Turborotalia opima	1	0	0	0	1	0	0	0	0	0	1	1	0	4
124	Turborotalia opima nana	1	1	0	0	0	0	1	0	0	0	0	1	0	4
	simple diversity=	60	52	48	73	56	68	91	75	65	70	62	83	14	
	benthic diversity=	51	43	38	69	48	66	81	71	62	64	58	72	13	
	planktonic diversity=	9	9	10	4	8	2	10	4	3	6	4	11	1	
	planktonics total							260							817
660	Chiloguembelina			6				2.69%							

	SAMPLE	E50	E73	E127	E131	E132	E133	E150	E154	E159	E160	E163	E179
T.C	TAXON	0	0	0	0	0	0	0	0	0	0	0	0
63	Alabamina tenuimarginata*	0	1	0	0	1	0	1	1	0	0	0	1
58	Angulogerina tenuistriata	0	0	0	1	0	0	0	0	0	0	0	1
66	Anomalinoides macralabra*	1	1	1	0	1	0	0	0	0	0	0	1
67	Anomalinoides pinguinglabra*	1	0	0	0	0	0	0	0	0	0	0	0
613	Astacolus crepidulus	1	0	1	0	0	0	1	1	1	0	1	0
276	Astrononion australe	0	0	0	0	0	0	0	0	0	0	1	0
86	Astrononion centroplax	0	0	0	0	0	0	0	1	1	1	1	0
10	Bolivina jacksonensis*	0	0	0	0	0	0	0	1	0	1	0	0
185	Bolivina reticulata (cf. pontis)	0	0	0	1	0	0	0	0	1	0	0	0
414	Buliminella seminuda	0	0	0	0	0	0	0	0	1	0	0	0
154	Carpentaria globiformis	0	0	0	1	1	0	0	1	0	0	1	0
135	Cassidulina cuneata	0	0	0	0	0	0	0	0	1	0	0	1
415	Cassidulina laevigata*	0	0	1	0	0	0	1	1	0	0	1	1
137	Cassidulina pseudocrassa	1	0	1	1	1	1	0	1	0	1	1	1
138	Chrysalogonium verticale*	1	0	1	0	0	0	1	1	0	0	0	0
69	Cibicides brevoralis*	1	0	0	1	1	0	0	0	1	0	0	0
206	Cibicides cygnorum Carter, 1964	0	0	0	0	0	0	0	0	1	0	1	0
249	Cibicides karreriformis	0	0	0	0	0	0	0	0	1	0	0	0
73	Cibicides lobatulus	1	1	1	1	1	1	1	1	1	1	1	1
78	Cibicides mediocris	1	0	1	1	0	1	0	0	1	1	0	1
162	Cibicides molestus	0	0	0	1	0	0	0	0	0	0	0	0
179	Cibicides subhaidingeri	0	0	0	0	0	0	0	0	0	0	0	1
25	Cibicides thiara	0	0	0	0	0	0	0	0	1	0	1	0
328	Cribrigoessella sp.	0	0	0	1	0	0	0	0	0	0	0	0
140	Dentalina mutata*	0	0	0	1	0	0	0	1	1	0	0	0
333	Dentalina semirugosa (see Quilty, 1974)	0	0	0	0	0	1	0	0	0	0	0	0
12	Dentalina soluta*	1	0	0	0	0	1	0	0	1	0	1	0
211	Dentalina sp. (=Marginulina durrcina)	1	0	0	0	0	0	0	0	0	0	0	0
492	Dentalina sp.1	0	0	0	0	0	1	1	0	1	0	0	0
420	Dentalina subsoluta	1	0	0	0	0	0	0	0	0	0	0	0
335	Discorbinella stachi	0	0	0	0	0	0	0	0	1	0	0	0
56	Discorbis balcombensis	0	0	0	0	0	0	0	0	0	0	0	1
152	Dorothia minima*	0	0	0	0	0	0	0	1	1	0	0	0
230	Dorothia parri	0	0	0	0	0	0	1	1	0	1	0	1
80	Dyocibicides sp.*	0	0	0	1	0	0	0	0	0	0	0	1
61	Eponides lornensis	1	0	0	0	0	1	0	1	1	0	0	1
62	Eponides repandus	1	1	0	1	0	0	1	1	0	1	1	1
14	Fissurina aperta*	1	1	1	0	1	1	1	0	0	1	0	1
526	Fissurina aureoligera	0	1	1	1	1	1	1	1	1	1	1	0
190	Fissurina bifida	1	0	0	1	1	1	1	0	1	1	1	1
11	Fissurina crassiannulata	1	0	1	1	1	1	1	1	0	1	1	1
160	Fissurina flintiana	0	0	1	1	1	0	0	1	0	1	0	0
149	Fissurina marginata*	0	0	0	0	0	0	1	0	1	0	0	0
418	Fissurina orbigyana	1	0	0	1	0	0	0	0	0	0	0	0
191	Fissurina submarginata	0	0	1	0	0	0	0	0	0	0	0	1
53	Gaudryina crespinae	1	0	0	1	1	0	0	1	0	1	0	1
51	Glandulina symmetrica	0	0	0	0	0	0	0	1	0	0	1	1
8	Globocassidulina subglobosa*	1	1	1	1	0	0	1	1	1	0	0	1
30	Globulina gibba	0	1	1	1	1	0	0	1	0	0	1	0
422	Guttulina communis	0	0	0	0	0	0	0	0	0	1	1	0
421	Guttulina irregularis*	1	1	0	1	0	1	0	1	1	0	1	1
355	Guttulina pacifica (see Barker,pl)	0	0	0	0	1	0	0	0	0	0	0	0
27	Guttulina problema*	1	0	0	1	0	0	0	0	0	1	0	0
233	Guttulina yabei	0	0	0	0	0	0	0	1	0	0	0	0
59	Gyroidinoides allani*	0	1	0	0	1	1	1	1	1	0	0	1
164	Gyroidinoides zelandica	0	0	0	0	0	0	0	0	0	0	1	0
242	Hanzawaia scopos	1	0	1	0	0	0	1	0	0	0	0	1
90	Heronallenia lingulata*	1	1	0	1	0	1	0	1	1	1	0	0
89	Heronallenia parri*	1	0	1	1	0	1	0	0	1	1	1	1
35	Homalohedra acuticosta	0	0	0	1	1	0	0	0	0	1	0	0
71	Karreria moaria	0	1	0	0	0	0	0	0	1	0	0	0
20	Kolesnikovella australis	0	0	1	1	0	1	0	0	0	1	1	1
560	Lagena cf. L.nebulosa	0	0	0	0	0	1	0	0	0	0	0	0
178	Lagena gibbera	0	0	0	0	1	0	0	0	0	0	0	0
32	Lagena hispida	0	0	1	0	0	1	0	0	0	0	0	0
194	Lagena hispidula	1	0	0	1	0	1	1	0	0	1	0	1
199	Lagena laevis	0	0	0	1	0	0	0	1	0	1	0	0
363	Lagena sp.1	0	0	0	1	0	0	0	0	0	0	0	0
36	Lagena striata	0	0	1	1	1	1	1	1	0	1	1	1
34	Lagena substriata*	0	0	0	0	0	0	0	0	1	0	0	0
594	Lagena sulcata cf. var spicata	1	0	0	0	0	0	0	0	0	0	1	0
280	Lagena sulcata*	1	0	0	1	1	1	1	1	1	1	1	1
43	Lenticulina (Robulus) gyroscalprus*	1	0	1	0	1	1	0	1	0	1	1	1
166	Lenticulina (Robulus) pliocaenicus	1	0	0	0	0	0	0	0	0	0	0	1
39	Lenticulina cf nitida*	1	1	1	0	0	1	0	0	0	1	0	0
528	Lenticulina cf. L.loculosa	0	0	0	0	0	1	0	0	0	0	0	0
245	Lenticulina gibba	1	0	0	1	0	1	0	1	1	1	1	0
216	Lenticulina thalmani	0	1	0	1	0	1	0	1	0	0	0	0
217	Marginulinopsis cf bradyi	1	0	0	0	1	1	0	0	0	0	0	0
97	Marginulopsis hydropica	0	0	0	0	0	1	0	0	0	0	0	0
229	Neoconorbina terquemi	0	0	0	0	0	0	0	0	1	0	0	0
148	Nodosarella sp.	0	0	0	1	0	1	0	1	1	1	1	0
262	Nodosaria lamnulifera	0	0	0	0	0	0	0	1	0	0	0	0
136	Nodosaria mutabilis	1	0	0	0	0	0	0	0	0	0	0	0
303	Nodosaria seperans	0	0	0	1	0	1	0	0	1	0	0	0
247	Notorotalia howchini	0	0	1	0	0	0	1	0	0	0	1	0
88	Notorotalia sp.	0	0	0	0	0	0	1	1	1	1	0	0
31	Oolina hexagona*	1	0	1	1	0	1	1	1	1	1	1	1
52	Oolina sp.	1	1	0	1	1	0	0	1	0	0	1	1
79	Operculina victoriensis	0	0	0	0	0	0	0	1	0	0	0	0
85	Parrellina crespinae	0	1	0	0	0	0	0	0	1	0	0	0
95	Parvicarinina altocamerata	0	0	0	1	0	0	0	0	0	0	0	0
94	Parvicarinina coronata	0	0	0	1	0	0	0	0	1	0	0	0
250	Patellina corrugata *	0	0	0	1	0	1	0	0	1	0	1	1
461	Plectofrondicularia awamoana	0	0	0	1	0	0	0	0	1	1	0	0
221	Plectofrondicularia proparri	0	0	1	0	1	0	0	0	0	0	0	0
81	Pullenia bulloides*	0	1	1	0	1	0	0	1	0	0	1	0
82	Pullenia quinqueloba*	1	0	1	1	1	1	0	1	1	0	1	1
561	Pyrgo cf. vespertilio	0	0	0	0	0	0	0	0	1	0	0	0
207	Pyrulina fusiformis	0	0	1	1	1	1	0	1	1	0	1	0
24	Pyrulina gutta	1	1	0	1	1	1	0	1	1	0	1	1
576	Pyrulina polita	0	0	0	0	0	1	0	0	0	0	0	0
231	Sigmoidella elegantissima	1	0	0	0	0	0	0	1	0	0	0	1
435	Sigmomorphina obesa	0	0	1	0	1	1	0	0	1	1	0	0
139	Siphonina australis*	1	0	1	0	0	0	0	1	1	0	1	1
153	Siphotextularia awamoana	0	0	0	0	0	1	0	1	1	0	0	1
410	Sphaeroidina bulloides*	0	1	1	1	0	0	1	1	1	0	1	1
259	Spirillina sp ?unilatera	0	0	0	1	0	0	0	0	0	0	0	0
108	Stomatorbina concentrica*	1	1	1	1	0	1	0	1	1	1	1	0
577	Stomatorbina lornensis	0	0	0	1	1	0	0	0	0	0	0	0
494	Textularia awamoana	1	0	1	0	0	0	0	1	0	0	0	0
54	Textularia marsdeni	0	1	0	1	1	1	1	1	1	1	0	1
181	Textularia vertebralis	1	0	1	0	0	0	0	0	0	0	0	0
22	Trifarina bradyi	0	0	0	1	0	1	0	1	1	0	0	0
219	Trifarina costornata (see Hay&Buz)	0	0	0	1	0	0	0	0	0	1	1	0
200	Tritaxia victoriensis	0	0	1	0	0	0	0	0	0	1	0	1
21	Uvigerina proboscidae*	0	0	0	1	0	0	0	0	1	0	0	0
29	Uvigerina reussella	0	0	0	0	0	1	0	0	0	0	0	0
501	Vaginulina sp ?acanthonucleus	1	0	0	0	0	0	0	0	0	0	0	0
573	Vaginulinopsis cf. tasminica	0	0	0	0	0	0	0	1	0	0	0	0
145	Victoriella conoidea	1	1	1	1	1	1	1	1	1	1	1	1
125	Globigerina brazieri	0	0	0	0	0	0	0	0	1	0	0	0
121	Globigerina ciperoensis	0	0	0	0	0	0	0	0	0	0	1	0
122	Globigerina euapertura	0	0	0	1	0	0	0	1	1	0	0	0
275	Tenuitellinita juvenilis	0	0	0	0	0	0	0	0	0	0	1	0
123	Globigerina labiacrassata	0	0	0	0	0	0	0	0	0	0	1	0
235	Globigerinella obesa	0	0	0	0	0	0	0	0	0	0	0	1
116	Globigerina praebulloides	0	0	0	1	0	1	0	1	1	1	0	0
127	Globoquadrina dehiscens	0	0	0	0	0	1	1	0	0	1	0	0
189	Globorotalia suteri	0	0	0	0	0	0	0	0	0	0	1	0
479	Tenuitella opima	0	0	0	0	0	0	0	1	0	0	0	0

