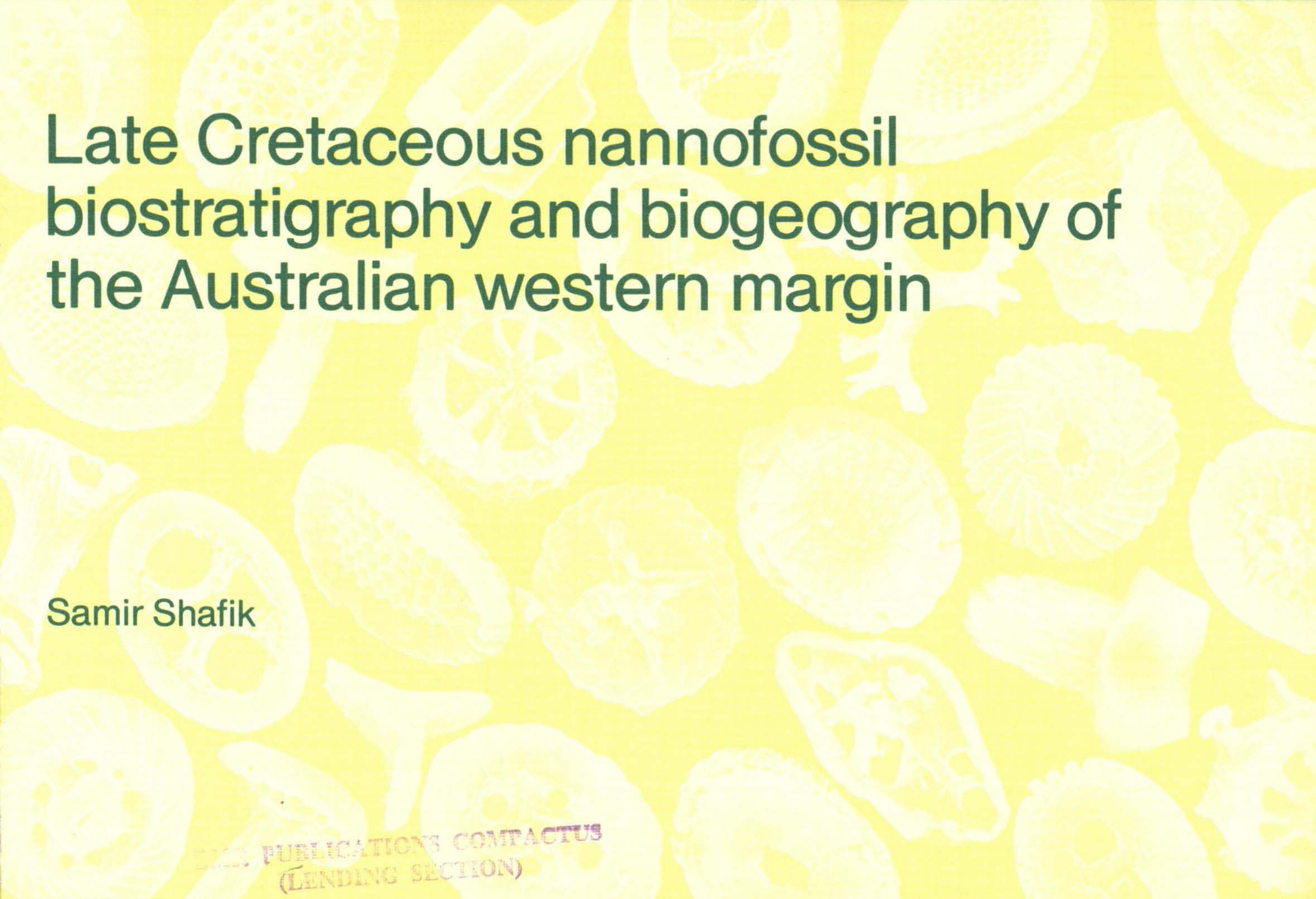
Report 295

Late Cretaceous nannofossil biostratigraphy and biogeography of the Australian western margin



Samir Shafik

Bureau of Mineral Resources, Geology and Geophysics

Department of Primary Industries and Energy
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REPORT 295

LATE CRETACEOUS NANNOFOSSIL BIOSTRATIGRAPHY AND BIOGEOGRAPHY OF THE AUSTRALIAN WESTERN MARGIN

by

SAMIR SHAFIK

(Division of Marine Geosciences and Petroleum Geology)

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ABSTRACT

Calcareous nannofossils from 35 localities on the western margin of Australia and 10 other localities in the Indo-Pacific region have been studied. They have provided good means for understanding the geological history of sequences deposited in the Perth and Carnarvon Basins during the Late Cretaceous i.e. during an early stage in the formation of this Australian margin. In this study, the use of datum interval in biostratigraphic analysis is preferred than zones for reasons indicated.

Post-early Campanian sediments with calcareous microplanktic remains are recognised for the first time in the onshore Perth Basin. These sediments include a new upper Maastrichtian stratigraphic unit which is informally named the Breton Marl. Sediments older than late Coniacian in the Perth Basin are barren of calcareous nannofossils. In the Carnarvon Basin a new lithostratigraphic unit, the Beedagong Claystone, is formally proposed for sediments containing a late Turonian - Coniacian calcareous nannofossil succession. Thus, the biostratigraphic sequence of events is different in the two basins. Fifteen significant biostratigraphic events are identified in the Carnarvon Basin, spanning the late Turonian - late Maastrichtian interval. Thirteen significant biostratigraphic events are identified in the Perth Basin, spanning the interval late Coniacian/early Santonian - late Maastrichtian. It is only from the base of the planktic section to slightly above the (early Campanian) highest occurrence of *Marthasterites furcatus* where the biostratigraphy is similar in the two basins; events above this interval are mostly different. Coccolith biostratigraphic resolution for the late Campanian - late Maastrichtian interval is finer in the Perth Basin than in the Carnarvon Basin.

Two regional hiatuses, coincident with formational contacts, are identified in each basin: (1) an intra-Campanian hiatus between the Gingin Chalk and the overlying Lancelin Beds in the Perth Basin, coeval with an hiatus between the Toolonga Calcilutite and the overlying Korojon Calcarenite in the Carnarvon Basin; and (2) a middle Maastrichtian hiatus between the Lancelin Beds and overlying Breton Marl in the Perth Basin, and between the Korojon Calcarenite and the overlying Miria Marl in the Carnarvon Basin; continuous deposition at the Beedagong-Toolonga contact is indicated on coccolith evidence. The long-standing but always somewhat controversial correlation of the Toolonga Calcilutite with part or all of the Korojon Calcarenite, is shown to be incorrect. Coccolith assemblages are described which characterise each of the lithostratigraphic units; these provide a more precise and less expensive means of identification of the units in subsurface sections than geophysical methods.

The distribution of coccoliths in the Perth and Carnarvon Basins, together with results from areas surrounding Australia (Kerguelen, Naturaliste and Ontong Java Plateaux, Ninetyeast Ridge, Papua New Guinae, and New Zealand), as well as previously published data, show that several species are reliable temperature indicators. These species include *Biscutum coronum, B. magnum, Certatolithoides aculeus, Cribrosphaerella daniae, Micula murus, Misceomarginatus pectinatus, Monomarginatus quaternarius, Nephrolithus corystus, N. frequens, Seribiscutum primitivum, Quadrum gothicum, Q. trifidum* and *Petrarhabdus copulatus* among others. It is suggested that the absence of the highly resistant *Watznaueria barenasae* and the relative abundance of members of the *Micula staurophora/concava/murus/prinisii* complex are also useful climatic pointers. The floras indicate the presence of three biogeographic provinces during the Maastrichtian: an Austral Province (encompassing the Perth Basin and other locations in the Southern Hemisphere including New Zealand), an Extratropical Province (including the Carnarvon Basin and many locations in its Northern Hemisphere counterpart), and a Tropical Province which includes areas in the immediate north of Australia (e.g. Papua New Guinea). Evidence for the existence of these provinces along the Australian western margin is first seen in the late Campanian, and become progressively more clearly defined in the Maastrichtian.

The general similarity of the Santonian-early Campanian coccolith successions in the two basins suggests similar watermasses and a uniform climate. Even so, the distribution of the early Campanian *Biscutum coronum* indicates cooler water conditions in the Perth Basin compared with the Carnarvon Basin, where only the southern sector has evidence of cold spells/cooling bursts. The uniform and equable climate during the Santonian along the Australian western margin matches the evidence of a Coniacian-Santonian global warming from other palaeontological and palaeotemperature data. Also, the coccolith evidence points to the development of a steeper thermal gradient between the watermasses of the Perth and Carnarvon Basins during the late Campanian - early Maastrichtian, consistent with a wordwide decline in temperatures during the later Cretaceous, documented elsewhere. However, during the late Campanian, two short warm episodes are detected in the austral Perth Basin; one cold spell is also detected during the late Campanian in the extratropical Carnarvon Basin.

A short global warm event during the late Maastrichtian is proposed to explain an invasion by tropical species, such as *Micula murus*, into the Austral Province (Perth Basin) and its northern counterpart, the Boreal Province.

A hypothesis is put forward to explain the reversed order of stratigraphic appearance of the late Maastrichtian index species, the (bipolar) austral/boreal *Nephrolithus frequens* and the tropical *Micula murus*, in areas ascribed to the Extratropical Province, and to also explain their extreme rarity in the extratropical Miria Marl from which they were not previously recorded. Thus, the Miria Marl is dated as late Maastrichtian, consistent with the foraminiferal evidence, rather than the previous middle Maastrichtian age suggested by the prominence of *Lithraphidites quadratus*. The lowest occurrence of *Cribrosphaerella daniae* in the Austral Province, and the highest occurrence of *Broinsonia parca* in the Tropical Province are proposed as criteria for approximating the Campanian/Maastrichtian boundary. However, the extinction of *B. parca* is shown to be diachronous, becoming younger away from the tropics.

The coccolith evidence suggests that the Upper Cretaceous carbonates of both basins were deposited in nearshore or shelf palaeoenvironments. Three Upper Cretaceous, eustatically related, carbonate sedimentation cycles are identified in the Carnarvon and Perth Basins. The resultant unconformity-bounded sediment packages are termed the Toolonga/Gingin, Korojon/Lancelin, and Miria/Breton Sequences. The oldest, Cycle A, commenced during the late Turonian (base of Beedagong Claystone) in the northern portion of the Carnarvon Basin; this is earlier than in the southern portion of the basin, where it began during the late Coniacian/early Santonian (base of Toolonga Calcilutite). In the Perth Basin it also commenced during the late Coniacian/early Santonian (base of Gingin Chalk). The transgression, apparently from a northerly direction, over a near-peneplained surface of the onshore Carnarvon and Perth Basins, was rapid during the late Coniacian/early Santonian, but rates of sedimentation were slow during the early phase. This cycle terminated during the early Campanian in both basins. Cycle B (late Campanian - early Maastrichtian) took place at about the same time in both basins, resulting in the accumulation of virtually coeval units (Korojon Calcarenite in the Carnarvon Basin and Lancelin Beds in the Perth Basin). Similarly, Cycle C began about the same time (during the late Maastrichtian) in both basins, resulting in the formation of the Miria Marl (Carnarvon Basin) and Breton Marl (Perth Basin). These three cycles are correlated with three third-order eustatic cycles described by Kauffmann in the Western Interior Basin of North America, and are consistent with the Upper Cretaceous sea-level curve and sequence stratigraphy of Haq & others. Events occurring during the Australian cycles are also apparently contemporaneous with, and thus support, the global extent of other events: during Cycle A an acceleration in the rate of sedimentation (accompanied by a maximum inundation) in both basins occurred during the mid/late Santonian interval (Datum Interval: lowest occurrence of *Lucianorhabdus cayeuxii* to lowest occurrence of *Calculites obscurus*) which brackets the event of maximum flooding during the Upper Cretaceous Cycle 3.4 of Haq & others; the same Australian event correlates with a significant middle Santonian transgressive pulse previously recorded in the Western Interior Basin of North America.

INTRODUCTION

This study investigates the biostratigraphy and biogeography of Late Cretaceous (Turonian & Senonian/Naturalistian, Howlandian & Bermudan) calcareous nannofossils from onshore sections on the western margin of Australia, and uses these fossils to test published allocyclic schemes dealing with major changes in global sea-level and palaeotemperature. For the purpose of this study, the western margin is the coastal region of Australia between Cape Leeuwin (in the south) and Barrow Island (in the north) inclusively (Latitudes 35° to 18° S), i.e. essentially the Perth and Carnarvon Basins (Fig. 1).

The formation of the western margin began during the Early Jurassic in the north (north of Barrow Island, Exmouth Plateau region) and during the Early Cretaceous in the south (South Perth Basin region). It is shown that the onshore sequence deposited during the Early Jurassic - Early Cretaceous lacks calcareous nannofossils; the oldest such fossils being rare occurrences in a Lower Cretaceous unit (Gearle Siltstone) in the northern Carnarvon Basin. It is in the Upper Cretaceous sequences that nannofossils become important in both the onshore Perth and Carnarvon Basins.

The western margin of Australia extended across several palaeolatitudes during the Late Cretaceous (Fig. 2). Reconstructions by Scotese & others (1986) place this margin between palaeolatitudes 60° and 40° S during the Coniacian (ca 84 Ma) and indicate a shift of about 5 degrees to the north by the Maastrichtian (ca. 66 Ma). Possible provincialism or latitudinal differentiation of Late Cretaceous nannofossil assemblages was investigated by examination of stratigraphic sections well spaced latitudinally along this margin, in the Perth and Carnarvon Basins and on the Northwest Shelf.

Few papers have been published on Upper Cretaceous calcareous nannofossils from Australia. Studies on Upper Cretaceous coccoliths from land-based sections along the Australian western margin are limited to those species recorded (by Deflandre, 1959; and Thierstein, 1974, 1976; but chiefly by Shafik, 1978b) from a few Santonian outcrops in the Perth Basin; Thierstein (1977) dated a few samples from the carbonate units of the Perth and Carnarvon Basins, without listing their coccolith species. On the other hand, foraminiferids have long been the major biostratigraphic tools used for the Upper Cretaceous of Western Australia (e.g. Belford, 1958; Edgell, 1964;

Figure 1. Sketch map of Australia and surroundings, showing the marginal basins of western and southern Australia, selected DSDP sites in the Indian Ocean and Southwest Pacific Oceans, and locations in Papua New Guinea and New Zealand.

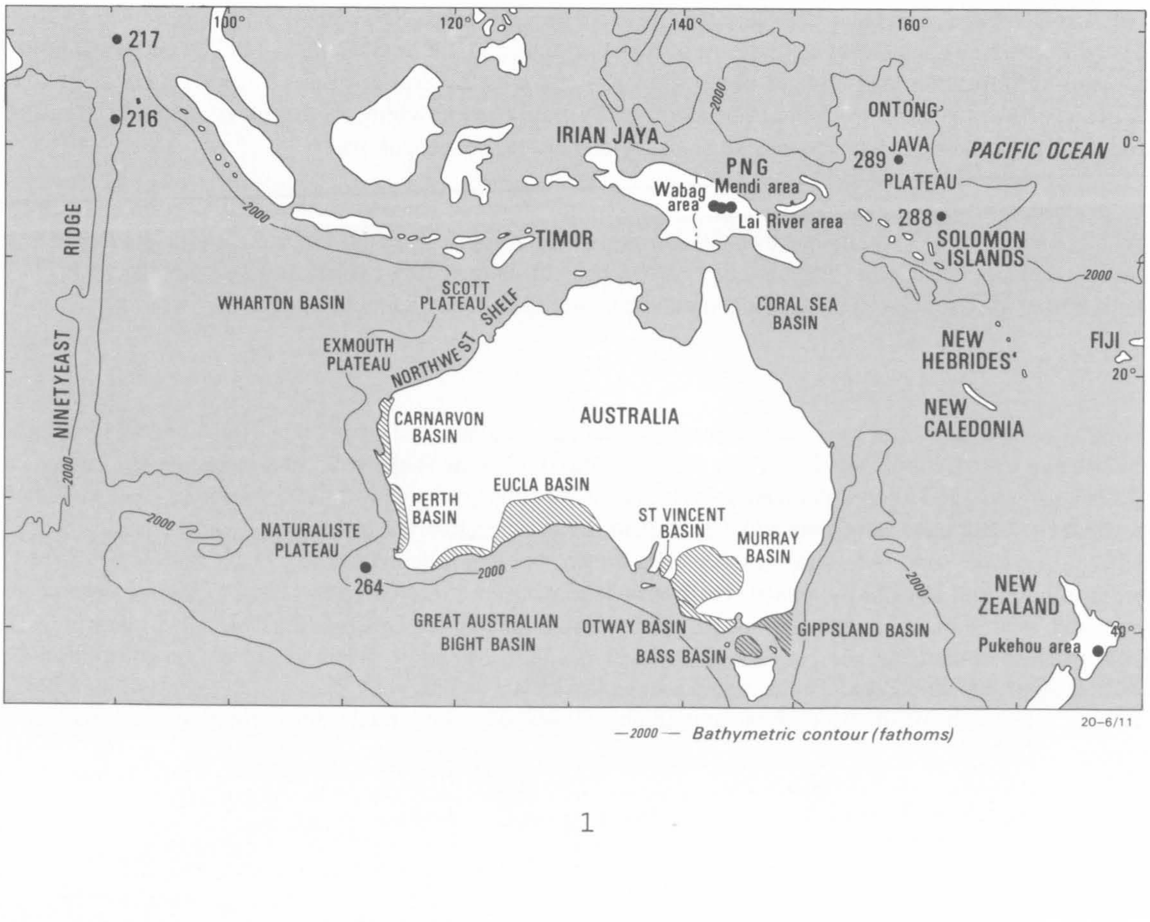
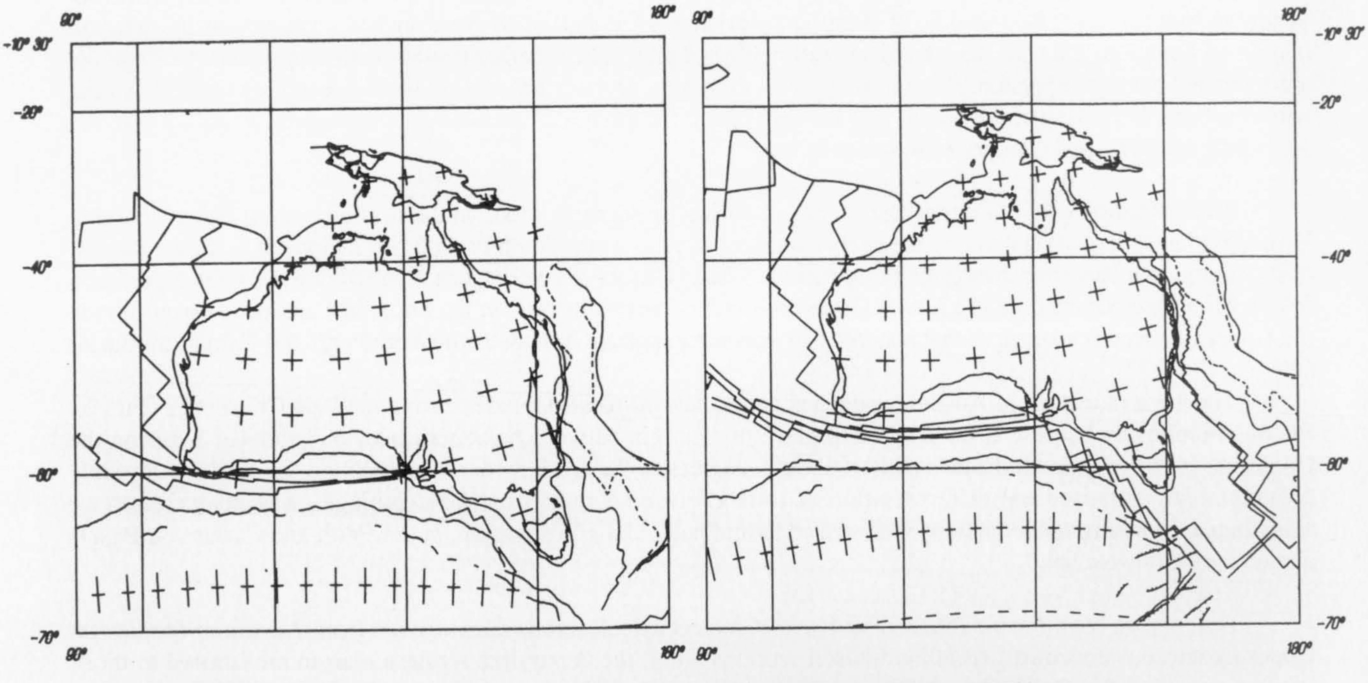


Figure 2. Palaeolatitudes for Australia during four time slices within the Late Cretaceous - Early Tertiary interval (after Scotese & others, 1986).



Coniacian (84 Ma)

Maestrichtian - Early Tertiary (66 Ma)

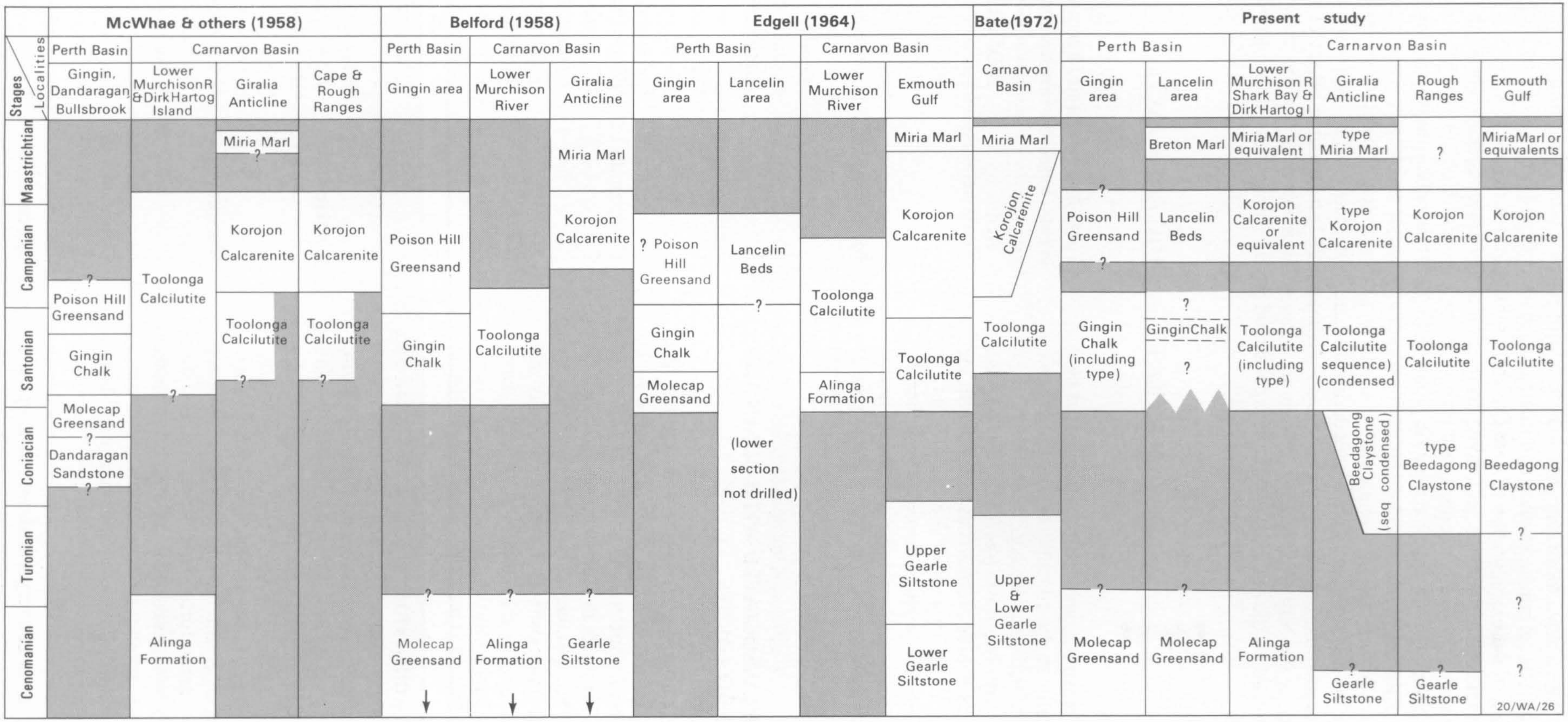
McGowran, 1968, 1977; Apthorpe, 1979). In addition, ostracods have also been used for local biostratigraphic studies (Bate, 1972). In contrast to the few data published on Cretaceous nannofossils from Australia, a great wealth of papers dealing with these fossils from elsewhere has accumulated since the early 1960's. Early benchmark papers include those by Stover (1966) and Cepek & Hay (1969a, b). Significant advances in the field of nannofossil biostratigraphy occurred in the early 1970's and continued on, initially as culmination of several factors such as improvements in microscope optics, successful application of electron microscopy and the huge amount of DSDP (and lately ODP) data becoming available. Important papers dealing with Late Cretaceous nannofossil biostratigraphy, include those by Manivit (1971), Roth & Thierstein (1972), Bukry (1973b, c), Thierstein (1971, 1974, 1976), Roth (1978), Sissingh (1978) and Perch-Nielsen (1979e). As a result of the enormous amount of work on Late Cretaceous nannofossils, some of the limitations in nannofossil biostratigraphy, such as biostratigraphic consequencies of provincial distribution of a biostratigraphic marker, are rapidly being acknowledged. Improvements in nannofossil biostratigraphic resolution in Cretaceous sediments are undeniably being achieved.