APPENDIX G2 - samples listed in cluster groups

12/10/94 14:53:14.75 OUTG Oligocene data - 12 October 1994

GROUP BY MEMBERSHIP LISTING ----->

GROUP: 1 10 MEMBR/S

MG112 (1), RR232.8 (2), RR233.8 (3), MB173.1 (4), RR214.2 (5), MB171.9 (6), MG98 (7), MB171.1 (8), MB169.3 (9), MF48-45m(10)

GROUP: 2 36 MEMBR/S

MG120 (11), MG102 (12), MG100(13), MG88 (14), MG59 (15), MG46 (16), MG94 (21), MG74 (22), MG70 (23), MG57 (24), MB172.5 (25), 2W131.1 (26), W155 (17), MB175.3 (18), MG126 (19), MG124 (20), MG122 (27), MG118 (28), MG110 (29), MG62 (30), MB180.2 (31), MG60 (32), MB168.7 (33), MB168 (34), MG114 (35), MG106 (36), MG80 (37), MG50 (38), MG20 (39), RR200.5 (40), MG40 (45), RR235.2 (46), MB174.1 (41), MG116(42), MG108 (43), MG78 (44)

GROUP: 3 48 MEMBR/S

MB165.5 (47), RR232.2 (48), MB174.7 (49), MG26 (50), MB180.8 (51), MB176.5 (52), MB166.8 (53), 2W149.3 (54), E73 (63), 2W103.6 (64), RR225.5 (65), MB192.4 (66), MB173.5 (67), MB169.9 (68), E150 (69), 2W134.1 (70), MB175.9 (75), MB167.4 (76), RR227.5 (77), MB181.4 (78), MB178.9 (79), R26 (80), 2W121.9 (81), 2W88.7 (82), RR192.5 (83), MB182(84), MB177.1 (85), RR112.5 (86), 2W117.3 (87), RR209.5 (88), MB178.3 (89), A2 (90), A5 (95), 2W143.9 (96), W182 (97), W136 (98), 2W106.9 (55), MG44 (56), MB179.5 (57), R24 (58), 2W146.3 (59), MG48 (60), MG32 (61), 1AR (62), MG52 (71), OB54.86 (72), MG55 (73), MG53 (74)

GROUP: 4 163 MEMBR/S

Sub-group 4a

WMC29 (91), E132 (92), 2W128 (93), MB170.5 (94), 2W94.8 (107), RR196.5 (108), 2W137.2 (113), OB122.5 (114), 2W125 (119), OB135.6 (120), MB191.1 (121), MB190.1 (122)

Sub-group 4b

OB92.96 (99), OB89.92 (100), MB191.8 (101), A6 (102), OB79.25 (109), R30 (110), R13 (111), MF96-93 (112), RR220.2 (103), A28 (104), A27 (105), E127 (106), MB187.1 (115), A26 (116), R14 (117), R22 (118), R7 (123), R4 (124), R16 (125), R19 (126), R20 (127), E160 (128), R25 (151), R21 (152), WMC30.6 (153), RR120.5 (154), R29 (133), R17 (134), E133 (135), E163 (136)

Sub-group 4c

RR115.5 (129), 2W86.9 (130), W162 (131), W120 (132), 2W139.6 (137), MB177.7 (138), R18 (139), 2W147.8 (140), 2W114.3 (141), 2W85.3 (142), MF99-96 (165), 2W155.4 (166), 2W110 (167), OB114.3 (168), MB189 (169), E159 (170), RR202.2 (143), OB99.06 (144), OB77.20 (145), MB189.5 (146), R3 (147), E50 (148), RR116.5 (149), A3 (150), RR114.5 (159), OB67.06 (160), R15 (161), OB91.44 (162), A1 (163), E179 (164), W140 (155), RR234.2 (156), RR226.5 (157), A29 (158), WMC27.5 (179), E131 (180), E154 (181), RR110.5 (182), OB57.91 (183), MB185.2 (184)

Sub-group 4c

2W109.1 (171), OB111.25 (172), A25 (173), RR118.5 (174), MF102-99(175), OB125.88 (176), OB101.80 (177), MB188.3 (178), OB96.01 (189), OB121 (190), OB117.34 (191), OB42.67 (192), OB115.82 (223), WMC36.4 (224), OB130.15 (227) OB36.58 (228), MB185.9 (193), RR127.5 (194), MF72-69 (195), MB183.2 (196), WMC37.5 (197), RR121.5 (198), MF87-84 (199), MF57-54 (200), RR194.5 (201), OB105.15 (202), MB186.5 (203), MB182.6 (204), WMC23.4 (205), 2W112.8 (206), OB108.24 (207), MB190.7 (208), RR119.5 (219), W150 (220), W132 (221), OB132.38 (222), WMC28.3 (229), WMC24.3 (230), MF78-75 (231), OB82.30 (232), OB73.15 (233), OB60.96 (234), RR125.5 (235), OB70.10 (236), OB119.7 (241), WMC33.9 (242), MF90-87 (243), MF84-81 (244), OB88.39 (245), MB184 (246), WMC25.3 (247), OB128.9 (248), OB85.34 (249), W152 (250), OB135.02 (251), W142 (252), OB51.82 (253), MF51-48 (254), W148 (255), MF81-78 (256), RR111.5 (257), R23 (185), WMC29.6 (186), WMC24.8 (187), RR123.5 (188), WMC36.9 (209), WMC34.4 (210), WMC32.7 (211), WMC31.4 (212), WMC35 (225), WMC32.1 (226), WMC26.3 (213), WMC22.8 (214), WMC26.9 (217), WMC23.8 (218), WMC33.4 (237), MF65-60 (238), WMC35.6 (239), RR117.5 (240), MB184.6 (215), WMC36 (216)

composite standard units

	A	B	C	D	E	F	G	H	I
1	*T.C.*	Murray Base	Murray Tops	StVin Bases	StVin Tops	Otway Bases	Otway Tops	comp. bases	comp. tops
2	*63*	1.5	6.4	1	1.3	0.001	8	0.001	8
3	*65*	1.5	5			7.3	8.2	1.5	8.2
4	*302*					7.5	7.8	7.5	7.8
5	*225*					3.2	8.5	3.2	8.5
6	*303*	5.5	5.5			5.7	8.7	5.5	8.7
7	*42*	6.5	8.2					6.5	8.2
8	*255*					5	5	5	5
9	*209*					1.6	5.7	1.6	5.7
10	*305*	4.8	6	1.1	1.7	0.001	2	0.001	6
11	*18*	2	7.9	1	2	0.001	8.5	0.001	8.5
12	*556*			0.25	1.5			0.25	1.5
13	*58*	2	6.9			1.2	8.5	1.2	8.5
14	*198*					1.2	6.1	1.2	6.1
15	*307*					1.2	3.7	1.2	3.7
16	*66*	1.7	8.5	1	2	0.001	8.7	0.001	8.7
17	*67*	1.7	8.5	0.25	2	0.001	8.7	0.001	8.7
18	*241*	5.4	8.5			2.6	8.3	2.6	8.5
19	*68*	2.5	6.15			8.5	8.5	2.5	8.5
20	*254*	5.2	5.55					5.2	5.55
21	*436*	2.6	2.6					2.6	2.6
22	*613*	6.2	6.2					6.2	6.2
23	*252*	6.5	6.5			1.9	1.9	1.9	6.5
24	*558*					0.1	2.95	0.1	2.95
25	*276*	1.5	6.3	1	2	0.001	5.7	0.001	6.3
26	*86*					2.8	8.7	2.8	8.7
27	*4*	6.9	7.5					6.9	7.5
28	*481*	4.85	5.65	1.2	2.8	1.1	3	1.1	5.65
29	*611*	4.9	8.3					4.9	8.3
30	*16*	2.6	6.45					2.6	6.45
31	*311*	1.95	2	0.001	1.4	1.2	1.2	0.001	2
32	*312*			0.8	1.9	1.2	3.5	0.8	3.5
33	*10*	3	4.4	0.5	2	0.001	8.7	0.001	8.7
34	*19*	4.5	8.5					4.5	8.5
35	*480*	4.85	5.35	2.4	2.9			2.4	5.35
36	*210*	1.5	6.35	0.6	1.7	0.35	8.15	0.35	8.15
37	*17*	2.5	8.3	2	4.5	1.8	8.5	1.8	8.5
38	*185*	6.7	8.5			7.2	7.2	6.7	8.5
39	*201*	1.5	8.5			3.2	7.9	1.5	8.5
40	*13*	2.5	7.4			8.5	8.5	2.5	8.5
41	*107*	5.4	6.5					5.4	6.5
42	*176*	5.4	6.8			7.5	8.5	5.4	8.5
43	*5*	1.7	6.9	1.2	4.2	0.001	6.5	0.001	6.9
44	*541*					1.8	3.2	1.8	3.2
45	*6*	5.65	5.7			1.5	1.8	1.5	5.7
46	*260*					5.7	5.7	5.7	5.7
47	*100*	3.3	3.3			1.8	4.25	1.8	4.25
48	*170*	3	5.45			1.6	2.1	1.6	5.45
49	*468*					4.35	7.7	4.35	7.7
50	*282*					7.15	7.5	7.15	7.5
51	*183*	3	7					3	7
52	*48*	4.5	7.5					4.5	7.5
53	*264*	2.5	8.3			6	8.7	2.5	8.7
54	*154*					2.3	8.2	2.3	8.2
55	*188*	1.7	5.45			3.95	7.5	1.7	7.5
56	*135*	2.6	6.37			1.6	7.8	1.6	7.8
57	*415*	1.5	6.5	1	1.6	0.1	8.7	0.1	8.7
58	*495*	5.37	5.45					5.37	5.45
59	*106*			0.001	2			0.001	2
60	*105*	1.5	3	1.8	1.8	0.15	2.95	0.15	3
61	*472*	6.3	6.35					6.3	6.35
62	*138*	1.7	5.45	1.2	1.8	1.6	8.7	1.2	8.7
63	*69*	1.5	8.2	0.1	2	1.2	8.5	0.1	8.5
64	*206*	6.5	6.5			7	7.6	6.5	7.6
65	*249*	6.7	6.9			2.5	8.2	2.5	8.2
66	*73*	1.5	8.3	2	4.5	2	8.7	1.5	8.7
67	*78*	1.5	8.3	1.1	2	1.8	8.5	1.1	8.5
68	*162*	1.5	8.2			2.05	8.1	1.5	8.2
69	*321*	5.45	5.55			0.001	3.9	0.001	5.55
70	*70*	1.5	6.7	0.001	4.5	1.2	8.5	0.001	8.5
71	*74*	2.5	5.4			1.2	7.7	1.2	7.7
72	*72*	4.85	6.25			1.2	8.2	1.2	8.2
73	*278*					3.2	8.3	3.2	8.3

composite standard units

	A	B	C	D	E	F	G	H	I
74	179					2.05	8.2	2.05	8.2
75	25	6.5	6.5			0.001	1.75	0.001	6.5
76	77	2.5	8.3	0.9	1.8	1.2	8.7	0.9	8.7
77	529			1	2	0.001	1.8	0.001	2
78	570	5.5	5.65					5.5	5.65
79	147	5.4	5.37					5.4	5.37
80	292					7.9	8	7.9	8
81	621	5.3	5.37					5.3	5.37
82	530	5.55	5.6			1.8	7.8	1.8	7.8
83	33	2.5	8.3	1	4	1.8	8.5	1	8.5
84	46	7.2	7.2					7.2	7.2
85	47	2.5	7.4			0.3	7.8	0.3	7.8
86	161					7.05	7.05	7.05	7.05
87	211	5.1	5.1					5.1	5.1
88	492	5	5.37	2	4.5	0.001	7.3	0.001	7.3
89	186	3.3	3.3			1.8	7.5	1.8	7.5
90	141	3.3	5.45	1.2	1.4	2.05	8.7	1.2	8.7
91	331			1.3	1.9	3.5	3.9	1.3	3.9
92	140	3.3	5.4			0.95	7.7	0.95	7.7
93	12	1.5	7.5	0.8	3.65	0.001	8.5	0.001	8.5
94	506	5	5.1					5	5.1
95	420					1.8	7.75	1.8	7.75
96	203	5.3	8.5			2.5	8.1	2.5	8.5
97	232	3.7	8.5			3.2	8	3.2	8.5
98	93	2.6	4.8			1.2	8.1	1.2	8.1
99	277	2	5.45			5.7	7.7	2	7.7
100	459	4.85	6.37			6	8.5	4.85	8.5
101	56	5.7	7			3.3	8.5	3.3	8.5
102	91	5.4	5.4			7.15	8	5.4	8
103	56					1.2	3.9	1.2	3.9
104	57			1.25	1.4	1.2	3.85	1.2	3.85
105	55	1.5	7.4					1.5	7.4
106	146	2.5	4.8			3.3	3.3	2.5	4.8
107	443	4.85	6.45	1	1.9	0.25	7.3	0.25	7.3
108	256	5.3	6.7			3.9	5.8	3.9	6.7
109	152	2.5	8.5			3	8.7	2.5	8.7
110	230	8.5	8.5			3.4	8.2	3.4	8.5
111	80	5.1	6.7			1.2	8.5	1.2	8.5
112	601	3.2	4.8			7.75	8.3	3.2	8.3
113	202	4.3	4.3			8	8	4.3	8
114	454					6.1	8	6.1	8
115	61	6	8.3	0.7	1.3	0.4	8.5	0.4	8.5
116	62	1.5	8.5	0.9	1.8	0.4	8.5	0.4	8.5
117	165	5.4	8.3			4.5	8	4.5	8.3
118	177	4.85	6.5			1.8	5.7	1.8	6.5
119	14	2.5	8.5	1.3	4.5	1.4	7.9	1.3	8.5
120	526	5.3	5.3			8.4	8.4	5.3	8.4
121	190	5.5	8.3			1.8	8.7	1.8	8.7
122	11	1.5	8.5	1	4.5	0.001	8.7	0.001	8.7
123	160					6.1	8.7	6.1	8.7
124	38	2	8.3	1.05	3.8	0.5	8.7	0.5	8.7
125	586	5.2	8			3.3	3.3	3.3	8
126	149	3.3	8.5	1	3.8	1.8	8.5	1	8.5
127	418	2.5	5.95	1.1	4	1.8	8.7	1.1	8.7
128	195	1.7	8.3			7.2	7.7	1.7	8.3
129	196	4.8	8.2	2.2	3.75	6.1	6.1	2.2	8.2
130	656	5.4	8.3					5.4	8.3
131	208	4.75	6.9			1.8	7.9	1.8	7.9
132	536					1.8	2.9	1.8	2.9
133	193	5.55	5.6					5.55	5.6
134	587	5.6	5.55					5.6	5.55
135	295					4.2	4.2	4.2	4.2
136	191	3.3	8.5			1.8	8.2	1.8	8.5
137	581					7.7	7.7	7.7	7.7
138	269	5.8	7					5.8	7
139	268	5	6			6.8	8.7	5	8.7
140	343					1.4	3.8	1.4	3.8
141	37	4.75	6.38	3	4.4	1.5	6.5	1.5	6.5
142	53	2.5	8.5			1.8	8.7	1.8	8.7
143	449	3.3	3.3			7.5	8.2	3.3	8.2
144	60	2	6.8	2	4.4	0.001	8.5	0.001	8.5
145	51	3.3	7.3	1	3.5	0.001	7.8	0.001	7.8
146	518			1.4	4.3	8.4	8.4	1.4	8.4

	A	B	C	D	E	F	G	H	I
147	348					1.95	3.9	1.95	3.9
148	513					8.7	8.7	8.7	8.7
149	15	1.7	8.5	2.05	4.5	2.9	8.3	1.7	8.5
150	8	1.5	8.5	0.001	4.5	1.2	8.7	0.001	8.7
151	189					7.7	7.7	7.7	7.7
152	30	5.8	6.7	0.1	2	0.35	7.8	0.1	7.8
153	422	3	6.3	2.6	4.5	3.1	7.8	2.6	7.8
154	353			0.9	3.7	1.2	3.9	0.9	3.9
155	421	2.5	5.7	0.4	3.7	1.6	8.2	0.4	8.2
156	354			1.4	2			1.4	2
157	27	1.5	8.5	0.25	3.7	1.2	8.5	0.25	8.5
158	426			1	1.1	1.3	1.8	1	1.8
159	26	3	5.95	0.001	2	0.001	7.8	0.001	7.8
160	233					6.1	7.3	6.1	7.3
161	59	1.7	7.3	2	4.5	0.001	8.7	0.001	8.7
162	164	5.7	7.2	0.5	1.5	0.7	8.2	0.5	8.2
163	242	4.6	8.5			2	8.7	2	8.7
164	447	1.7	4.4					1.7	4.4
165	90	1.5	8.5	1.3	4.2	0.001	8.5	0.001	8.5
166	89	1.7	6.5	0.9	4.4	0.001	8.7	0.001	8.7
167	237	1.7	5.8					1.7	5.8
168	156	1.5	5.45			1.8	3.15	1.5	5.45
169	157					3.5	3.95	3.5	3.95
170	35	5	7			1.6	7.9	1.6	7.9
171	71					2.55	8.7	2.55	8.7
172	98	1.5	5.45	0.001	2	0.001	3.2	0.001	5.45
173	20	1.7	8.3			1.2	8.7	1.2	8.7
174	625	4.9	5.5					4.9	5.5
175	294					1.8	8.5	1.8	8.5
176	168	2	8.3			1.8	7.15	1.8	8.3
177	32			1.2	4.5	1.6	8.7	1.2	8.7
178	194	2	8.5	1.1	1.9	0.001	3.4	0.001	8.5
179	290	3.3	3.3			3.15	7.5	3.15	7.5
180	584	5.35	5.37	1.3	3.7			1.3	5.37
181	36	1.5	7.5			1.6	8.5	1.5	8.5
182	34	1.5	8.3	1.1	4.4	1.2	8.5	1.1	8.5
183	280	4.8	6.35	0.001	4.5	0.001	8.7	0.001	8.7
184	594					1.6	7.9	1.6	7.9
185	469					0.001	2.05	0.001	2.05
186	104					0.001	2.05	0.001	2.05
187	45					0.001	8.7	0.001	8.7
188	41					1.2	3.7	1.2	3.7
189	39	4.85	7.3	2.7	4.5	1.2	8.5	1.2	8.5
190	244	5.5	8			7.2	8.3	5.5	8.3
191	245	1.7	6.35	1	2	1.45	8.7	1	8.7
192	528	7.3	7.3	1.2	1.9	6.9	7.5	1.2	7.5
193	428					1.2	1.7	1.2	1.7
194	216	5.4	5.35	2.8	2.8	2.1	8.5	2.1	8.5
195	75					2.05	2.1	2.05	2.1
196	451			0.001	1			0.001	1
197	2					3	6.6	3	6.6
198	192	5.1	7					5.1	7
199	429					2.05	2.05	2.05	2.05
200	217					7.8	7.75	7.8	7.75
201	97	2.5	6	2.7	4.8	3.9	7.3	2.5	7.3
202	462			0.5	1	0.1	0.4	0.1	1
203	150	2.6	5.45			2.05	8.2	2.05	8.2
204	267					7.7	7.8	7.7	7.8
205	263					7.9	7.9	7.9	7.9
206	229					3.2	7.75	3.2	7.75
207	596					1.6	1.8	1.6	1.8
208	257					3.85	8.2	3.85	8.2
209	136					4.25	7.8	4.25	7.8
210	525	5	6	1.3	1.3	1.2	1.8	1.2	6
211	246	5.8	5.8			8.5	8.5	5.8	8.5
212	452			1.1	2			1.1	2
213	173	6.3	8.5			3.1	8.5	3.1	8.5
214	247	2.5	8.5			2.4	8.2	2.4	8.5
215	87	4.4	4.4			5	5	4.4	5
216	588					2.9	3.1	2.9	3.1
217	31	2.5	6.37	0.1	4.5	0.001	8.7	0.001	8.7
218	285					2	3.2	2	3.2
219	52	2.5	8.5			1.8	8.5	1.8	8.5

composite standard units

	A	B	C	D	E	F	G	H	I
220	***406***	1.7	5.5					1.7	5.5
221	***199***	4.85	8.5			3.15	8.7	3.15	8.7
222	***271***	2	8.2					2	8.2
223	***83***	6.9	7.2					6.9	7.2
224	***85***	3	5.9	3.1	4.5	1.8	8.2	1.8	8.2
225	***95***	2.6	5.9			3	7.7	2.6	7.7
226	***94***	3.3	6.9			1.2	7.7	1.2	7.7
227	***250***	1.7	8.5	1	1.5	1.2	7.9	1	8.5
228	***440***	1.5	6.5	2.1	4.5	3.4	7.75	1.5	7.75
229	***498***					5.7	8.2	5.7	8.2
230	***442***	5.3	6.1					5.3	6.1
231	***103***	4.75	5.1					4.75	5.1
232	***215***	4.6	5.9			2	7.8	2	7.8
233	***433***	2.5	5.45					2.5	5.45
234	***44***	1.5	8.5	1	2	0.4	8.1	0.4	8.5
235	***430***	2.6	2.6					2.6	2.6
236	***283***					7.3	7.9	7.3	7.9
237	***221***					3.2	8.5	3.2	8.5
238	***50***	2.6	5.37					2.6	5.37
239	***92***	2.5	8			3.3	7.8	2.5	8
240	***636***					2.05	7.15	2.05	7.15
241	***159***			1	1.9	0.05	2	0.05	2
242	***81***	1.5	7	1.2	1.4	0.001	8.7	0.001	8.7
243	***82***	1.5	8.3	1.2	2	0.001	8.7	0.001	8.7
244	***228***	1.5	1.7					1.5	1.7
245	***207***	3	4.8	2	2.5	1.8	8.5	1.8	8.5
246	***24***	5.4	6.9			1.75	7.7	1.75	7.7
247	***575***					1.8	3.1	1.8	3.1
248	***9***	1.7	3.3	1.3	1.4			1.3	3.3
249	***1***	2.5	7.4	0.001	1.9	1.2	8	0.001	8
250	***405***	2.5	5.65	1.2	1.9	1.8	8.2	1.2	8.2
251	***407***	5.1	5.1	1.3	1.8			1.3	5.1
252	***243***	4.3	5.9			7.05	7.25	4.3	7.25
253	***102***	2	5.65	1	2	0.001	2.95	0.001	5.65
254	***521***					7.5	7.7	7.5	7.7
255	***43***	1.5	7.5	0.4	4.5	0.4	8.7	0.4	8.7
256	***166***	5	7			1.8	8.3	1.8	8.3
257	***458***	2.5	4.8					2.5	4.8
258	***223***					3.2	3.4	3.2	3.4
259	***634***			1.1	1.6			1.1	1.6
260	***174***	3.3	7					3.3	7
261	***380***			0.9	4.9	0.2	1.8	0.2	4.9
262	***231***	1.5	8.5	1.15	1.7	0.2	8.1	0.2	8.5
263	***626***	4.75	5.55					4.75	5.55
264	***435***					1.8	7.8	1.8	7.8
265	***167***					6.4	6.4	6.4	6.4
266	***134***					1.8	7.75	1.8	7.75
267	***139***	2	8.5	1.2	1.9	0.3	8.7	0.3	8.7
268	***153***	2.5	4.8			1.8	8.5	1.8	8.5
269	***272***	4.9	5.7			5.7	8.5	4.9	8.5
270	***300***					1.8	3.5	1.8	3.5
271	***410***	1.5	6.35	1.4	4.2	1.3	8.7	1.3	8.7
272	***226***	4.8	5.55	2.05	4.2	1.5	3.3	1.5	5.55
273	***64***	1.5	5.37	1.15	1.35	0.1	3	0.1	5.37
274	***635***			1.2	1.2	0.001	2.05	0.001	2.05
275	***218***					0.6	1.7	0.6	1.7
276	***445***	2.6	2.6					2.6	2.6
277	***212***					2	2	2	2
278	***259***	6.9	8			3.8	8.5	3.8	8.5
279	***515***	4.85	5.5			2	8.2	2	8.2
280	***509***	5.3	5.3			2	8.2	2	8.2
281	***108***	2.5	6.7			0.4	8.5	0.4	8.5
282	***470***					1.8	1.8	1.8	1.8
283	***270***	5.4	8.3			2.45	8	2.45	8.3
284	***388***					2.55	8.2	2.55	8.2
285	***494***					6.4	8.7	6.4	8.7
286	***158***	2.6	4.4	2.2	4.5	6.4	8.7	2.2	8.7
287	***143***			1.25	1.3			1.25	1.3
288	***49***	5	6.1	1.4	1.7	3.1	3.9	1.4	6.1
289	***490***	4.85	5.45	2.05	3.7			2.05	5.45
290	***389***			1.7	1.7			1.7	1.7
291	***54***	6	8			3	8.5	3	8.5
292	***511***					2.5	8.2	2.5	8.2