In addition to studying calcareous nannofossils from Upper Cretaceous sections in the Perth and Carnarvon Basins and on the Northwest shelf, this investigation uses material from areas adjacent to Australia: the Kerguelen and Naturaliste Plateaux, Ninetyeast Ridge, Papua New Guinea, the Ontong Java Plateau and New Zealand (Fig. 1). This enabled a deeper appreciation of the palaeogeographic distribution of key nannofossil species.

OBJECTIVES

A major objective of this study was biostratigraphic, to correlate the Upper Cretaceous lithostratigraphic units in the Perth and Carnarvon Basins (see Table 1), and to provide a time scale for local non-biological events. In the Perth Basin, the published foraminiferal record is based on two lithostratigraphic units, the Gingin Chalk and Lancelin Beds, which are Santonian/Campanian and Campanian in age respectively. Until this study, these units were known only in separate areas, and their stratigraphic relationship could not be determined. A third (younger) unit was identified in here, and informally named the Breton Marl. Also a more complete Upper Cretaceous calcareous microplanktic record could be indicated for the Perth Basin than was possible previously using foraminiferids and ostracods because of the large number of sections studied. In the Carnarvon Basin, problems in correlation of the Upper Cretaceous lithostratigraphic units have persisted for the last two decades. These problems were identified, and with reference to a scheme of coccolith biostratigraphic events, described in this study, attempts were made at their

Table 1. Age of West Australian Upper Cretaceous lithostratigraphic units as given by previous investigators and in this study.



elucidation. Also a new lithostratigraphic unit, the Beedagong Claystone, was formally proposed at the base of the Upper Cretaceous carbonate sequence in that basin. A second main objective was biogeographic. Because an understanding of the biogeography of Late Cretaceous coccoliths is crucial to achieving reliable biostratigraphy, special attention was given to the geographic distribution of key biostratigraphic coccolith species. This resulted in Maastrichtian coccolith biogeographic provinces being identified. By combining biostratigraphy and palaeobiogeography, it was possible to tackle problems in global nannobiostratigraphy (notably the relative order of appearance of the key biostratigraphic species *Nephrolithus frequens* and *Micula murus* in mid-latitude sections). A third objective of this study was to use the coccoliths and other evidence to determine sedimentation patterns and cycles along the Australian western margin during the Late Cretaceous, and to test presumed global movements in sea-level documented by investigators such as Kauffman (1984) and Haq & others (1987). Upper Cretaceous sediments along the Australian western margin are generally in the form of wedges thickening offshore. In such situations, records of the effects of eustatic changes should be more obvious in onshore sections than in their offshore counterparts.

BIOSTRATIGRAPHIC APPROACH

The biostratigraphic approach adopted here relies basically on the concepts of biostratigraphic event/biohorizon/datum (see, e.g. Table 2) rather than on formally described zones (see Tables 3 & 4A-4B). This approach avoids problems associated with the use of the latter (discussed below). Thus the formulated biostratigraphic schemes (e.g. Tables 21, 23 & 25) and biostratigraphic assignments in this study are expressed as datum intervals, making use of the notational method proposed by Bukry (1981) (examples are given below).

PROBLEMS ASSOCIATED WITH ZONES AND ZONAL ASSIGNMENTS

Late Cretaceous coccolith biostratigraphic zonations are currently in a choatic state with duplication of zone names as one of the main problems. Zones with the same name but defined by different index species, and/or covering different stratigraphic intervals (e.g. *Eiffellithus eximius* and *Marthasterites furcatus* zones in Table 3), have caused confusion and miscorrelation by non-specialists; Table 3 is a summary of most published Late Cretaceous zones, arranged alphabetically. Some of the difficulties could be alleviated by designating the author and year of publication of the zone used (e.g. *Broinsonia lacunosa* zone **of Roth, 1978**), or by using unique codes of letters and numbers for individual zonations, as suggested by Bukry (1981) (e.g. V76-1, V76-2, etc. meaning Verbeek's zonation published in 1976 first zone, second zone, etc.), with reference to a zonal directory based on the same form of notation. Practice has shown that a more accurate coccolith biostratigraphy of a particular region often requires the use of zones drawn from more than one zonation (see, e.g. Miller, 1983), emphasising the need for such a directory's compilation as Table 3. There are difficulties with proposal. A zonal directory would need to be updated periodically as new relevant publications appear.

Table 2. A synthesis of sequences of biostratigraphic events, based on varoius zones defined in Table 3.

AGE	BIOSTRATIGRAPHIC EVENT
Maastrichtian	**Micula prinsii*
	**Nephrolithus frequens*
	**Micula murus*
	**Lithraphidites quadratus*
	**Arkhangelskiella cymbiformis*
	+Reinhardtites levis
	+Tranolithus orionatus
	+Quadrum trifidum
Campanian	*+Broinsonia parca*
	+Reinhardtites anthophorus
	**Reinhardtites levis*
	**Quadrum trifidum*
	**Quadrum gothicum*
	**Ceratolithoides aculeus*
	+Marthasterites furcatus
	+Bukryaster hayii
	**Broinsonia parca*
Santonian	**Calculites obscurus*
	**Lucianorhabdus cayeuxii*
	**Reinhardtites anthophorus*
Coniacian	**Micula staurophora*
	**Reinhardtites biperforatus*
	**Marthasterites furcatus*
Turonian	**Eiffellithus eximius*,
	or **Kamptnerius magnificus*
	**Lucianorhabdus maleformis*
	**Ahmuellerella octoradiata*
	**Quadrum gartneri*
Cenomanian	**Gartnerago obliquum*

*Lowest occurrence +Highest occurrence
Sequential order of some of the events is tentative; see text for explanations (p.60).

Inevitably, this built-in uncontrollable expansion of the directory may limit its usefulness.

Other problems of zonal assignments relate to the spatial distribution of species and the quality of sample material. Provincial distribution and diagenesis may cause the absence of particular zonal markers from a given region or stratigraphic section (even though the material at hand could be contemporaneous with the stratigraphic ranges of these particular species), rendering the use of their zones impractical. For example, poor preservation and limited diversity of nannofossils in the South African Cretaceous, forced Siesser (1982) to broadly assign his material to the international stages instead of to nannobiostratigraphic zones. This problem could be overcome by defining **longer or more suitable zones** for the given region or stratigraphic section, as has been the practice even among recently published works. But this has only added to the problem of duplication of zone names (e.g. *Marthasterites furcatus* zone of Wise, 1983 -- see Tables 3 & 4A-4B; see also zones described recently by Filewicz, 1986 which were previously known under different names from Perch-Nielsen's 1977 paper).

In sections with high coccolith diversity, more biostratigraphic events may be identifiable than those originally recorded in zonal reference section(s), and in such cases, the application of zones would be a hindrance to accuracy and resolution.

Most zones are based on events of lowest occurrences in order to overcome errors which could be caused by undetectable reworking; because of their minute and usual great abundance, coccoliths are prone to reworking. Such zones may not necessarily be suitable for the study of subsurface samples, where the possibility of downhole contamination in drillholes dictates the use of events of **highest** occurrences, as ditch cuttings are generally the only material available. Gartner (1977) was of the opinion that problems of contamination and of reworking can be dealt with most effectively when biostratigraphic events based on lowest and highest occurrences are used without defining or naming formal zones.

ALTERNATIVE BIOSTRATIGRAPHIC PRACTICE

Compared with the rigid system of formal zones, the biostratigraphic event (=datum) interval concept is flexible: once a coccolith sequence of events (of lowest and highest occurrences) has been most accurately assembled (ideally after having been tested repeatedly), assignment of assemblages could be made to an interval not necessarily limited by two successive events. New events can be inserted or added to the sequence without invalidating any previous biostratigraphic (interval) assignment. Thus, in dealing with the nannofossil biostratigraphy of the Australian Lower Tertiary, Shafik (1978a, 1983, 1985b) has consistently and successfully applied the biostratigraphic event interval concept instead of zones.

Thierstein (1976) advocated the use of biohorizons by choosing to describe Mesozoic coccolith biostratigraphic events of first and last occurrences of key species rather than zones. He listed the following three criteria for selecting biohorizons:

1. Distinct first (or last) occurrences, established and correlated in as many sections as possible;
2. Ease in identification using optical microscopy;
3. Need for an event in a certain stratigraphic interval.

Gartner (1977) added the following two criteria regarding selection of a marker species:

1. The species should be a reasonably common constituent of the assemblage;
2. The species should have a widespread geographic distribution, preferably being cosmopolitan.

The rejection of a biohorizon, because it does not fulfill the above criteria, does not necessitate revision of the biostratigraphic sequence to which it once belonged. On the other hand, when an unsuitable defining event is removed from a zonal scheme, modification of that scheme (i.e., redefinition of relevant zone(s)) becomes necessary.

Roth (1978) listed some criteria for the selection of index species but only a few groups of Cretaceous coccoliths satisfied them. Besides being easy to recognise, and having a wide latitudinal distribution, the index species should be oceanic, resistant to preservational changes, and should have short stratigraphic ranges (Roth, 1978).

Bukry (1981) described a code for the use of the biostratigraphic interval concept in Cainozoic coccolith biostratigraphy, which conveyed stratigraphic information directly in a zonal format; the biostratigraphic interval was indicated as DI (datum interval). A similar code is adopted for this study where * denotes lowest occurrence, and + highest occurrence. Two examples of this usage are given below:

Table 3. A compilation of Turonian-Maastrichtian coccolith zones, arranged alphabetically.

AGE	LOWER BOUNDARY	UPPER BOUNDARY	PUBLICATION
	Arkhangelskiella cymbiformis zone		
Maastrichtian	+*Reinhardtites anthophorus*	**Tetralithus murus or Nephrolithus frequens*	Perch-Nielsen, 1972
Maastrichtian	+*Tetralithus trifidus*	**Lithraphidites quadratus*	Martini, 1976; Perch-Nielsen, 1977; Pflaumann & Cepek, 1982; Haq, 1983
Maastrichtian	+*Reinhardtites levis*	**Nephrolithus frequens*	Sissingh, 1977
Maastrichtian	+*Uniplanarius trifidus*	**Lithraphidites quadratus*	Hattner & Wise, 1980
Maastrichtian	+*Uniplanarius trifidus/ Uniplanarius gothicus*	+*Lithraphidites quadratus(1)*	Varol, 1983
Maastrichtian	+*Quadrum trifidum*	**Lithraphidites quadratus*	Doeven, 1983; Stradner & Steinmetz, 1984
	Arkhangelskiella ethmopora zone		
Campanian	**Arkhangelskiella ethmopora*	**Kamptnerius punctatus*	Cepek & Hay, 1969a, b
	Arkhangelskiella specillata zone		
Campanian	**Arkhangelskiella specillata*	**Tetralithus aculeus*	Manivit, 1971
Coniacian	**Arkhangelskiella specillata*	**Marthasterites furcatus*	Verbeek, 1976
	Biscutum coronum zone		
Campanian/ Maastrichtian	+*Marthasterites furcatus* **Biscutum coronum*	+*Biscutum coronum*	Wise, 1983
	Broinsonia lacunosa zone		
Coniacian	**Broinsonia lacunosa*	**Micula concava*	Verbeek, 1976
Coniacian/ Santonian	**Broinsonia lacunosa*	**Tetralithus obscurus* **Micula concava* **Lithraphididites helicoideus*	Roth, 1978
	Broinsonia parca zone		
Campanian	+*Eiffellithus angustus*	**Tetralithus trifidus*	Bukry, 1973b
Campanian	+*Eiffellithus eximius*	**Tetralithus trifidus*	Roth, 1973
Campanian	**Broinsonia parca*	**Tetralithus aculeus*	Verbeek, 1976; Roth, 1978
Campanian	+*Marthasterites furcatus*	**Tetralithus aculeus*	Perch-Nielsen, 1977; Pflaumann & Cepek, 1982
Campanian	**Broinsonia parca*	**Prediscosphaera stoveri*	Crux, 1982
Campanian	**Broinsonia parca*	**Ceratolithoides aculeus*	Haq, 1983; Doeven, 1983; Varol, 1983
Campanian	+*Marthasterites furcatus*	**Ceratolithoides aculeus*	Stradner & Steinmetz, 1984
	Calculites obscurus zone		
Campanian	**Calculites obscurus*	**Aspidolithus ex gr. parcus*	Sissingh, 1977
	Calculites ovalis zone		
Campanian	+*Marthasterites furcatus*	**Ceratolithoides aculeus*	Sissingh, 1977