composite standard units

	A	B	C	D	E	F	G	H	I
293	491	4.85	5.45					4.85	5.45
294	181	6.5	7.2			4.85	7.9	4.85	7.9
295	22	2.9	8.5			1.8	8.7	1.8	8.7
296	219	5	4.8			2.9	7.25	2.9	7.25
297	370	4.6	6.38	0.2	4.2	0.001	2	0.001	6.38
298	175	1.5	5.7			2.05	3.15	1.5	5.7
299	409	1.5	5.5	1.4	2	1.2	1.65	1.2	5.5
300	413			1.3	2	1.6	8.2	1.3	8.2
301	200	8.2	8.2			6	6.4	6	8.2
302	624					7.5	8	7.5	8
303	28					8.5	8.5	8.5	8.5
304	400			0.001	1.2			0.001	1.2
305	401			0.9	1.3			0.9	1.3
306	23					1.6	7.8	1.6	7.8
307	213	4.85	5.45					4.85	5.45
308	21	2	8	2.3	4.5	0.001	8.7	0.001	8.7
309	29			1.1	1.65	3	8.7	1.1	8.7
310	148	3	3	2.5	4	0.5	8.7	0.5	8.7
311	501	5.4	5.37					5.4	5.37
312	620	5.3	5.37					5.3	5.37
313	404			0.2	1.5	1.2	3.8	0.2	3.8
314	145					2.1	8.2	2.1	8.2
315	512					8.7	8.7	8.7	8.7
316	291					2.3	8.2	2.3	8.2
317	111	1.7	5.4	3.05	4.5	3.1	3.1	1.7	5.4
318	113	4.85	5.5	3.5	4.2	1.8	3.5	1.8	5.5
319	236					7.05	7.1	7.05	7.1
320	114	4.8	5	0.8	4.5	0.001	4.85	0.001	5
321	119	4.6	6.38			1.2	8.7	1.2	8.7
322	261	6.9	8.3	2.5	2.9			2.5	8.3
323	273	6	6.5			4.85	7.8	4.85	7.8
324	125	5	7.4			1.5	8.5	1.5	8.5
325	120	6.3	8.3	3.7	4	4.5	8.7	3.7	8.7
326	121	2	8.3			3.95	8.7	2	8.7
327	172					6.4	6.4	6.4	6.4
328	122	3.3	6.35	2.9	4.5	1.6	8.3	1.6	8.3
329	126	4.6	7.4	2.2	4.5	0.6	5	0.6	7.4
330	287	4.9	6.7	1.3	1.6	0.001	7.7	0.001	7.7
331	116	3.3	6.8	0.8	3.7	0.2	7.8	0.2	7.8
332	117	6.7	8.5			6	8.7	6	8.7
333	118			0.001	1.4	0.001	2	0.001	2
334	235	8	8			5	7.8	5	8
335	182	8	8			7.2	7.2	7.2	8
336	478					6	7.7	6	7.7
337	127					7.8	8.5	7.8	8.5
338	660					7.8	7.8	7.8	7.8
339	274					0.2	8	0.2	8
340	123	4.8	6.9	2.2	4	1.2	8.1	1.2	8.1
341	115	2.6	5.9	2.8	4.2	2.5	5.9	2.5	5.9
342	568			1.1	1.1	0.5	1	0.5	1.1
343	110	1.7	6.2	1	3.8	0.001	4.1	0.001	6.2
344	109	1.5	6	1.1	3.05	0.001	3.3	0.001	6
345	132	5	8.2	0.001	2	1.4	2.1	0.001	8.2
346	130	1.5	6.8	0.001	4.5	1.2	7.8	0.001	7.8
347	129	4.75	6.3			1.2	3.05	1.2	6.3
348	131	1.5	8.5	2.4	4.5	1.2	8.5	1.2	8.5
349	275	1.5	6.38			4.35	7.15	1.5	7.15
350	286					0.001	0.2	0.001	0.2
351	133	2.6	3.3			1.2	3.5	1.2	3.5
352	265	6.8	8.3			7.15	7.7	6.8	8.3
353	473					0.1	1.4	0.1	1.4
354	124	7.2	8.5			0.6	7.3	0.6	8.5
355	479	4.75	8.5			3	7.5	3	8.5
356	412			0.7	1.85			0.7	1.85
357	306			0.001	2			0.001	2
358	408			1	2			1	2
359	453			0.9	1.3			0.9	1.3
360	346					0.8	3.8	0.8	3.8
361								0	0
362	661			1.4	1.7	1.4	1.8	1.4	1.8
363	662			0.4	1.75	0.5	1.6	0.4	1.75
364	663			1.1	1.75	0.1	2	0.1	2
365	664			1.3	1.5			1.3	1.5

composite standard units

	A	B	C	D	E	F	G	H	I
366	***665***			1	2	0.55	1.9	0.55	2
367	***666***			1.2	1.8			1.2	1.8
368	***667***			1.2	1.65			1.2	1.65
369	***668***			1.9	1.9	0.3	2	0.3	2
370	***669***					1.7	1.85	1.7	1.85
371	***670***					0.2	1.65	0.2	1.65
372	***671***					1.7	2	1.7	2
373	***672***					0.001	2	0.001	2

COHORT A (0)	%SURVIVING	COHORT B(1.2)	% SURVIVING	COHORT B2 (1.	%SURVIVING	COHORT C (2.0	%SURVIVING	OBCOHORT D (	%SURVIVING	OBCOHORT G (	%SURVIVING
CSU (N=40)		CSU (N=33)		CSU (N=31)		CSU (N=9)		CSU (N=13)			
0	100.0%	1.2	100.0%	1.8	100.0%	2.01	100.0%	3.1	100.0%	6	100.0%
0.2	97.5%	1.65	97.0%	1.9	96.8%	2	88.9%	3.4	92.3%	6.1	88.9%
1.75	95.0%	1.7	93.9%	2.9	93.5%	3.2	77.8%	5	84.6%	6.4	77.8%
1.8	92.5%	1.8	90.9%	3.1	90.3%	7.8	66.7%	6.6	76.9%	7.3	66.7%
2	82.5%	3.5	81.8%	3.15	87.1%	8.2	33.3%	7.5	69.2%	7.7	55.6%
2.05	75.0%	3.7	75.8%	3.2	83.9%	8.5	22.2%	7.75	61.5%	8	44.4%
2.95	72.5%	3.85	72.7%	3.5	77.4%	8.7	0.0%	8.3	46.2%	8.5	33.3%
3.2	70.0%	3.9	66.7%	4.25	74.2%			8.5	7.7%	8.7	0.0%
3.3	67.5%	6.1	63.6%	5.7	71.0%			8.7	0.0%		
3.4	65.0%	7.7	57.6%	7.15	67.7%						
3.9	62.5%	7.8	54.5%	7.5	64.5%						
4.1	60.0%	7.9	51.5%	7.75	58.1%						
4.85	57.5%	8	48.5%	7.8	51.6%						
5.7	55.0%	8.1	42.4%	7.9	48.4%						
6.5	52.5%	8.2	39.4%	8.2	38.7%						
7.3	50.0%	8.5	18.2%	8.3	35.5%						
7.7	47.5%	8.5	12.1%	8.5	9.7%						
7.8	42.5%	8.7	0.0%	8.7	0.0%						
8	40.0%										
8.5	30.0%										
8.7	0.0%										

MURRBASCOHORTS Tue, 21 Feb 1995 8:33

MurrBas	B1	%SURV	B2	%SURV	C	%SURV	D	%SURV	F	%SURV
1	1.5	100.0%	1.7	100.0%	2.0	100.0%	3.0	100.0%	4.8	100.0%
2	1.7	97.3%	3.3	94.4%	5.5	91.7%	3.5	87.5%	5.3	84.6%
3	3.0	94.6%	4.4	88.9%	5.7	83.3%	4.4	75.0%	5.5	61.5%
4	5.4	91.9%	5.5	83.3%	6.3	75.0%	5.0	62.5%	5.5	53.8%
5	5.4	86.5%	5.5	77.8%	8.2	66.7%	5.5	50.0%	5.7	46.2%
6	5.5	81.1%	5.8	72.2%	8.3	16.7%	5.9	37.5%	6.2	38.5%
7	5.5	75.7%	6.2	66.7%	8.5	0.0%	6.3	25.0%	6.4	30.8%
8	6.0	73.0%	6.3	61.1%			8.3	0.0%	6.5	23.1%
9	6.3	70.3%	6.5	55.6%					7.3	15.4%
10	6.4	67.6%	7.3	50.0%					8.0	7.7%
11	6.5	64.9%	8.3	0.0%					8.5	0.0%
12	6.8	62.2%								
13	7.4	59.5%								
14	7.5	54.1%								
15	8.3	0.0%								