Table 3 (continued)

AGE	LOWER BOUNDARY	UPPER BOUNDARY	PUBLICATION
	Ceratolithoides aculeus zone		
Campanian	*Ceratolithoides aculeus	*Tetralithus nitidus	Sissingh, 1977
Campanian	*Ceratolithoides aculeus	*Quadrum gothicum	Verbeek, 1977; Doeven, 1983; Stradner & Steinmetz, 1984
Campanian	*Ceratolithoides aculeus	*Tetralithus trifidus	Haq, 1983
Campanian	*Ceratolithoides aculeus	*Uniplanarius gothicus	Varol, 1983
	Chiastozygus initialis zone		
Maastrichtian	*Chiastozygus initialis	*Lithraphidites quadratus	Cepek & Hay, 1969a, b
Maastrichtian	*Chiastozygus initialis	*Munarianus lesliae	Risatti, 1973
	Corollithion exiguum zone		
Turonian	*Corollithion exiguum	*Tetralithus pyramidus	Cepek & Hay, 1969a, b
Turonian	*Corollithion exiguum	*Micula staurophora	Manivit, 1971
Turonian	*Corollithion exiguum	*Micula decussata	Roth, 1973
Turonian	+Lithraphidites acutum	*Micula staurophora	Pflaumann & Cepek, 1982
	Cribrosphaera circula zone		
Maastrichtian	*Cribrosphaera circula	*Ramsaya swanseana	Risatti, 1973
	Eiffellithus angustus zone		
Campanian	*Broinsonia parca	+Eiffellithus angustus	Bukry & Bramlette, 1970
Campanian	*Broinsonia parca	+Tetralithus gothicus trifidus and Eiffellithus angustus	Roth & Thierstein, 1972
Campanian	*Broinsonia parca	*Tetralithus nitidus trifidus	Gartner, 1974
	Eiffellithus eximius zone		
Campanian	*Broinsonia parca	+Eiffellithus eximius	Roth, 1973
Turonian	*Eiffellithus eximius	+Arkhangelskiella specillata	Verbeek, 1976
Santonian/ Campanian	*Broinsonia parca	+Marthasterites furcatus	Perch-Nielsen, 1977; Pflaumann & Cepek, 1982; Stradner & Steinmetz, 1984
Turonian/ Coniacian	*Eiffellithus eximius	*Marthasterites furcatus	Manivit & others, 1977; Haq, 1983;
Turonian			Doeven, 1983
Campanian	*Broinsonia parca	*Tetralithus trifidus	Proto Decima & others,1978
Santonian/ Campanian	*Broinsonia parca constrica	*Marthasterites furcatus	Hattner & Wise, 1980
Turonian/ Coniacian	*Eiffellithus eximius	*Micula staurophora	Crux, 1982
Campanian	*Uniplanarius trifidus	+Eiffellithus eximius	Varol, 1983
	Eurhabdus scotus zone		
Maastrichtian	*Eurhabdus scotus	*Cribrosphaera circula	Risatti, 1973
	Gartnerago obliquum zone		
Santonian	+Marthasterites furcatus	*Broinsonia parca	Roth, 1973
Cenomanian/ Turonian	*Gartnerago obliquum	*Micula staurophora	Thierstein, 1974

Table 3 (coninued)

AGE	LOWER BOUNDARY	UPPER BOUNDARY	PUBLICATION
	Gartnerago obliquum zone		
Cenomanian/ Turonian	+_Lithraphidites acutum_	*_Micula staurophora_ _Tetralithus pyramidus_	Roth, 1978
	Gartnerago obliquus zone		
Cenomanian/ Turonian	*_Gartnerago obliquus_	*_Corollithion exiguum_	Manivit, 1971
	Heliorthus concinnus zone		
Maastrichtian	*_Heliorthus concinnus_	*_Lithraphidites quadratus_	Risatti, 1973
	Kamptnerius magnificus zone		
Turonian/ Campanian	*_Kamptnerius magnificus_	*_Tetralithus aculeus_	Cepek & Hay, 1969a
Santonian	*_Kamptnerius magnificus_	*_Broinsonia parca_	Manivit, 1971
Turonian/ Coniacian	*_Kamptnerius magnificus_	*_Marthasterites furcatus_	Thierstein, 1974
Coniacian	*_Kamptnerius magnificus_	*_Marthasterites furcatus_ *_Eiffellithus eximius_	Roth, 1978
Turonian	*_Kamptnerius magnificus_	+_Thiersteinia ecclesiastica_(2)	Wise, 1983
	Kamptnerius punctatus zone		
Campanian	*_Kamptnerius punctatus_	*_Kamptnerius magnificus_	Cepek & Hay, 1969a, b
	Liliasterites angularis zone		
Turonian	*_Liliasterites angularis_	*_Marthasterites furcatus_	Stradner & Steinmetz, 1984
	Lithraphidites praequadratus zone		
Maastrichtian	+_Tetralithus trifidus_	*_Lithraphidites quadratus_ s.str.	Roth, 1978
	Lithraphidites quadratus zone		
Maastrichtian	*_Lithraphidites quadratus_	*_Markalius astroporus_	Cepek & Hay, 1969a
Maastrichtian	*_Lithraphidites quadratus_	*_Nephrolithus frequens_	Cepek & Hay, 1969b; Gartner, 1974; Perch-Nielsen, 1977; Doeven, 1983
Maastrichtian	+_Tetralithus trifidus_	*_Micula mura_	Bukry, 1973b; Roth, 1973
Maastrichtian	*_Lithraphidites quadratus_	*_Nephrolithus frequens or Tetralithus murus_	Martini, 1976
Maastrichtian	*_Lithraphidites quadratus s.str._	*_Micula mura or Nephrolithus frequens_	Roth, 1978
Maastrichtian	*_Lithraphidites quadratus_	*_Micula mura_	Pflaumann & Cepek, 1982; Haq, 1983; Varol, 1983
	Lithastrinus floralis zone		
Santonian	+_Thiersteinia ecclesiastica_	+_Lithastrinus floralis_	Wise, 1983
	Lucianorhabdus cayeuxii zone		
Santonian	*_Lucianorhabdus cayeuxii_	*_Calculites obscurus_	Sissingh, 1977

Table 3 (continued)

AGE	LOWER BOUNDARY	UPPER BOUNDARY	PUBLICATION
	Lucianorhabdus cayeuxii zone		
Coniacian	*Cylindralithus asymmetricus Kamptnerius magnificus and Lucianorhabdus cayeuxii	*Tetralithus obscurus	Smith, 1981
Santonian	*Lucianorhabdus cayeuxii	*Broinsonia parca	Crux, 1982; Haq, 1983
	Lucianorhabdus maleformis zone		
Turonian/ Coniacian	*Lucianorhabdus maleformis	*Marthasterites furcatus	Sissingh, 1977
Santonian	*Lucianorhabdus cayeuxii, Lucianorhabdus maleformis, Tetralithus obscurus and Tetralithus ovalis	*Broinsonia parca	Shafik, 1978b
Coniacian/ Santonian	*Lucianorhabdus maleformis	*Reinhardtites anthophorus	Crux, 1982
	Marthasterites furcatus zone		
Campanian	*Marthasterites furcatus	*Arkhangelskiells ethmopora	Cepek & Hay, 1969a, b
Coniacian	*Marthasterites furcatus	*Kamptnerius magnificus	Manivit, 1971
Coniacian/ Santonian	*Marthasterites furcatus	+Marthasterites furcatus	Roth, 1973
Coniacian	*Marthasterites furcatus	*Broinsonia lacunosa	Verbeek, 1976
Coniacian/ Santonian	*Marthasterites furcatus	*Broinsonia parca	Perch-Nielsen, 1977; Pflaumann & Cepek, 1982; Stradner & Steinmetz, 1984
Coniacian	*Marthasterites furcatus	*Micula ex gr. staurophora	Sissingh, 1977; Haq, 1983
Coniacian	*Marthasterites furcatus	*Lucianorhabdus cayeuxii, Lucianorhabdus maleformis, Tetralithus obscurus and Tetralithus ovalis	Shafik, 1978b
Coniacian	*Marthasterites furcatus Eiffellithus eximius	*Broinsonia lacunosa	Roth, 1978
Coniacian/ Santonian	*Marthasterites furcatus	*Broinsonia parca constricta	Hattner & Wise, 1980
Santonian/ Campanian	+Lithrastrinus floralis	+Marthasterites furcatus *Biscutum coronum	Wise, 1983
	Micula concava zone		
Santonian	*Micula concava	*Zygodiscus spiralis	Verbeek, 1976
Santonian	*Micula concava	*Rucinolithus hayii	Verbeek, 1977
	Micula decussata zone		
Turonian	*Micula decussata	*Marthasterites furcatus	Roth, 1973
	Micula mura zone		
Maastrichtian	*Micula mura	*Cruciplacolithus tenuis	Bukry, 1973b
Maastrichtian	*Micula mura	+most Cretaceous species	Roth, 1973
Maastrichtian	*Micula mura	+Arkhangelskiella cymibiformis & most other Certaceous forms	Perch-Nielsen, 1977
Maastrichtian	*Micula mura	*Biantholithus sparsus	Varol, 1983

Table 3 (continued)

AGE	LOWER BOUNDARY	UPPER BOUNDARY	PUBLICATION
	Micula mura/Nephrolithus frequens zone		
Maastrichtian	_*Micula mura and/or Nephrolithus frequens_	_*Lithraphidites quadratus_ s.str.	Roth, 1978; Cepek & others, 1980
	Micula murus zone		
Maastrichtian	_*Micula murus_	_+Micula murus_	Stradner & Steinmetz, 1984
	Micula staurophora zone		
Turonian/ Coniacian	_*Micula staurophora_	_*Marthasterites furcatus_	Manivit, 1971
Turonian	_*Micula staurophora_	_*Kamptnerius magnificus_	Thierstein, 1974
Turonian	_*Micula staurophora_	_*Marthasterites furcatus_	Perch-Nielsen, 1977; Pflaumann & Cepek, 1982
Coniacian/ Santonian	_*Micula ex gr. staurophora_	_*Reinhardtites anthophorus_	Sissingh, 1977; Haq, 1983
Turonian	_*Micula staurophora Tetralithus pyramidus_	_*Kamptnerius magnificus_	Roth, 1978
Coniacian	_*Micula staurophora_	_*Lucianorhabdus maleformis_	Crux, 1982
	Munarius lesliae zone		
Campanian	_*Munarius lesliae_	_*Ottavianus giannus_	Risatti, 1973
	Nephrolithus frequens zone		
Maastrichtian	_*Nephrolithus frequens_	_+most Cretaceous species_	Cepek & Hay, 1969a; Gartner, 1974; Doeven, 1983
Maastrichtian	_*Nephrolithus frequens_	_+Nephrolithus frequens_	Sissingh, 1977
Maastrichtian	_*Nephrolithus frequens_	_+Micula mura_	Perch-Nielsen, 1977
	Ottavianus giannus zone		
Campanian/ Maastrichtian	_*Ottavianus giannus_	_*Eurhabdus scotus_	Risatti, 1973
	Prediscosphaera stoveri zone		
Campanian	_*Prediscosphaera stoveri_	_not defined_	Crux, 1982
	Quadrum gartneri zone		
Cenomanian/ Turonian	_*Quadrum gartneri_	_*Eiffellithus eximius_	Manivit & others, 1977; Verbeek, 1977; Crux, 1982; Haq, 1983;
Turonian			Doeven, 1983
	Quadrum gothicum zone		
Campanian	_*Quadrum gothicum_	_*Quadrum trifidum_	Verbeek, 1977; Doeven, 1983; Stradner & Steinmetz, 1984

Table 3 (continued)