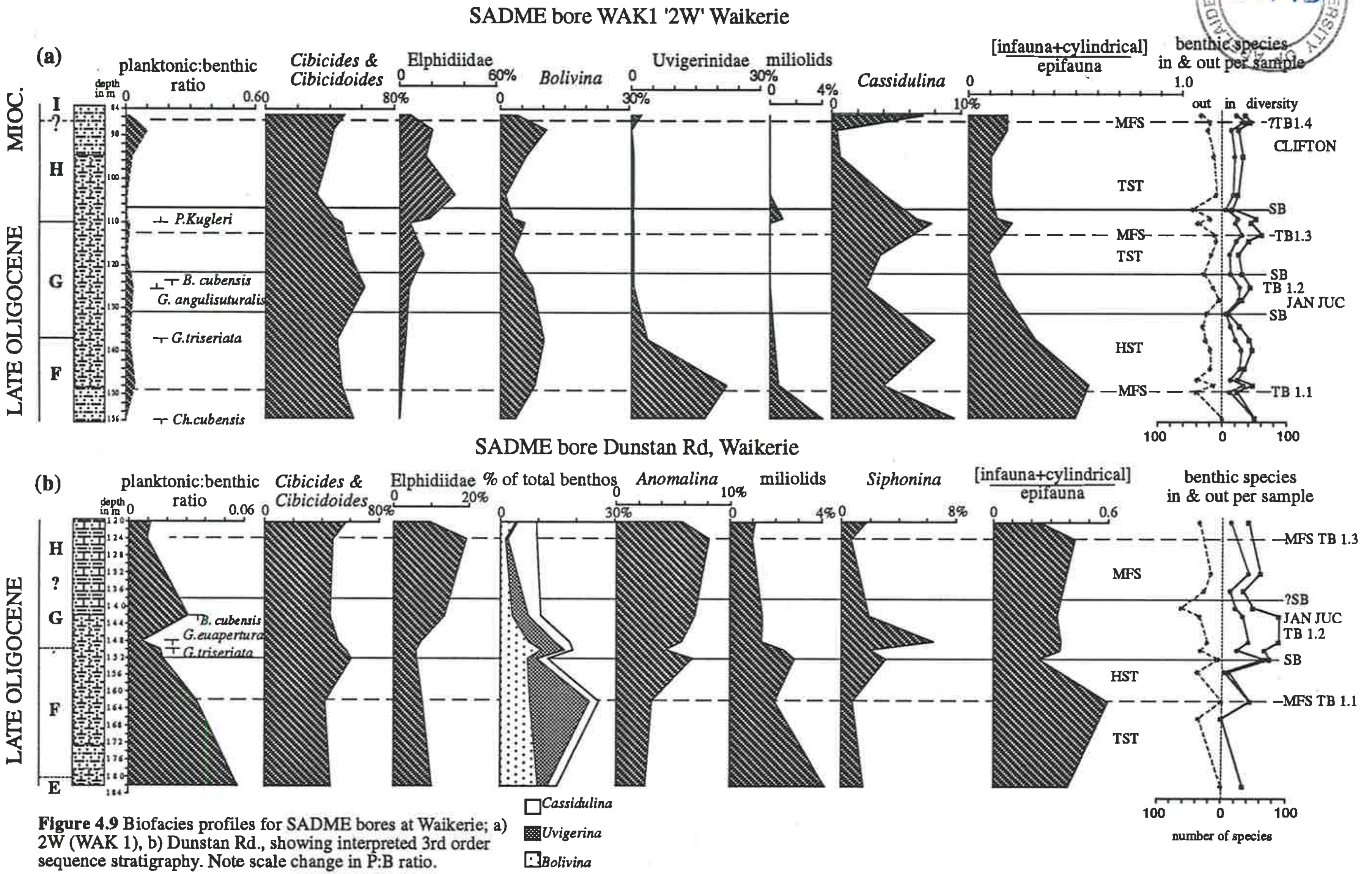


Figure 4.9 Biofacies profiles for SADME bores at Waikerie; a) 2W (WAK 1), b) Dunstan Rd., showing interpreted 3rd order sequence stratigraphy. Note scale change in P:B ratio.

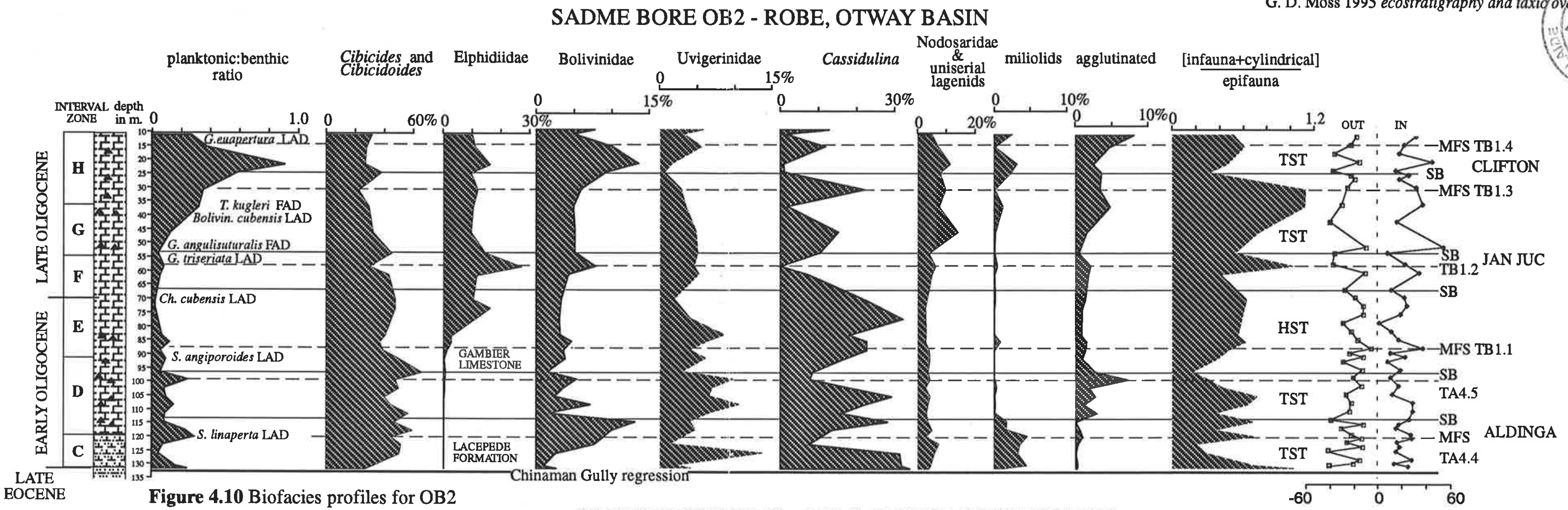


Figure 4.10 Biofacies profiles for OB2

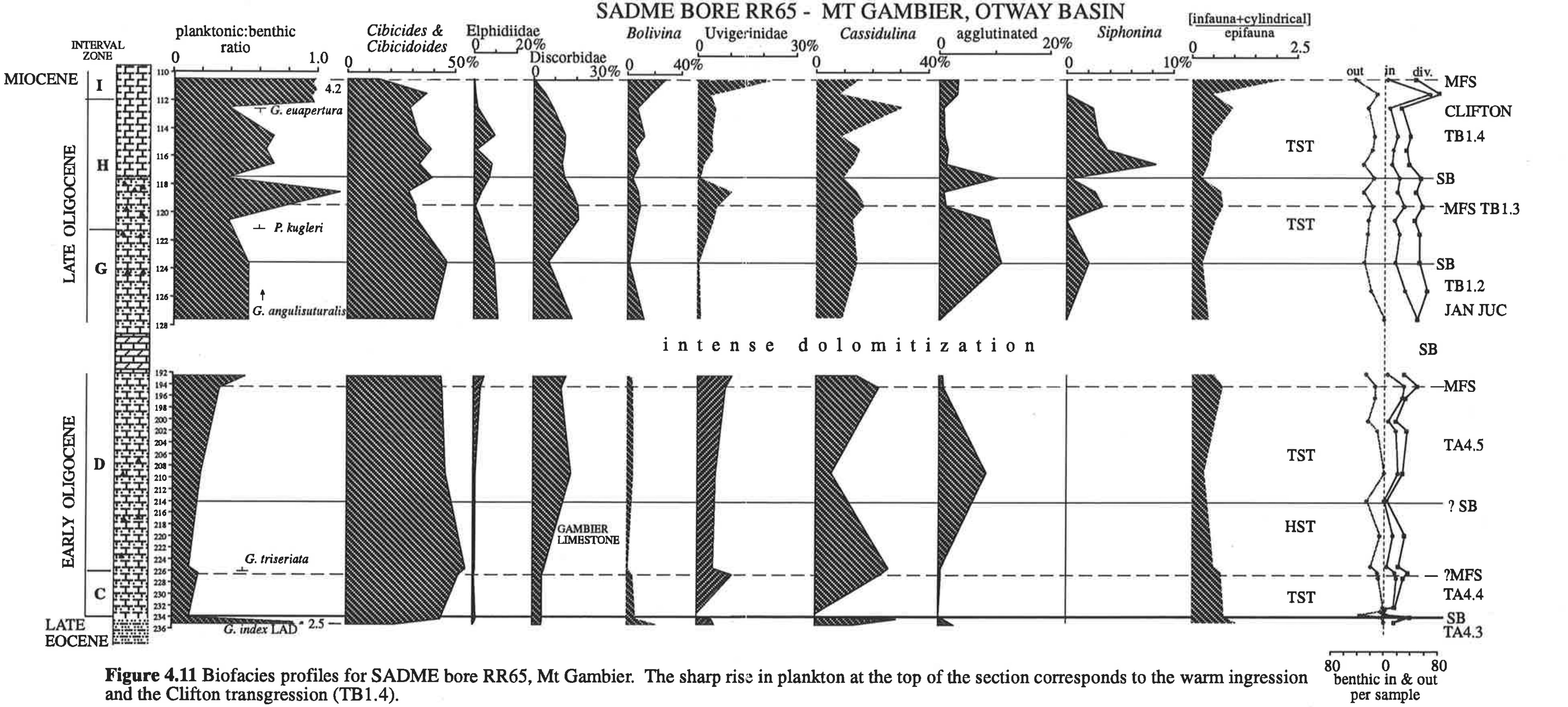


Figure 4.11 Biofacies profiles for SADME bore RR65, Mt Gambier. The sharp rise in plankton at the top of the section corresponds to the warm ingression and the Clifton transgression (TB1.4).

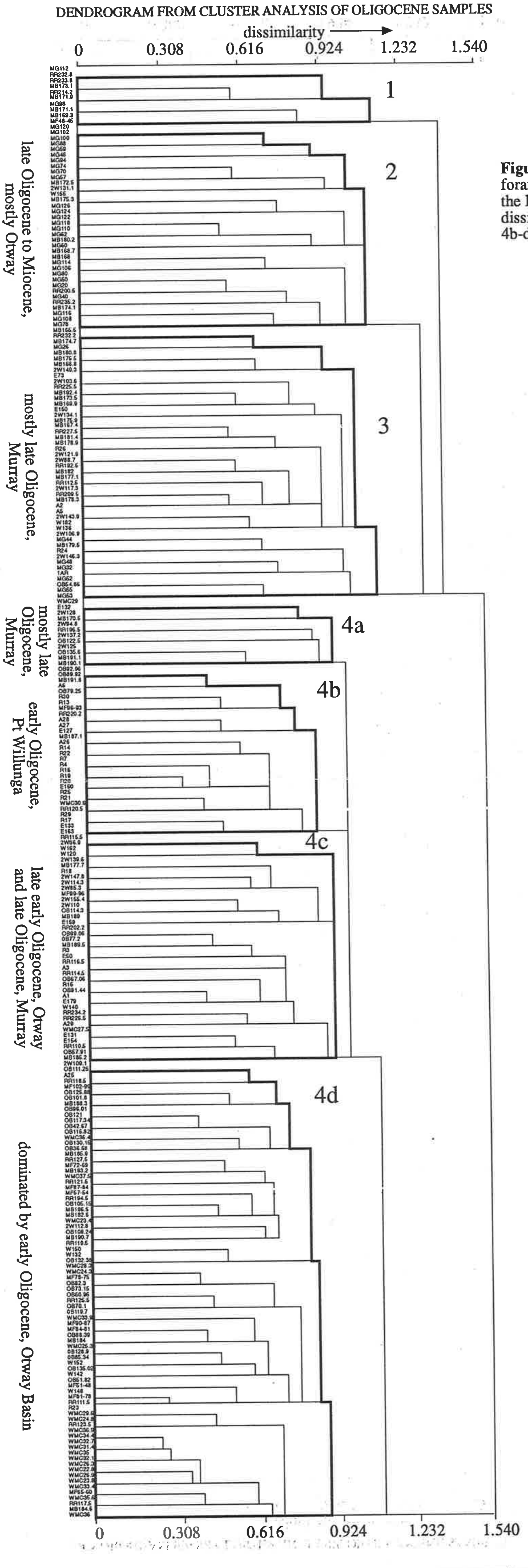
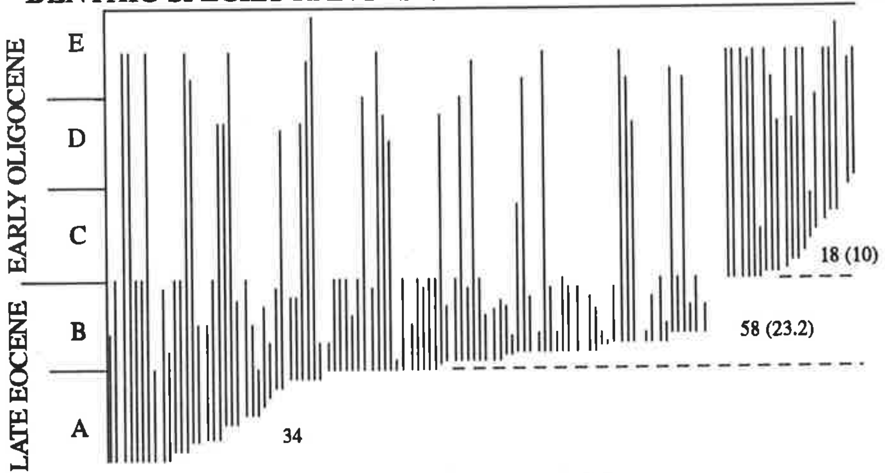


Figure 5.9 Cluster analysis of Oligocene assemblages of foraminiferal taxa. Clustering of samples from intervals in the late Oligocene (groups 1 to 4a) show greater dissimilarity than those in the early Oligocene (groups 4b-d). Horizontal axis shows increasing dissimilarity.