AGE	LOWER BOUNDARY	UPPER BOUNDARY	PUBLICATION
	Quadrum trifidum zone		
Campanian/ Maastrichtian	**Quadrum trifidum*	**Lithraphidites quadratus*	Verbeek, 1977
Campanian/ Maastrichtian	**Quadrum trifidum*	+*Quadrum trifidum*	Doeven, 1983; Stradner & Steinmetz, 1984
	Ramsaya swanseana zone		
Maastrichtian	**Ramsaya swanseana*	**Heliorthus concinnus*	Risatti, 1973
	Reinhardtites anthophorus zone		
Maastrichtian	*not given*	+*Reinhardtites anthophorus*	Perch-Nielsen, 1972
Santonian	**Reinhardtites anthophorus*	**Lucianorhabdus cayeuxii*	Sissingh, 1977; Crux, 1982; Haq, 1983; Stradner & Steinmetz, 1984
	Reinhardtites levis zone		
Maastrichtian	+*Tranolithus phacelosus*	+*Reinhardtites levis*	Sissingh, 1977
	Rucinolithus hayii zone		
Santonian	**Rucinolithus hayii*	**Zygolithus spiralis*	Verbeek, 1977
Santonian	**Rucinolithus hayii*	**Broinsonia parca*	Doeven, 1983
	Tetralithus aculeus zone		
Campanian	**Tetralithus aculeus*	**Chiastozygus initialis*	Cepek Hay, 1969a
Campanian	**Tetralithus aculeus*	**Lithraphidites quadratus*	Manivit, 1971
Campanian	**Tetralithus aculeus*	**Tetralithus gothicus*	Martini, 1976; Verbeek, 1976; Perch-Nielsen, 1977; Pflaumann & Cepek, 1982
Campanian	**Tetralithus aculeus*	**Tetralithus trifidus*	Roth, 1978
	Tetralithus gothicus zone		
Campanian	**Tetralithus gothicus*	**Lithraphidites quadratus*	Verbeek, 1976
Campanian	**Tetralithus gothicus*	**Tetralithus trifidus*	Perch-Nielsen, 1977; Pflaumann & Cepek, 1982
	Tetralithus gothicus trifidus zone		
Campanian/ Maastrichtian	**Tetralithus gothicus trifidus*	**Lithraphidites quadratus*	Roth & Thierstein, 1972
	Tetralithus murus zone		
Maastrichtian	**Tetralithus murus*	*Cretaceous terminal extinctions*	Martini, 1969; Perch-Nielsen, 1972
Maastrichtian	**Tetralithus murus*	+*Tetralithus murus*	Bukry & Bramlette, 1970
Maastrichtian	**Tetralithus murus*	**Nephrolithus frequens*	Verbeek, 1976; Perch-Nielsen, 1977
	Tetralithus nitidus zone		
Campanian	**Tetralithus nitidus*	**Tetralithus trifidus*	Sissingh, 1977

Table 3 (continued)

AGE	LOWER BOUNDARY	UPPER BOUNDARY	PUBLICATION
	Tetralithus nitidus trifidus zone		
Campanian/ Maastrichtian	**Tetralithus nitidus trifidus*	+*Tetralithus nitidus trifidus*	Bukry & Bramlette, 1970
Campanian/ Maastrichtian	**Tetralithus nitidus trifidus*	**Lithraphidites quadratus*	Gartner, 1974
	Tetralithus pyramidus zone		
Turonian	**Tetralithus pyramidus*	**Marthasterites furcatus*	Cepek & Hay, 1969a, b
Turonian	**Tetralithus pyramidus*	**Eiffellithus eximius*	Verbeek, 1976
Turonian	**Tetralithus pyramidus*	**Lucianorhabdus maleformis*	Sissingh, 1977
	Tetralithus trifidus zone		
Campanian/ Maastrichtian	**Tetralithus trifidus*	+*Tetralithus trifidus*	Bukry, 1973b; Roth, 1973, 1978; Perch-Nielsen, 1977; Pflaumann & Cepek, 1982; Haq, 1983
Campanian	**Tetralithus trifidus*	+*Reinhardtites anthophorus*	Sissingh, 1977
	Thiersteinia ecclesiastica zone		
Coniacian/ Santonian	**Marthasterites furcatus*	+*Thiersteinia ecclesiastica*	Wise, 1983
	Tranolithus phacelosus zone		
Campanian/ Maastrichtian	+*Reinhardtites anthophorus*	+*Tranolithus phacelosus*	Sissingh, 1977
	Uniplanarius gothicus zone		
Campanian	**Uniplanarius gothicus*	**Uniplanarius trifidus*	Hattner & Wise, 1980; Varol, 1983
	Uniplanarius trifidus zone		
Campanian/ Maastrichtian	**Uniplanarius trifidus*	+*Uniplanarius trifidus*	Hattner & Wise, 1980
Maastrichtian	+*Eiffellithus eximius*	+*Uniplanarius trifidus/ Uniplanarius gothicus*	Varol, 1983
	Zygodiscus spiralis zone		
Santonian	**Zygodiscus spiralis*	**Broinsonia parca*	Verbeek, 1976

***Lowest occurrence** **+Highest occurrence**

*species A to *species B = Partial Range zone; *species A to +species A = (Total) Range zone; +species A to *species B = Partial Range zone; *species A to +species B = Concurrent Range zone; +species to A *species B = Gap zone.

(1) The lower boundary of the overlying zone in Varol's (1983) scheme is defined as the first (lowest) occurrence of *Lithraphidites quadratus*, evidently in his defininition of the upper boundary of the *Arkhangelskiella cymbiformis* zone the 'last' wrongly replaced the 'first'.

(2) In his Figure 4, Wise (1983) defined the top of his *Kamptnerius magnificus* zone by the first appearance datum of *Marthasterites furcatus*. This seems more logical than his definition of the same zone in his text which is followed in the above table.

Table 4A. Correlation of Campanian-Maastrichtian zonal schemes.

Age	Cepek & Hay (1969)	Manivit (1971)	Bukry & Bramlette (1970), Roth (1973), Bukry (1973, 1974)	Risatti (1973)	Verbeek (1976)	Sissingh (1977)	Roth (1978)	Wise (1983) Wind & Wise (1983)
MAASTRICHTIAN	*Nephrolithus frequens*	*Nephrolithus frequens*	*Micula mura*	No data	*Nephrolithus frequens* (A)	*Nephrolithus frequens*	NC 23	No data
	Lithraphidites quadratus	*Lithraphidites quadratus*		*Lithraphidites quadratus*	*Micula mura* (A')	*Arkhangelskiella cymbiformis*	NC 22	
			Lithraphidites quadratus @		*Lithraphidites quadratus*			*Biscutum magnum*
	Chiastozygus initialis	*Tetralithus trifidus*		*Heliorthus concinnus*	*Tetralithus gothicus*	@	NC 21	*Biscutum coronum*
			Tetralithus nitidus	*Ramsaya swanseana*		*Reinhardtites levis* @	NC 20	
				Cribrosphaera circula		*Tranolith phacelosus* @		
CAMPANIAN	(B')					*Tetralithus trifidus*		
	Tetralitus aculeus		*Broinsonia parca* @	*Eurhabdus scotus*			NC 19	
				Ottavianus giannus				
			Eiffellithus eximius	*Munarinus lesliae*				
				Chiastozygus initialis (B)	*Tetralitus aculeus*	*Ceratolithoides aculeus*		
				Tetralithus aculeus				
	Kamptnerius magnificus (in part)	*Arkhangelskiella specillata*		No data	*Broinsonia parca*	*Calculites ovalis* @	NC 18	
						Aspidolithus parcus		*Marthasterites furcatus*
							SANTONIAN see Table 4 B	

Zonal boundaries ——— *Good correlation* – – – *Tentative correlation*

20/WA/24

@ Boundaries based on extinctions; other boundaries are based on lowest occurrences.

(A) The earliest occurrence of *Nephrolithus frequens* Gorka relative to (A') the earliest occurrence of *Micula mura* (Stradner) is according to Verbeek (1976); other workers (eg Gartner *in* Cita & Gartner, 1971) believe that the two events are coeval.

(B-B') Although the definitions of these boundaries are the same in both publications, they are differently placed here; Risatti (1973) indicated that his concept of *Chiastozygus initialis* (Gorka) is different from that of Cepek & Hay (1969)

Table 4B. Correlation of late Cenomanian-Santonian zonal schemes.

Age	Cepek & Hay (1969)	Manivit (1971)	Roth (1973)	Thierstein (1974)	Verbeek (1976)	Manivit & others (1977)	Sissingh (1977)	Roth (78)	Wise (1983)
CAMPANIAN	▲*Kamptnerius magnificus*	*Arkhangelskiella specillata* (C)	*Eiffellithus eximius*	No data	*Broinsonia parca*	No data	*Calculites ovalis* (A)	NC 18	*Biscutum coronum*
							Aspidolithus parcus		*M. furcatus*
SANTONIAN		*Kamptnerus magnificus*	*Gartnerago obliquus* (A)		*Zygodiscus spiralis*		(D) *C. obscurus*	17	
				Marthasterites furcatus	*Micula concava*		*Lucianorhabdus cayeuxii*	NC 16	*Lithastrinus floralis*
			Marthasterites furcatus				*R. anthophorus*		
CONIACIAN	*K. punctatus*	*Marthasterites furcatus*			*Broinsonia lacunosa*		*Micula staurophora*		
	A. ethmopora								
	M. furcatus				*Marthasterites furcatus*		*Marthasterites furcatus*	NC 15	*Thiersteinia ecclesiastica*
TURONIAN	*Tetralithus pyramidus* (E)	*Micula staurophora*	*Micula decussata*	*Kamptnerius magnificus*	*Arkhangelskiella specillata*	*Eiffellithus eximius*	*Lucianorhabdus maleformis* (B)	NC 14	*Kamptnerius magnificus*
				Micula staurophora	*Eiffellithus eximius*			NC 13	No data
		Corollithion exiguum	*Corollithion exiguum*	*Gartnerago obliquum*	*Tetralithus pyramidus*	*Quadrum gartneri*	*Tetralithus pyramidus*		
	C. exiguum				*Gartnerago obliquum*	▲*Lithraphidites acutum*	▲*Microrhabdulus decoratus*		
	▲*Chiastozygus cuneatus*	*Gartnerago obliquus*	▲*Lithraphidites alatus*					CENOMANIAN	
		▲*Staurolithites orbiculofenestrus*		▲*Lithraphidites alatus*	▲*Eiffellitus turriseiffeli*				

Zonal boundaries ——— *Good correlation* – – – *Tentative correlation* - - - - *Very doubtful correlation*

20/WA/25

(A) Boundary based on extinction of *Marthasterites furcatus* (Deflandre); other boundaries are based on lowest occurrences.

(B) Evidence for placing this boundary is the lowest occurrence of *Eiffellithus eximius* (Stover) and not that of *Lucianorhabdus maleformis* Reinhardt (see Sissingh, 1977 page 53)

(C) Definitions of base *A. specillata* zone and top *K. magnificus* zone use different criteria (compare Manivit, 1971 page 43 and 44)

(D) The entire zone has been assigned to the Campanian by its proposer

(E) Interval younger than mid *T. pyramidus* zone is Campanian in age according to Smith (1975); *B. parca* (Stradner) occurs throughout this interval (Cepek & Hay, 1969 Figure 4)

▲ (in part)

Example 1. A sample from Papua New Guinea (MFN-3079, see Appendix A) containing *Broinsonia parca*, *Ceratolithoides aculeus*, the *Reinhardtites anthophorus/R. levis* group, *Quadrum gothicum*, and *Q. trifidum*, is assignable to the interval between the lowest occurrence of *Q. trifidum* and the highest occurrence of *B. parca* (see Table 2). This biostratigraphic assignment is referred to as:

DI:**Quadrum trifidum/+Broinsonia parca.*

This assemblage is readily assignable to a number of zones in Table 3: *Quadrum trifidum* zone (Verbeek, 1977; Doeven, 1983), *Tetralithus gothicus trifidus* zone (Roth & Thierstein, 1972), *Tetralithus nitidus trifidus* zone (Bukry & Bramlette, 1970; Gartner, 1974), *Tetralithus trifidus* (Bukry, 1973b; several other investigators; Sissingh, 1977), and *Uniplanarius trifidus* (Hattner & Wise, 1980; Varol, 1983). Apart from the *Tetralithus trifidus* zone of Sissingh (1977), the other zones are in fact expressions of either the total range of *Q. trifidum* or the biostratigraphic interval between the lowest occurrences of *Q. trifidum* and of *Lithraphidites quadratus*. Either of these is, no doubt, a broader biostratigraphic assignment than the DI designated (for easy comparison consult Table 2).

Example 2. A sample from the type locality of the Korojon Calcarenite, Western Australia (MFN-320, see Appendices A & B), containing the index species *Broisonia parca*, *Calculites obscurus*, *Ceratolithoides aculeus*, *Lucianorhabdus cayeuxii*, *Q. gothicum*, the *Reingardtites anthophorus/R. levis* group and *Petrarhabdus copulatus*, is assignable to either the biostratigraphic interval of the total stratigraphic range of *Quadrum gothicum*, or to the interval between the lowest occurrence of *Quadrum gothicum* and highest occurrence of *Broinsonia parca*. These biostratigraphic assignments are referred to as:

DI:**Quadrum gothicum/+Quadrum gothicum*
or DI:**Quadrum gothicum/+Broinsonia parca.*

This assemblage is readily assignable to a number of zones from Table 3: *Quadrum gothicum* zone (Verbeek, 1977; and others investigators), *Tetralithus aculeus* zone (Manivit, 1971; Roth, 1978), *Tetralithus gothicus* zone (Verbeek, 1976; Perch-Nielsen, 1977; others), *Tetralithus gothicus trifidus* zone (Roth & Thierstein, 1972), *Tetralithus nitidus* zone (Sissingh, 1977), *Tetralithus nitidus trifidus* zone (Bukry & Bramlette, 1970; Gartner, 1974), and *Uniplanarius gothicus* zone (Hattner & Wise, 1980; Varol, 1983). Most of these zones do not cover the same biostratigraphic interval: the lower boundaries of these zones are defined as the lowest occurrence of *Ceratolithoides aculeus*, the highest occurrence of *Eiffellithus eximius*, or mostly as the lowest occurrence of *Quadrum gothicum*; the upper boundaries are defined as the lowest occurrence of *Lithraphidites quadratus*, or of *Quadrum trifidum*. It is worth noting that *Quadrum trifidum* and *Eiffellithus eximius* occur sporadically in the type section of the Korojon Calcarenite from which sample MFN-320 was obtained: *Q. trifidum* has been recorded from levels lower than sample MFN-320, and *E. eximius* has been recorded below and above MFN-327 (see Checklist 7).

UPPER CRETACEOUS CLASTICS IN PERTH AND CARNARVON BASINS

The Perth and Carnarvon Basins straddle the Australian weastern margin (Fig. 1), from the town of Dampier in the north, to the Precambrian Leeuwin Block in the south. The basement Northampton Block separates the two basins. The eastern boundary of the Perth Basin is readily marked by the Darling Fault which coincides with the western edge of the Precambrian Yilgarn Block. More than half of the area of the Perth Basin is offshore. The eastern boundary of the Carnarvon Basin is defined by the sedimentary onlap onto the Precambrian metamorphic and igneous rocks of the Pilbara, Gascoyne and Yilgarn Blocks, the Australian western craton. The western boundary of the Carnarvon Basin is arbitrarily delineated by the edge of the continental shelf.

On a gross scale, the Upper Cretaceous lithological sequence along the Australian western margin (the Perth and Carnarvon Basins) consists of a lower predominantly clastic section and an upper shelf carbonate section. (Correlation and age-assignment of individual lithostratigraphic units are given in Table 1.) The lower clastic section is mostly poorly fossiliferous, with recorded species of little or no value for dating. In sharp contrast, the overlying carbonates are richly fossiliferous.

This part of the study deals with onshore Cretaceous clastic sediments from the Perth and Carnarvon Basins. Until this study, the coccoliths of these sediments were not known.

PERTH BASIN

The clastic unit underlying the famous Gingin Chalk of the Perth Basin is the Molecap Greensand of Fairbridge (1953). In its type locality (Gingin area; see Fig. 4, p. 21), the Molecap Greensand consists of about 8.53 metres (28 feet) of mainly dark greyish green glauconitic sandstone. Feldtmann (1963) recorded a dark reddish brown ferruginous band with phosphatic nodules and rare bone fragments, at the top of the greensand separating it from the overlying chalk. In June 1982, the writer observed several phosphatic nodule beds in the top part of the type section at Molecap Hill (Fig. 4).

The only calcareous nannofossils found in the many samples examined from the Molecap Greensand came from the uppermost phosphatic nodule bed, immediately below the Gingin Chalk. This nodule bed, which probably was formed at the advent of deposition of the Gingin Chalk (discussed in later in the study), yielded a few fragmentary specimens of the long-ranging Upper Cretaceous coccoliths, *Prediscosphaera cretacea, Watznaueria barnesae* and *Eiffellithus turriseiffeli.*

CARNARVON BASIN

STRATIGRAPHY

Marine Upper Cretaceous outcrops in the Carnarvon Basin (Fig. 6, p. 32) are limited to two major areas: the Lower Murchison River area in the south, and the Giralia Anticline in the north. In both areas, a predominantly clastic sequence is succeeded by shelf carbonates, with individual units differing in their details. The clastic unit in the Lower Murchison River area was described and named by Clarke & Teichert (1948), and later amended by Johnstone & others (1958) as the Alinga Formation. The stratigraphically equivalent unit in the Giralia Anticline in the north was described and named by Condon & others (1956) as the Gearle Siltstone.

Alinga Formation

According to Johnstone & others (1958), the type Alinga Formation consists of approximately 12 metres of glauconitic siltstone with a 2.7- metre bed of greensand at its base and much thinner bed of phosphatic nodules at the top. This formation crops out at Alinga Point in the Lower Murchison River area (Fig. 6). It rests conformably on the Lower Cretaceous Thirindine Formation, and underlies disconformably the Toolonga Calcilutite. Although radiolarians, fish remains and some belemnites have been found in the Alinga Formation, the biostratigraphic evidence is inconclusive, and so it tentatively regarded as Albian to Turonian - based on its perceived stratigraphic position (McWhae & others, 1958).

Material examined from the Alinga Formation in the present study came from three outcrops in the Lower Murchison River area: at Alinga Point (type section, sampled by the writer), Toolonga Point, and Pillarawa Hill (Fig. 6); see Appendix A for sample details.

Comment. Evidence presented below suggests that the phosphatic nodule bed (referred to above as being at the top of the Alinga Formation, according to Johnstone & others, 1958) should be regarded as the base of the overlying Toolonga Calcilutite.

Gearle Siltstone

The type section of the Gearle Siltsone is at C-Y Creek, on the western side of the Giralia Anticline (Fig. 8, p. 34), where "only the uppermost part of the formation is well exposed" (Condon, 1968, p. 27). The formation is essentially a sequence of dark bentonitic siltstone, claystone, and shale with primary barites and secondary gypsum - conformably overlying the Lower Cretaceous Windalia Radiolarite, in its reference section close to Remarkable Hill, Giralia Anticline (Condon, 1968).

The Gearle Siltstone ranges in thickness from 137 to slightly over 160 metres in the Giralia Anticline, but greater thicknesses have been reported in the Rough Range area to the north (e.g. about 585 metres in Rough Range #1 well, McWhae & others, 1958) where the formation has been differentiated into two distinct lithologies: a thick lower part of dark shale, and a relatively thin upper part consisting of calcareous claystone. Brown & others (1968) considered that the Lower/Upper Cretaceous boundary lies at the contact between these two parts of the Gearle Siltstone.

Radiolarians, ostracods, foraminiferids and non-calcareous microplankton have been found in outcrop samples of the Gearle Siltstone. Belford (1958) indicated that foraminiferids are rare in outcrop samples, and that arenaceous forms predominate. No planktic forms were recorded, and it was not possible to date the assemblages from the outcropping Gearle Siltstone. Based on an assemblage containing the planktic form *Globotruncana* (*Praeglobotruncana*) *delrioensis* in a core sample from the subsurface of the Rough Range area, Belford (1958) considered the age of the lower part of the formation as Albian. Foraminiferal assemblages from the upper part of the formation (=the Beedagong Claystone of this study, see below), not known from the outcropping Gearle Siltstone, included several planktic elements which were regarded by Belford (1958) as late Cenomanian. This age assignment was later revised to early and middle Turonian (see Belford & Scheibnerova, 1971).

Belford (1958) indicated that a Campanian foraminiferal assemblage with several planktic forms, recorded by Edgell (1952) and cited by Condon & others (1956) as from the top of the outcropping Gearle Siltstone, was incorrectly placed; the assemblage apparently came from the overlying carbonates.

An Albian to Turonian age has generally been adopted for the Gearle Siltstone (see Playford & others, 1975).

Remarks. Division of the Gearle Siltstone into upper calcareous claystone and lower dark shale units has been accomplished mainly in subsurface sections where the formation is very thick (e.g. Rough Range area). The upper calcareous unit seems to be absent in relatively thin subsurface occurrences of the formation, and in surface exposures in the Giralia Anticline it is either lacking or very poorly exposed being condensed. Where the two units could be recognised, they have been informally referred to as 'upper' and 'lower' Gearle Siltstone, whereas the undifferentiated sequence of the formation is simply referred to as the Gearle Siltstone. The 'upper Gearle Siltstone' has been identified in several drillholes in the Giralia Anticline, Rough Range, and Exmouth Gulf areas.

The present study recognises the 'upper Gearle Siltstone' as an independent lithostratigraphic unit, more allied to the carbonates above than to the underlying shales of the Gearle Siltstone. The new name Beedagong Claystone is proposed for this unit and will be discussed in a later section of this study.

According to Condon (1968) the Alinga Formation seems to grade laterally into the Gearle Siltstone. Earlier, McWhae & others (1958) used the stratigraphic position of the Alinga Formation to correlate it with part of the Gearle Siltstone. The marine fossils (including belemnites) known to occur in outcrops of both the Gearle Siltstone and Alinga Formation are of no apparent biostratigraphic value according to McWhae & others (1958) and Condon (1968).

COCCOLITH DISTRIBUTION IN ALINGA FORMATION AND ITS SIGNIFICANCE

Type section (at Alinga Point)

Very rare coccolith specimens of *Watznaueria barnesae* have been found only in some samples from the type section of the formation; other samples in the same section are devoid of coccoliths. The occasional specimen/fragment of *Watznaueria barnesae* may be *in situ* or possibly, represent contamination from the overlying Toolonga Calcilutite. A mechanism for contamination from the highly fossiliferous Toolonga Calcilutite is by percolating water. *Watznaeria barnesae* is common to abundant in all samples studied from the Toolonga Calcilutite in the same outcrop at Alinga Point. The writer's field experience confirmed that it is extremely difficult to obtain a "clean" sample of Alinga Formation especially from its upper part. The reason for this is a commonly occurring thin chalky film between the clay laminae of the upper part of the Alinga Formation; the chalky film is presumably from the overlying Toolonga Calcilutite, precipitated by percolating waters.

On the other hand, specimens of *Watznaueria barnesae* found in Alinga Formation could be *in situ* as a residual species, after severe dissolution. This species has been included among the more resistant species to diagenetic processes including dissolution by percolating (acidic) waters, and is often common in residual assemblages.

A sample from the phosphatic nodule bed between the Alinga Formation and the overlying Toolonga Calcilutite at Alinga Point was found to contain a rich coccolith assemblage, though preservation is not particularly good. Most specimens are recrystallised, and some are overgrown with secondary calcite. However, most species were readily identifiable. These included *Arkhangelskiella* spp., *Cretarhabdus surirellus*, ?*Cyclindralithus biarcus*, *Eiffellithus eximius*, *E. trabeculatus*, *Gartnerago obliquum*, *Kamptnerius magnificus*, *Manivitella pemmatoidea*, *Microrhabdulus belgicus*, *M. helicoideus*, *Prediscosphaera cretacea*, *P. spinosa*, *Reinhardtites biperforatus* and *Watznaueria barnesae*. The association of the key species *Eiffellithus eximius*, *Kamptnerius magnificus*, and *Reinhardtites biperforatus* suggests a late Coniacian to early Santonian age.

Pillarawa Hill section

Coccoliths have not been found in the uppermost (exposed) part of the Alinga Formation at Pillarawa Hill, Lower Murchison River area. However, a sample (MFN-253; Checklist 6) from the nodule bed between the Alinga Formation proper and the overlying Toolonga Calcilutite yielded a moderately diversified assemblage. This included *Ahmuellerela octoradiata*, *Braarudosphaera discula*, *Chiastozygus fessus*, *Biscutum melaniae*, *Cretarhabdus conicus*, *C. surirellus*, *Eiffellithus eximius*, *E. turriseiffeli*, *Gartnerago obliquum*, *Lithraphidites* sp., *Manivitella pemmatoidea*, *Microrhabdulus helicoideus*, *Stephanolithion laffittei*, *Reinhardtites biperforatus*, *Rhagodiscus splendens* and *Zygodiscus bicrescenticus*. A late Coniacian to early Santonian age is assigned to this assemblage.

Toolonga Point section

At Toolonga Point, the lower half of the Alinga Formation is totally barren of coccoliths, whereas the upper half includes two thin beds bearing some poorly preserved coccoliths, which are probably *in situ*. The assemblages from these two beds consist of *Watznaueria* spp. (including the long-ranging *W. barnesae*) predominating over rare (i.e. mostly single specimens) *Braarudosphaera* sp. cf. *B. africana*, *Chiastozygus fessus*, *Cretarhabdus surirellus*, *Eprolithus floralis*, *Haqius circumradiatus*, *Lithraphidites* sp., *Manivitella pemmatoidea*, *Quadrum gartneri*, *Parhabdolithus embergeri*, *Prediscosphaera cretacea*, *P. spinosa* and a small *Vekshinella* sp..

The occurrence of *Quadrum gartneri*, *Eprolithus floralis* and *Prediscosphaera spinosa*, and the absence of younger species such as *Kamptnerius magnificus* and *Eiffellithus eximius* suggest an early Turonian age.