Figure 5.4 BLANCHE POINT AND PORT WILLUNGA FORMATION BENTHIC SPECIES RANGES ORDERED BY FIRST APPEARANCE



LAST APPEARANCE

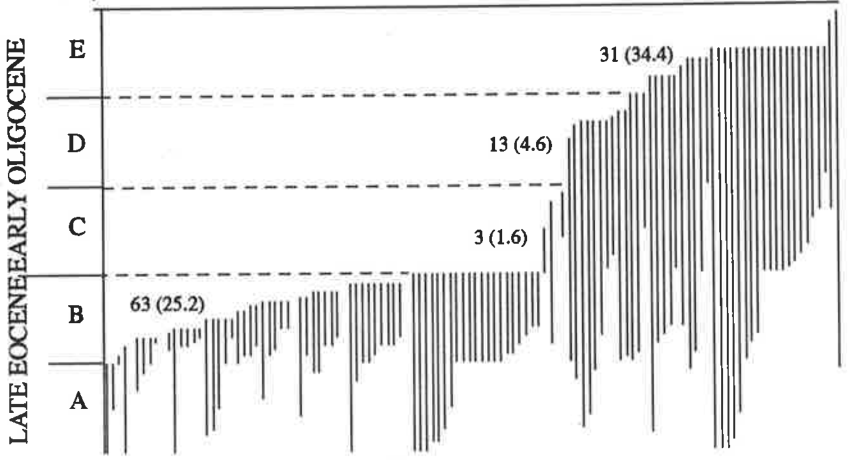
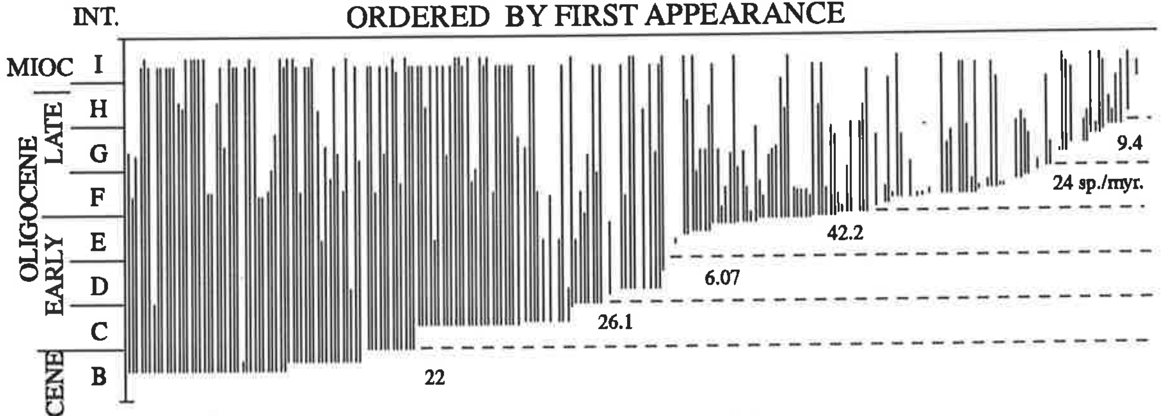


Figure 5.5 MURRAY BASIN BENTHIC SPECIES RANGES ORDERED BY FIRST APPEARANCE



LAST APPEARANCE

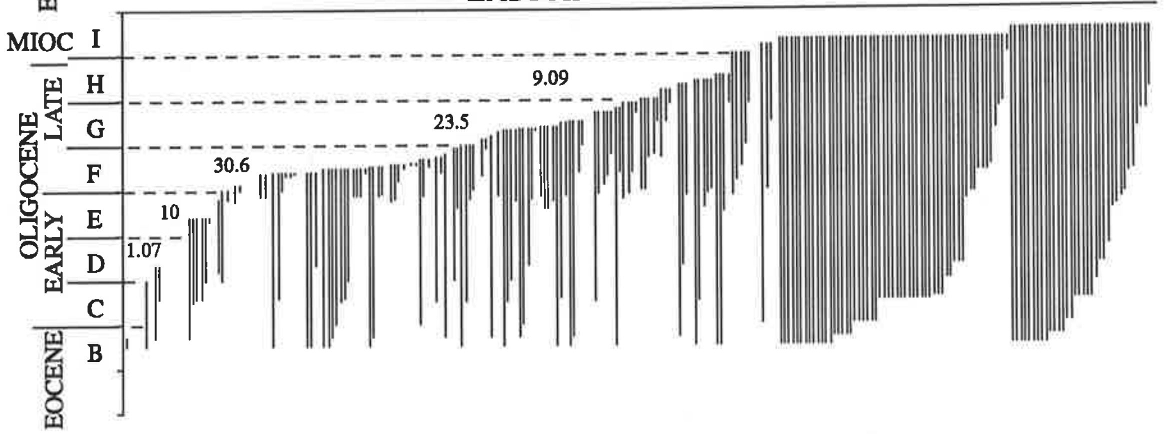
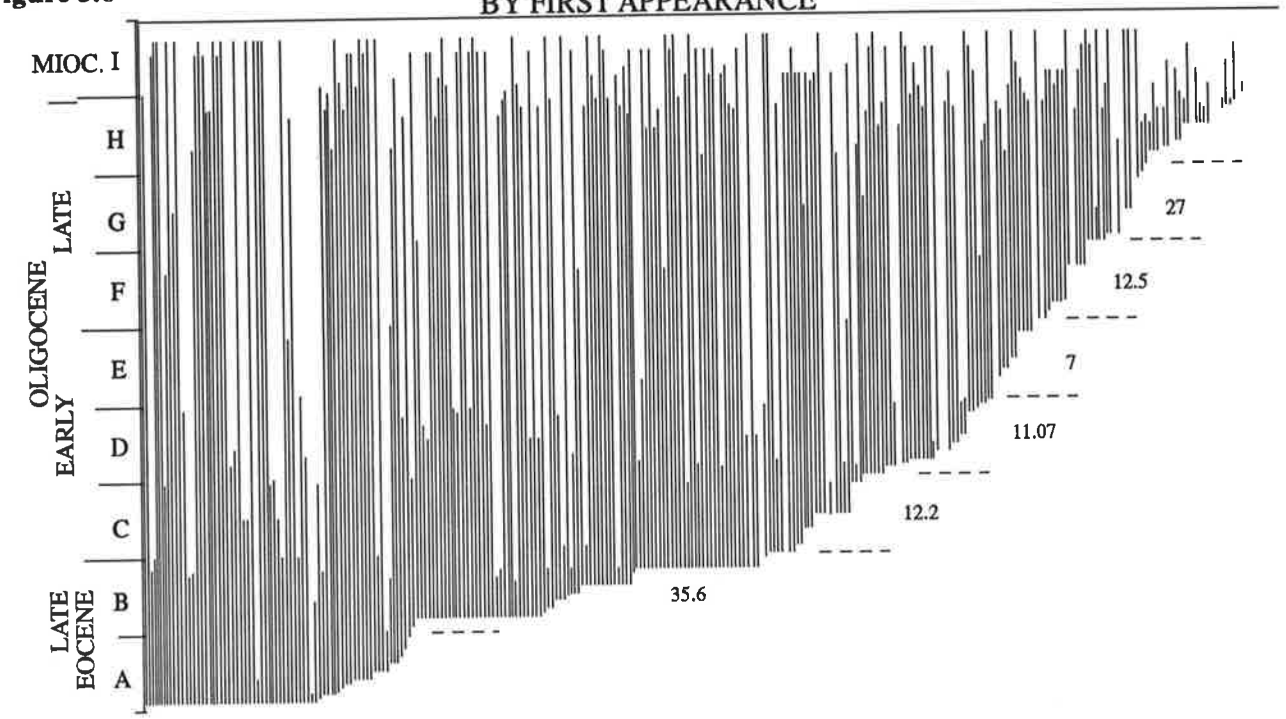
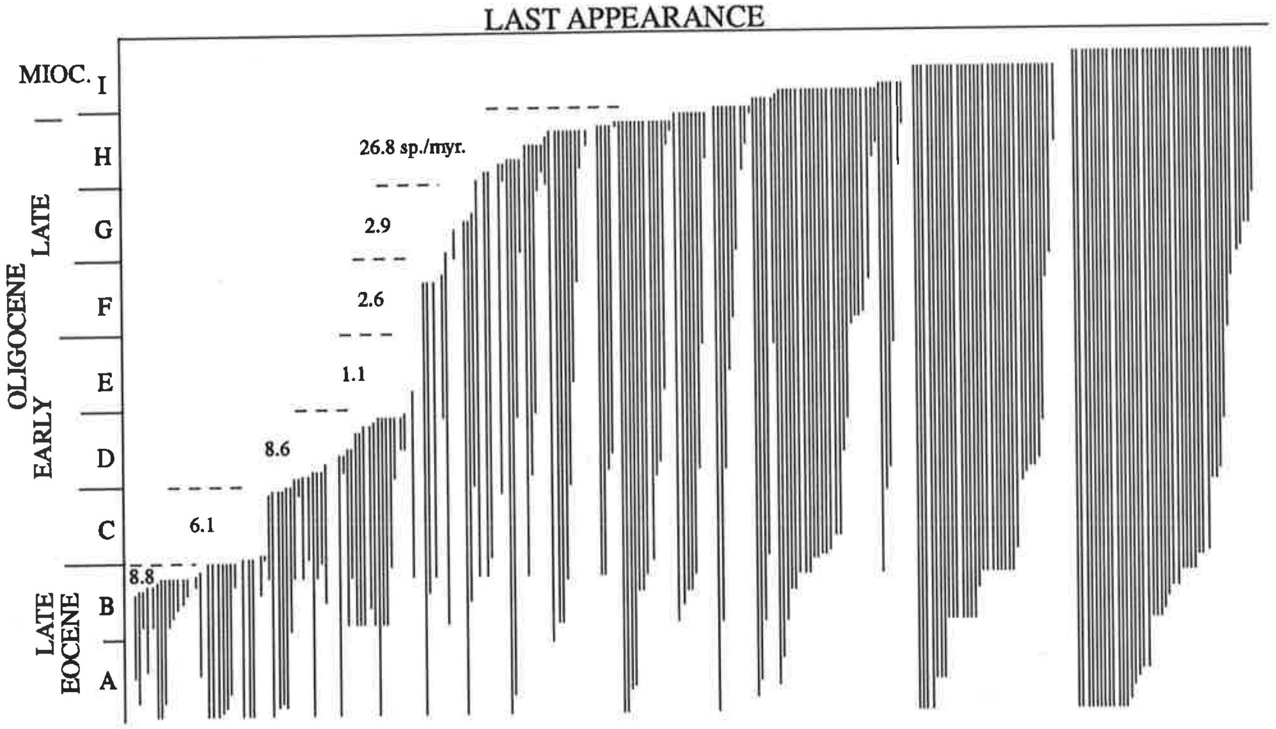


Figure 5.6 OTWAY BASIN BENTHIC SPECIES RANGES ORDERED BY FIRST APPEARANCE



LAST APPEARANCE



Figures 4-6 Benthic species ranges. Note: numbers are species appearing and disappearing per interval (number of species/myr). Calculated durations are in Table. 3.1.