Remarks. The reduced diversity of the assemblage from the Toolonga Point section and the rarity of its individual species, as compared with the assemblages from the nodule bed in both the Alinga Point and Pillarawa Hill sections, are probably due to differences in these sites initial accessibilty to the open sea and to differences in diagenetic effects. Better access to the open sea during the deposition of the nodule bed at the Pillawarra Hill and Alinga Point sites, permitted an influx of more calcareous nannoplanktic flora, most likely during a new sedimentation regime.

The distribution of coccoliths in the Alinga Formation (Toolonga Point section) is sporadic, but an up-section increase of these fossils could be detected. The lower half of the formation is devoid of coccoliths, and its upper half contains the occasional meagre assemblages. In contrast, the phosphatic nodule bed between the formation and the Toolonga Calcilutite contains richer and more diversified assemblages, similar to those in the Toolonga Calcilutite (detailed later). The pattern of coccolith distribution in the Alinga Formation is the result of two opposing factors: (i) accessibility to open-sea conditions to support an increasing coccolith abundance and diversity in time and, (ii) the destructive influence of diagenesis reducing both the abundance and diversity of the coccoliths. It would appear that access to the open sea was only possible during the deposition of the later part of the formation, and then only intermittently; deposition in shallow waters is suggested by the occurrence of species such as *Braarudosphaera* sp.. Good connection with the open sea on permanent basis seems to have commenced during the deposition of the nodule bed and continued through the sedimentation of the Toolonga Calcilutite (discussed later).

The phosphatic nodule bed, in both the Alinga Point and Pillarawara Hill sections, contains the same key species: *Ahmuellerella octoradiata*, *Eiffellithus eximius*, *Gartnerago obliquum*, *Microrhabdulus helicoideus*, *Micula staurophora* and *Reinhardtites biperforatus*; these collectively suggest a late Coniacian to early Santonian age. The coccolith assemblages from the upper half of the Alinga Formation include elements suggestive of an early Turonian age. A disconformity is thus indicated between the Alinga Formation and the nodule bed.

In their description of the Alinga Formation, Johnstone & others (1958) placed this nodule bed at its top. However, in view of the large age difference between the nodule bed and the underlying siltstones, and also the large difference in coccolith diversity, it is concluded that this nodule bed should **not** be considered as representing the top of Alinga Formation. The evidence presented in a later part of this study indicates no significant age difference between this nodule bed and the overlying Toolonga Calcilutite. Coccolith diversity in both the nodule bed and the Toolonga Calcilutite is comparable. This supports the writer's contention regarding the nodule bed as the base of the Toolonga Calcilutite.

COCCOLITH DISTRIBUTION IN GEARLE SILTSTONE AND SIGNIFICANCE

The type section of the Gearle Silstone (C-Y Creek, Giralia Anticline) is mostly devoid of coccoliths except for a few poorly preserved species recovered from a bed of soft dark siltstone within the upper part of the section. These coccoliths included *Eprolithus floralis*, *Haqius circumradiatus*, *Lithraphidites* sp., ? *Micula staurophora*, *Prediscosphaera cretacea*, *Watznaueria barnesae*, and *Reinhardtites* sp.. Dominant species are *W. barnesae* and *E. floralis*; other species are extremely rare. The comparatively limited diversity of the coccoliths is apparently due to diagenetic removal by percolating water (slightly acidic, H2SO4 from the pyrite in the formation); all coccolith specimens recovered are extremely etched. Nevertheless, the evidence from other outcrops of the Gearle Siltstone seems to suggest that initially the coccoliths were scarce. This is probably related mainly to the depth of deposition, proximity and accessibility to the open sea. Based on lithological and other palaeontological grounds, it is suggested that the Gearle Siltstone was deposited in a very shallow environment which had an intermittent access to open-sea conditions. Foraminiferal evidence of almost exclusively arenaceous forms (Belford, 1958), suggests deposition in an environment largely incapable of supporting calcareous microplankton life: shallow water body with restricted circulation.

The 'lower Gearle Siltstone' in several WAPET wells yielded meagre coccolith assemblage, similar to that from the type material of the formation. Dominant species are *Watznaueria barnesae* and *Eprolithus floralis.*

Remarks. Unlike the Gearle Siltstone and Alinga Formation, the stratigraphically equivalent unit (Molecap Greensand) in the Perth Basin is totally barren of coccoliths. This is significant because most investigators of the Australian Cretaceous regard these units as correlatives, particularly the Molecap Greensand (Perth Basin) and Alinga Formation (Carnarvon Basin) (see Table 1).

With marine conditions being more evident in the north (Alinga Point, Carnarvon Basin) than in the south (Molecap Hill, Perth Basin), it is not unreasonable to conclude that connection with the open sea along the Australian western margin during the deposition of the Cretaceous clastic units Gearle Siltstone, Alinga Formation and Molecap Greensand was from a northerly direction.

Marine conditions occurring along the Australian western margin in both the north (Alinga Point) and south (Molecap Hill) became similar during the formation of the nodule bed separating either the Alinga Formation or the Molecap Greensand from the (fully-marine) carbonates above.

DISCUSSION

During the Late Cretaceous a number of factors combined to bring a major change in depositional pattern along the continental western margin of Australia: from a predominantly terrigenous deposits to carbonates virtually lacking terrigenous components. High onshore relief, caused by Jurassic tectonism, was largely eroded away during the Early Cretaceous. Subsidence of a near-peneplained margin, about a hinge (chiefly the Darling Fault system), continued, and in combination with a major transgression during the early Senonian, effectively caused a change in the pattern of deposition to shelf carbonates with little or no terrigenous input.

UPPER CRETACEOUS CARBONATES IN PERTH BASIN

Little is known about the calcareous nannofossils of the Upper Cretaceous carbonates of the onshore Perth Basin. Published results by Deflandre (1959) and Thierstein (1974, 1976) include records of a few coccolith species from this sequence. Shafik (1978b) detailed Santonian nannofossil assemblages from the Perth Basin.

Until this study, Upper Cretaceous sediments containing calcareous microplanktic remains younger than the early Campanian were not known on the onshore of this basin.

STRATIGRAPHY

Upper Cretaceous sediments known to contain calcareous microfossils occur in the Perth Basin in two main areas: around the towns of Gingin and Lancelin, approximately 70 Km north and 110 Km northwest of Perth respectively (Fig. 3). These sediments are mainly chalk and marls. In the Gingin area, they were described and named by Glauert (1910) as the Gingin Chalk, and in the Lancelin area, they were informally referred to as the Lancelin Beds by Edgell (1964). A third carbonate unit, occurring in the subsurface of the Lancelin area, is differentiated in the present study, and informally named the Breton Marl.

GINGIN CHALK

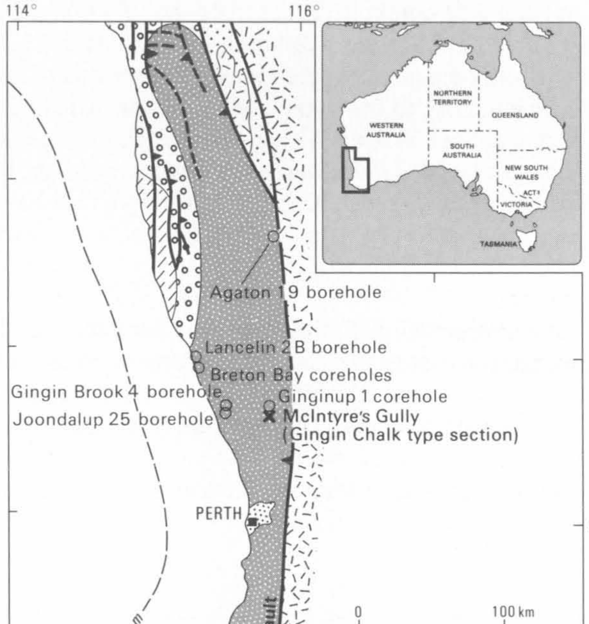
Outcrops of the Gingin Chalk (Glauert, 1910) in its type area show that the formation constitutes a middle unit in an apparently paraconformable sequence of three units belonging to the Coolyena Group of Cockbain & Playford (1973). The Molecap and Poison Hill Greensands of Fairbridge (1953) constitute the lower and upper units respectively in this paraconforamble sequence. The Gingin Chalk consists of mainly fine-grained chalks and marls and its contacts with these greensands are gradational in its type section, but abrupt in most other sections.

The Gingin Chalk has attracted a number of workers with diversified interests (e.g. Etheridge, 1913; Chapman, 1917; Withers, 1924, 1926; Spath, 1926; Feldtmann, 1951, 1963; Elliott, 1952; Glaessner, 1957; Belford, 1958, 1960; Neale, 1975; Shafik, 1978b). Contributions by these investigators are based on a spectrum of fossil groups which until recently (Shafik, 1978b), did not include coccoliths, even though Chapman (1917) recorded (in the fine fraction of washed samples) "flattened shirt-studs" which he referred to as coccoliths.

Shafik (1978b) reported on the coccoliths of outcrops of the Gingin Chalk in its type area, and a proposed a coccolith zone for the Santonian, based on the association of the key species *Calculites obscurus*, *C. ovalis*, *Lucianorhabdus cayeuxii* and *L. maleformis*. Apart from Shafik's (1978b) work, a few references to the coccoliths of the Gingin Chalk are noted in the literature: Deflandre (1959) figured a specimen of *Lucianorhabdus cayeuxii*, and Thierstein (1974, 1976) noted the occurrence of *Kamptnerius magnificus*, *Lucianorhabdus cayeuxii*, *Tetralithus obscurus* (=*Calculites obscurus*) and *T. ovalis* (=*Calculites ovalis*) in a sample from the Gingin Chalk. Thierstein (1977) assigned a Santonian age for four Gingin Chalk samples from the type area.

In relation to the standard (European) Cretaceous, the age of the outcropping Gingin Chalk in the type area has long been established as Santonian. This was based on the occurrence of plates

Figure 3. Location map showing the studied localities in the Perth Basin.



of the crinoid genera *Marsupites* and *Uintacrinus* (Withers, 1924, 1926). This early view has been adopted in several subsequent palaeontological studies (e.g. Neale, 1975), and has been supported by other independent evidence. Planktic foraminiferal analyses by Belford (1958, 1960) confirmed the Santonian age (see also Herb, 1974). The main elements of the foraminiferal fauna reported by Belford (1960) include the *Globotruncana lapparenti* group, *G. marginata*, *G. ventricosa*, *Bolivinoides strigillata strigillata* and *Rugoglobigerina (R.) piluta*.

Playford & others (1975, p. 251) adopted the Santonian age for the Gingin Chalk, but suggested a "possibility that the upper part of the formation extends into the Campanian". Ingram & Cockbain (1978) assigned half of a subsurface section in the Gingin area to the Campanian.

Material examined from the Gingin Chalk came from several outcrops and subsurface sections in the type area (Gingin), Lower Moore River, Lancelin and Watheroo areas (Fig. 3); see Appendix A for sample details.

LANCELIN BEDS

Edgell (1964) informally introduced the name "Lancelin Beds" for the Upper Cretaceous carbonates in Lancelin #2B borehole (Lat. 31° 04' 00" S - Long. 115° 19' 20" E; Fig. 3). These beds - seemingly not totally penetrated in Lancelin #2B borehole - consist of 13.7 metres of light grey marls becoming slightly darker and dominantly glauconitic near top, with fragments of *Inoceramus* occurring throughout. Edgell (1964) assigned a Campanian age to the type Lancelin Beds on account of the occurrence of the planktic foraminiferal species *Globotruncana marieri*, *G. ventricosa*, *G. globigerinoides*, and the benthic foraminiferal fauna *Bolivinoides granulatus* and *Neoflabellina praereticulata*. Based on a coccolith evidence in the present study, a correlation between the Lancelin Beds and the Campanian Gingin Chalk was not possible; the two units are non-correlatives. The informal name "Lancelin Beds" is retained in spite of some lithological resemblance between type material from the Gingin Chalk and Lancelin Beds.

Unlike the Gingin Chalk, the Lancelin Beds do not crop out and are known only from drillholes. The stratigraphic relationship between the Lancelin Beds and the Gingin Chalk has not previously been evaluated, because the two units were exclusively known in separate areas. The present study identified the Lancelin Beds overlying the Gingin Chalk in the Breton Bay #1 corehole, thus establishing their stratigraphic relationship.

Material studied from the Lancelin Beds came from two drillholes (Breton Bay #1 corehole and Joondalup #25 borehole), in addition to Lancelin #2B borehole.