BENTHIC SPECIES SURVIVORSHIP CURVES

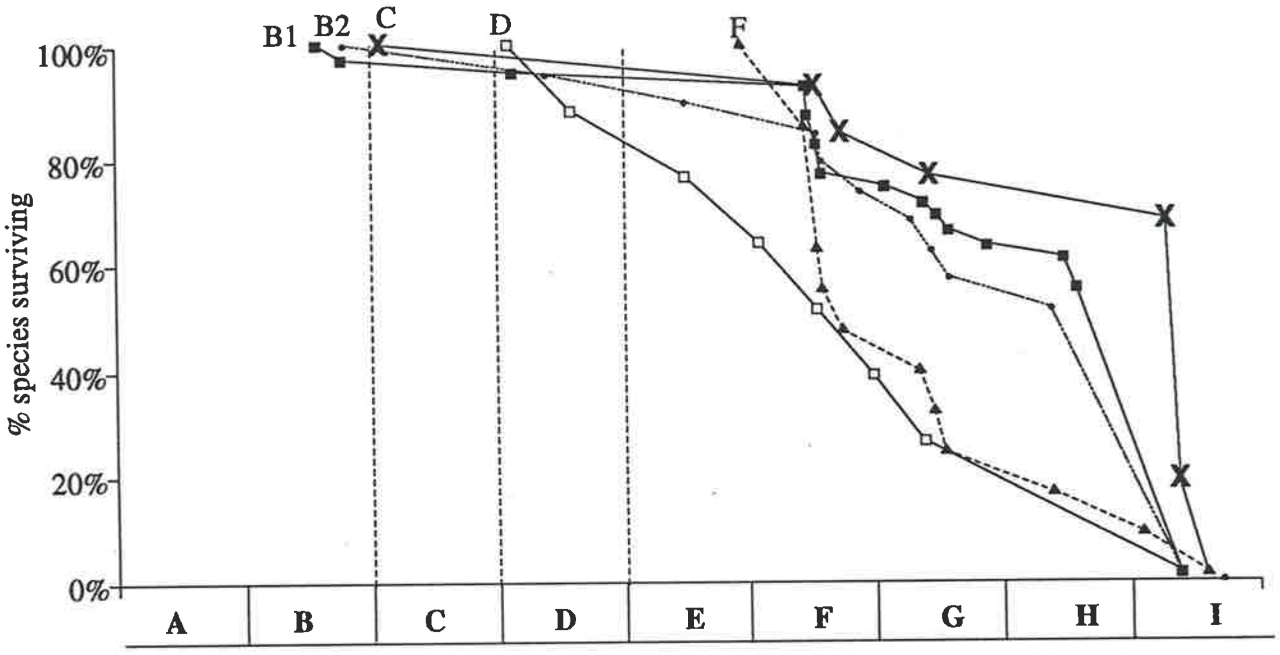

MURRAY BASIN

Figure 5.8a Benthic species survivorhip for the Murray Basin composite. Cohorts B1-F discussed in text.

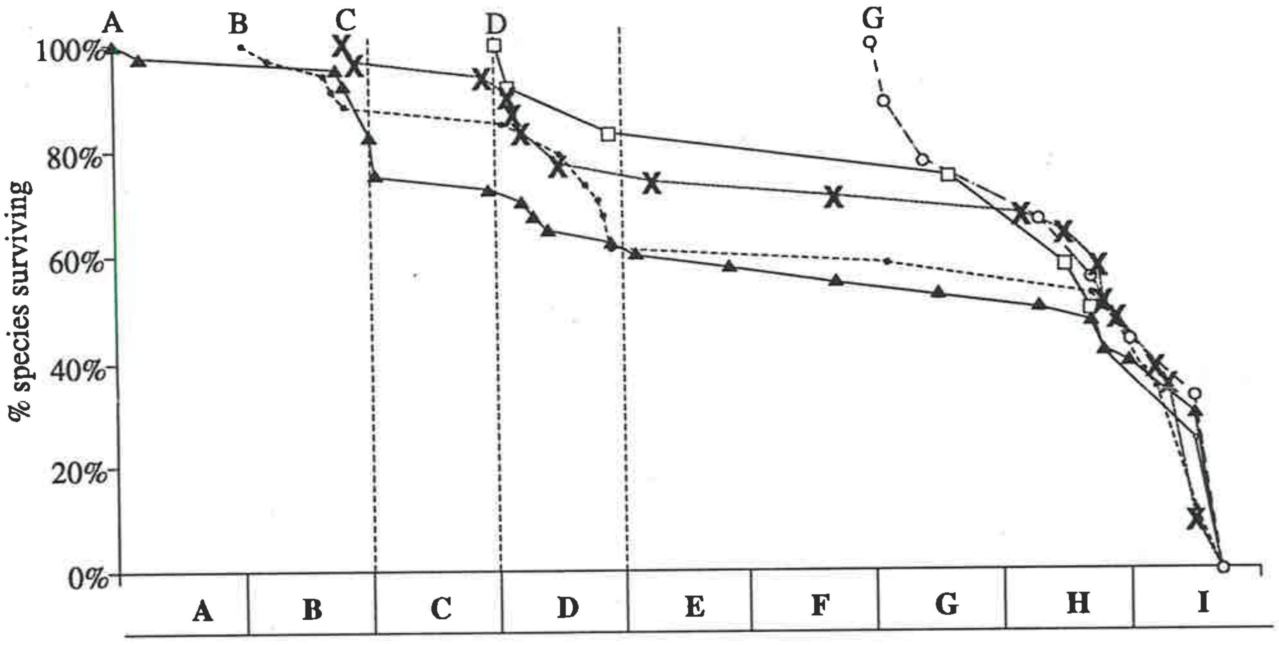

OTWAY BASIN

Figure 5.8b Benthic species survivorhip curves for a composite of the Otway Basin.

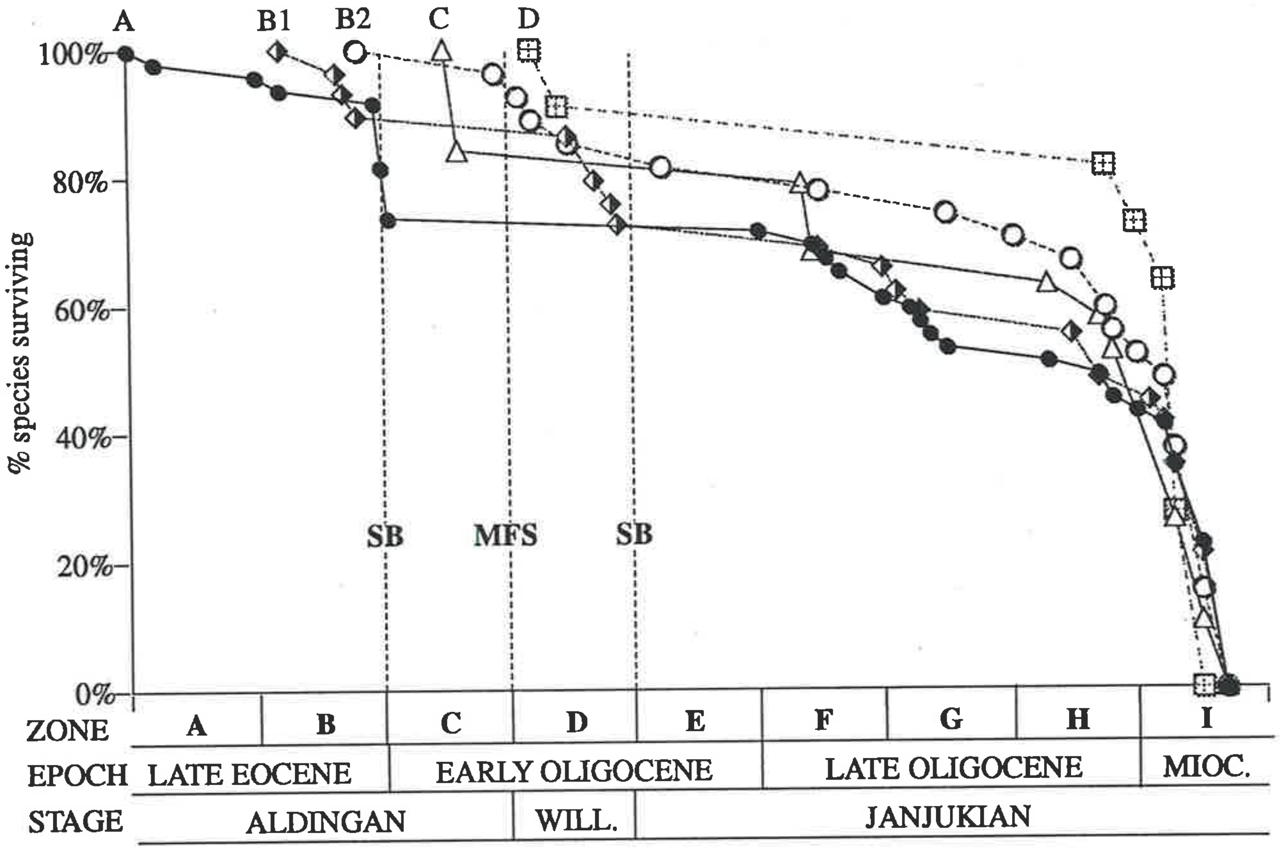

COMPOSITE

Figure 5.8c Grand composite of benthic species survivorhip from the late Eocene to the Miocene. All labelled cohorts are discussed in text.

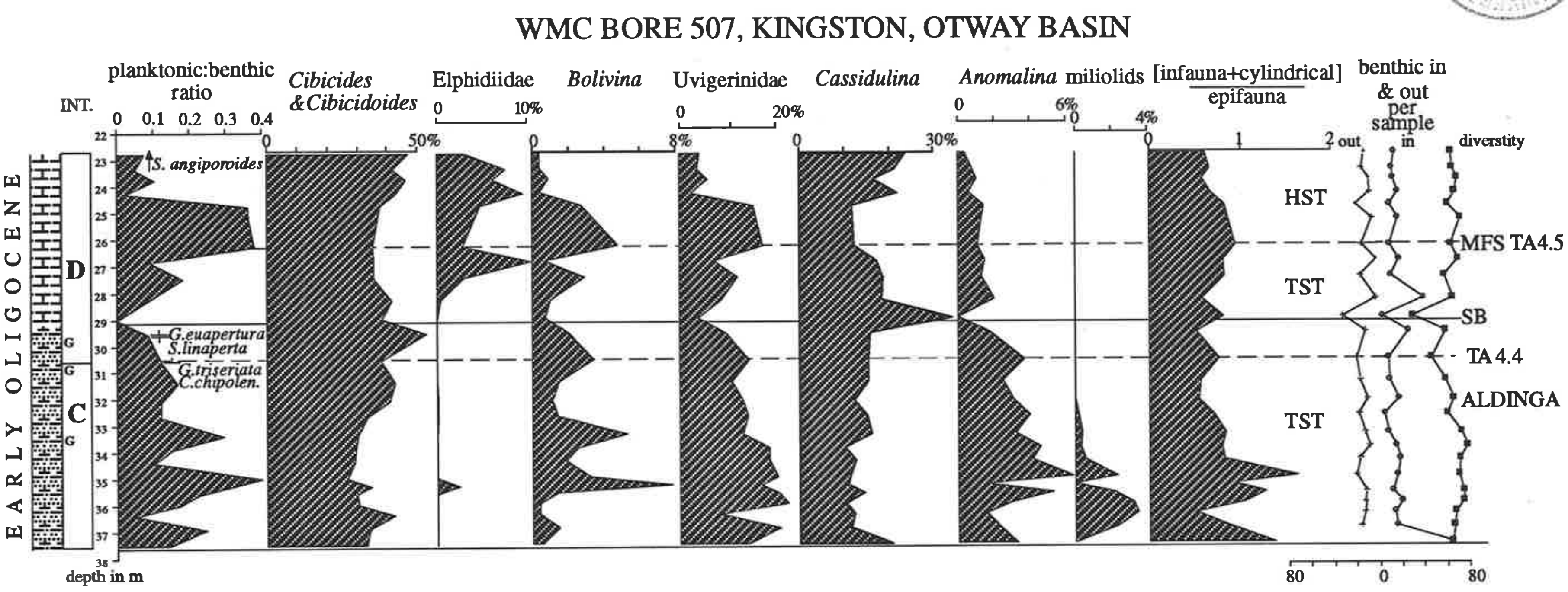


Figure 4.6 Biofacies profiles for SANR WMC507 at Kingston in the Otway Basin.

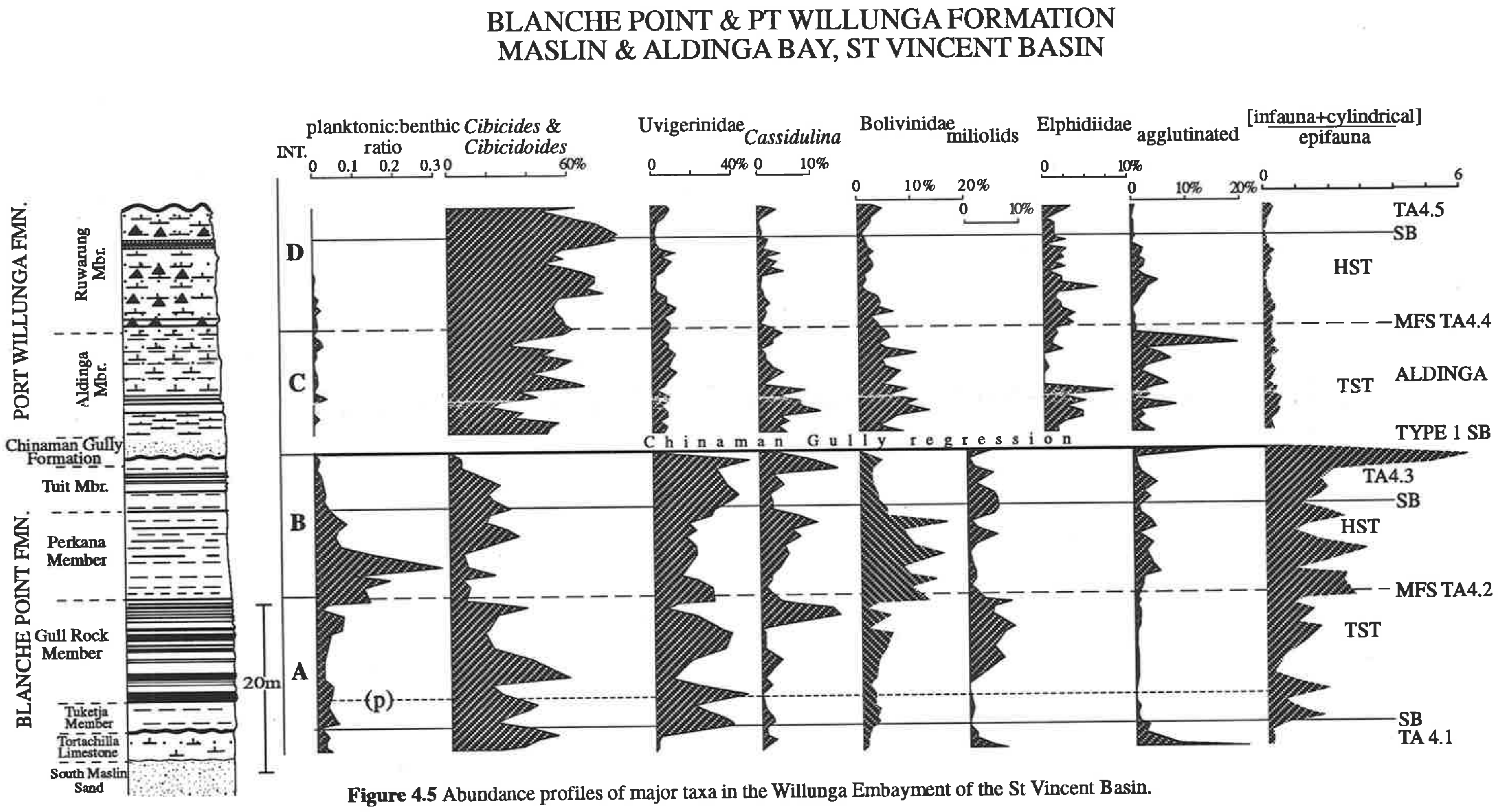


Figure 4.5 Abundance profiles of major taxa in the Willunga Embayment of the St Vincent Basin.

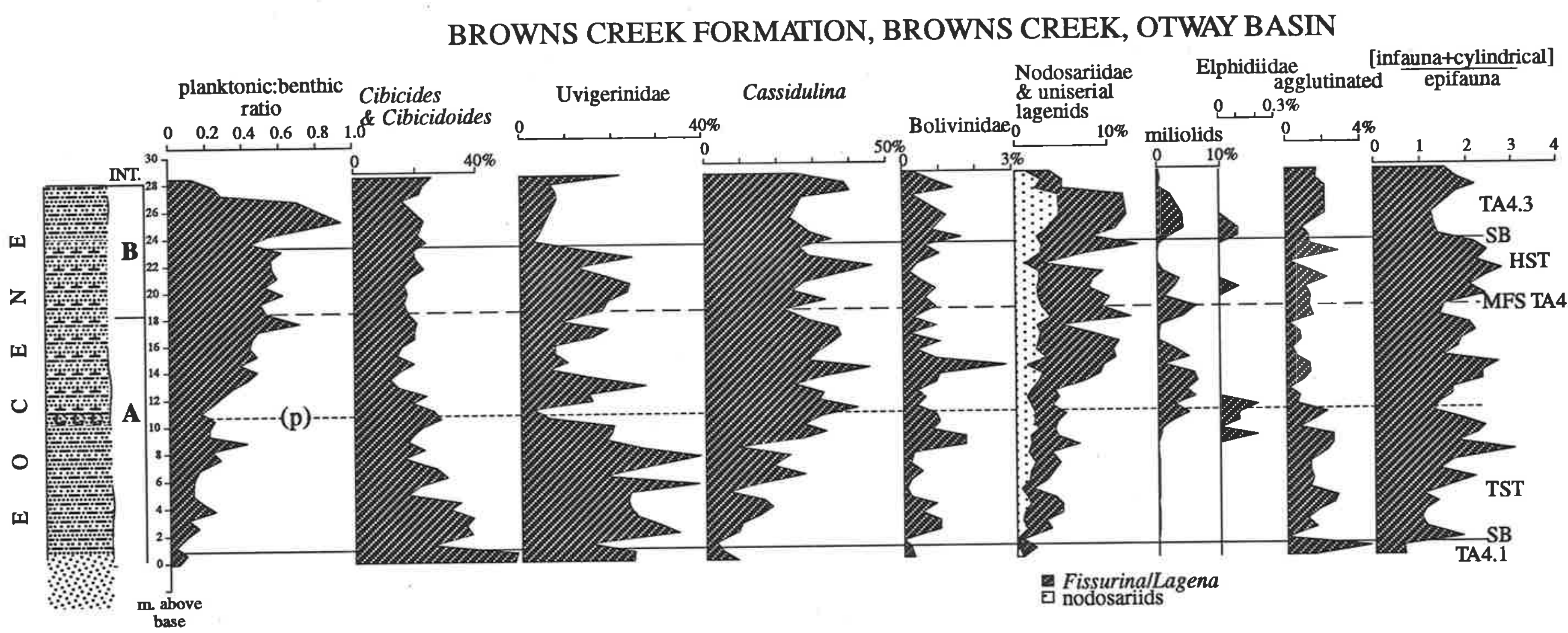


Figure 4.4 Biofacies profiles of important taxa in the Browns Creek Formation. Level (i) roughly correlating to an interval between parasequences, top of the distinctive greensand, is interpreted to be the coeval with the top of the glauconite-rich Tuketja Member in the Blanche Point Formation in the St Vincent Basin (Fig. 4.5).

Figure 4.2

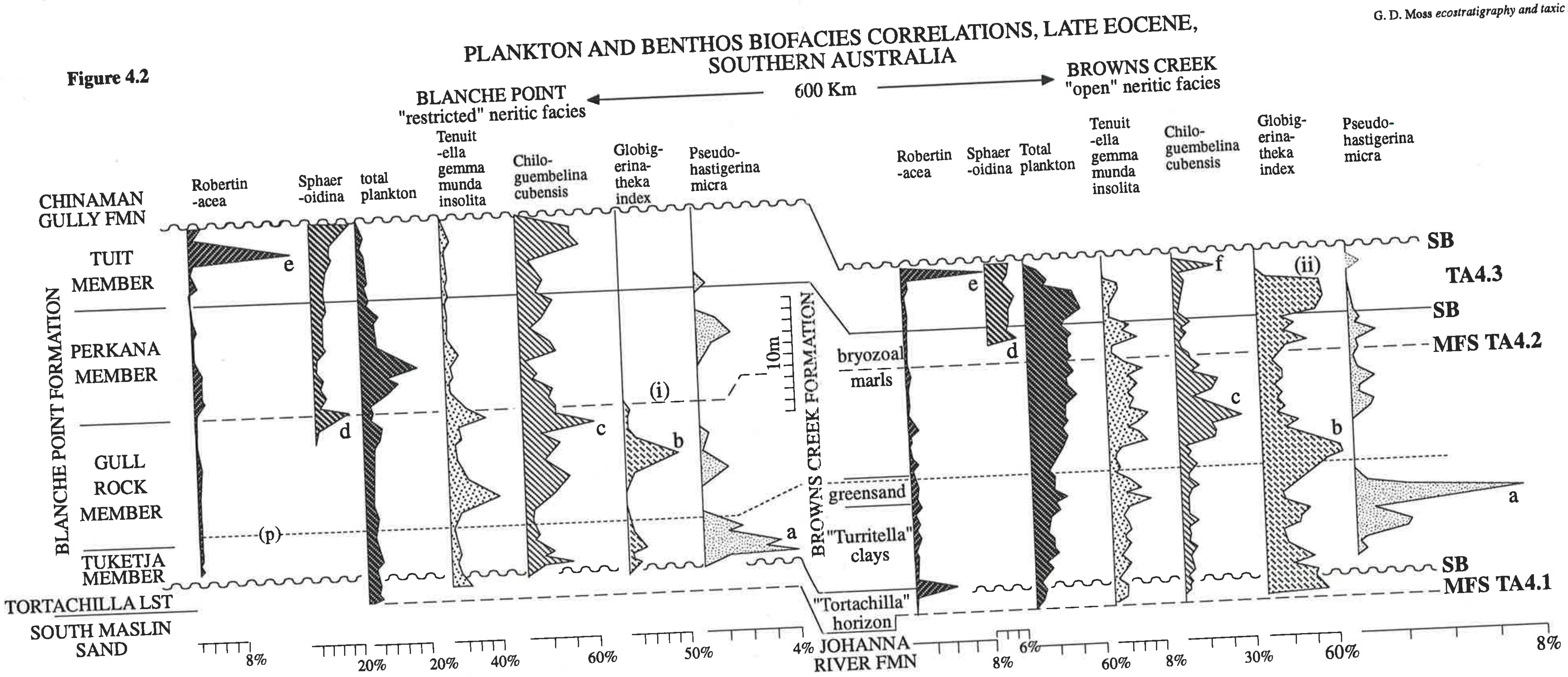


Figure 4.3