BRETON MARL

Hitherto, Maastrichtian sediments containing calcareous microfossils were unknown in the Perth Basin. The present study recorded Maastrichtian coccoliths from the upper part of the Upper Cretaceous carbonate section penetrated in the Lancelin area. This section in Breton Bay #1 corehole is identified here as consisting of three units: the Gingin Chalk (at the bottom), the Lancelin Beds and a new upper Maastrichtian unit, the (informally named) Breton Marl (at the top).

The type section of the Breton Marl is in Breton Bay #1 corehole (Lat. 31° 10' 36" S - Long. 115° 24' 06" E; Fig.3) and consists of mainly soft marl. It is relatively thin, being less than six metres thick, and is represented in this study by five cores. The underlying Lancelin Beds in Breton Bay #1 corehole is about 60 metres thick.

Material studied from the Breton Marl also includes four core samples from Breton Bay #5 corehole.

MATERIAL EXAMINED, COCCOLITH DISTRIBUTION AND SIGNIFICANCE

A brief description of each of the stratigraphic sections examined is given below; sample levels and other details are given in Appendix A. Coccolith distribution data presented in Checklists 1-4 (Appendix B) is based chiefly on optical micrscopy. Scanning electron microscopic examination of selected assemblages were undertaken mainly for taxonomic considerations.

GINGIN CHALK OUTCROPS IN TYPE AREA

Several outcrops of the Gingin Chalk in the Gingin area (Fig. 4) have been studied including the type section.

McIntyre's Gully outcrops (Gingin Chalk type section)

The type section is located at McIntyre's Gully, (Lat. 31° 19' S - Long. 115° 54' E; Fig. 4), on the "Strathalbyn" property, some 2.5 Km north of the town of Gingin. The exposures of the type Gingin Chalk (along McIntyre's Gully) are discontinuous, and the contacts with the underlying and overlying greensands (the Molecap and Poison Hill Greensands) are transitional. The lower part of the chalk is increasingly glauconitic towards the base, and similarly the upper part of the chalk becomes progressively glauconitic towards the top of the formation. The exact positions of the contacts with the underlying and overlying greensands are difficult to determine in the field, and are usually arbitrary determined. A total thickness of about 21 metres of mainly chalks and marls was sampled at McIntyre's Gully by the writer in June, 1983.

Figure 4. Location map showing the studied localities in the Gingin area, Perth Basin.

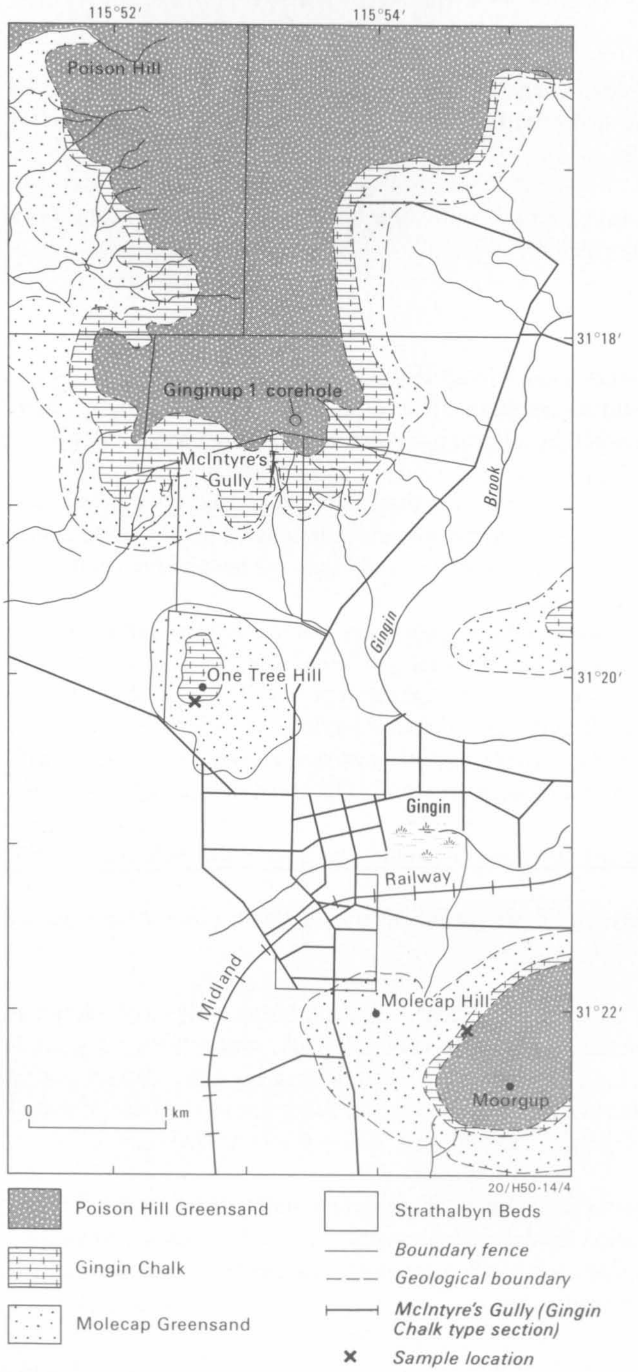


Table 5. Coccolith biostratigraphic summary of McIntyre's Gully section (type Gingin Chalk).

POISON HILL GREENSAND: no coccoliths

----------------------+ALL COCCOLITHS-------21.5 m

Preservation is only fair. Key species include _Broinsonia dentata, B. parca_ and related forms, _Eiffellithus eximius, Gartnerago obliquum, Micula concava, Reinhardtites anthophorus_ and _Tranolithus orionatus._ The hemipelagic species, _Acuturris scotus, Calculites obscurus, C. ovalis, Lucianorhabdus cayeuxii_ and _L. maleformis_ are present. Species prefering high-latitude conditions such as _Biscutum coronum_ and _Kamptnerius magnificus_ are also present.

---------------------*_Broinsonia parca_------------20.5 m

Rich assemblages including all key species present below with the addition of _Calculites obscurus_; morphotypes approaching _Broinsonia parca_ occur in the upper part. _Marthasterites furcatus, Lapideacassis cornuta_ and _Ottavianus giannus_ are sporadic.

---------------------*_Calculites obscurus_-----------5.1 m

Several key species are present: _Acuturris scotus, Broinsonia dentata_ and several other _Broinsonia, Calculites ovalis, Lithastrinus grillii, Lucianorhabdus cayeuxii, L. maleformis, Micula concava, Reinhardtites anthophorus_ and _R. biperforatus. Eiffellithus eximius, E. trabeculatus_ and _Gartnerago obliquum_ are also present. _Marthasterites furcatus_ and _Ottavianus giannus_ are more frequent than above. Sporadic _Boletuvelum_ spp., _Lapideacassis mariae_ and _Russellia laswelli_ are notable.

---------------------*_Lucianorhabdus cayeuxii_-----0.0 m

MOLECAP GREENSAND: no coccoliths

***Lowest occurrence** **+Highest occurrence**

figures are levels in metres from base of the chalk

Microfossil successions of the type Gingin Chalk section have not been reported upon previously. Results on macrofossils including some crinoids, particularly useful in biostratigraphic correlations, have been published (e.g. Withers, 1924, 1926). The European *Uintacrinus* and *Marsupites* zones, indicating Santonian age, have been identified by Feldtmann (1963) in the lower 6.1 m of the Gingin Chalk type section (see Fig. 5).

The type Gingin Chalk is rich with coccoliths, in sharp contrast with the underlying Molecap Greensand which is totally devoid of these fossils. The lowest occurrence of coccoliths in the McIntyre's Gully section is taken to indicate the base of the type Gingin Chalk. This is found to be in good agreement with the writer's field determination of this base.

Coccolith distribution in the Gingin Chalk type section is given in Checklist 1, and a biostratigraphic summary is presented in Table 5.

Key coccolith species identified among the lowest assemblages in the type Gingin Chalk section include *Acuturri scotus*, *Broinsonia dentata*, *Calculites ovalis*, *Lucianorhabdus cayeuxii*, *Micula concava*, *Marthasterites furcatus*, and *Reinhardtites anthophorus*; some other *Broinsonia* spp. including *B. handfieldi*, and *B. expansa*, and the new species *B. pseudoparca*.

The lowest occurrence of *Calculites obscurus* is approximately 5.1 metres above the base of the formation - in the upper part of the Santonian crinoid *Marsupites* zone as determined previously by Feldtmann (1963). *Broinsonia parca* is restricted to the top metre of the type Gingin Chalk.

The entry of the marker *Broinsonia parca* is taken to indicate the base of the Campanian. This biostratigraphic event marks the base of the Bermudan Stage (Bukry, 1973c).

Molecap Hill outcrops

The base of the Gingin Chalk is particularly well exposed at Molecap Hill (Lat. 31° 22' S - Long. 115° 54' E; Fig. 4), but the unit itself does not exceed 4.5 metres in thickness there. The Molecap Greensand/Gingin Chalk contact is sharp, and according to Feldtmann (1963) it is marked by a ferruginous band containing phosphatic nodules.

Feldtmann (1963) assigned the entire chalk outcrop at Molecap Hill to the Santonian crinoid *Uintacrinus* and *Marsupites* zones (see Fig. 5), and indicated that the ranges of the diagnostic species of these two zones overlap in this outcrop over the interval between 76 cm (2 feet 6 inches) and 96 cm (3 feet 2 inches) from the base of the chalk.

Field observations by the writer included the occurrence of several phosphatic nodule beds within the top 2-metre interval of the Molecap Greensand at Molecap Hill and Molecap Quarry. These beds, which are similar in appearance to the overlying Gingin Chalk, are barren of coccoliths except their uppermost bed where a meagre assemblage was identified, comprising very rare specimens/fragments of *Prediscosphaera cretacea*, *Watznaueria barnesae*, *Eiffellithus turriseiffeli*, and questionable *Cretarhabdus conicus* and *Zygodiscus bicrescenticus*. Coccolith distribution in samples collected from Molecap Hill and Molecap Quarry is given in Checklist 2.

The basal Gingin Chalk at Molecap Hill and Molecap Quarry contains abundant coccoliths including several key species: *Acuturris scotus*, *Lucianorhabdus cayeuxii* and *Kamptnerius magnificus* are abundant, and *Calculites obscurus* is rare; *Reinhardtites anthophorus*, *Tranolithus orionatus*, *Microrhabdulus helicoideus Broinsonia expansa* and *B. pseudoparca* are present (Checklist 2).

That *Calculites obscurus* was found at the base of the chalk at Molecap Hill and Molecap Quarry but not at McIntyre's Gully where the species first appears at 5.1 metres above the base of the chalk, supports the suggestion advanced by Feldtmann (1963) that some of the basal chalk at McIntyre's Gully is missing from the section at Molecap Hill. However, the same evidence seems to point to a possible condensed sequence of the basal chalk at Molecap Hill.

The coccolith assemblage recovered from the top part of the Gingin Chalk (immediately below the soil level) at Molecap Hill is largely similar to the assemblages identified from the remaining part of the formation - containing *Calculites obscurus*, *C. ovalis*, *Kamptnerius magnificus*, *Lucianorhabdus cayeuxii*, *Lucianorhabdus maleformis*, *Reinhardtites biperforatus*, *R. anthophorus*, and *Gartnerago obliquum*.

One-Tree Hill outcrop

Five samples were studied from the quarry at One-Tree Hill in the type area of the Gingin Chalk (Fig. 4). They contain similar coccolith assemblages (Checklist 2), characterised by the presence of the biostratigraphic key species, *Calculites obscurus, C. ovalis, Kamptnerius magnificus, Lucianorhabdus cayeuxii, L. maleformis* and *Reinhardtites anthophorus*, which suggests a correlation with the chalk at Molecap Hill.

Remarks. The evidence from the Molecap Hill outcrop as well as from the type Gingin Chalk indicates that the lowest occurrence of *Calculites obscurus* is late Santonian in age. This species first appears in the Gingin Chalk type section in the upper part of the Santonian crinoid *Marsupites* zone.

The presence of the hemipelagic species *Acuturris scotus, Calculites obscurus, C. ovalis, Kamptnerius magnificus, Lucianorhabdus cayeuxii* and *L. maleformis* in the outcrops of the Gingin Chalk in its type area indicate deposition in a nearshore or shelf environment.

Similar conclusions regarding the age and depositional environment of the Gingin Chalk outcrops of the type area were reached by Shafik (1978b).

SUBSURFACE GINGIN CHALK IN TYPE AREA

Ginginup #1 corehole

This corehole - sited on Mount Ginginup (Lat. 31° 19' 00" S - Long. 115° 54' 15" E; Fig. 4) -is about 3.5 Km north of the town of Gingin, and about one Km from the type section of the Gingin Chalk. Continuous coring recovered 21.18 metres of Gingin Chalk between 53.57- and 74.75-metre levels in Ginginup #1 corehole, a similar thickness to that of the type section.

Ingram & Cockbain (1978) discussed the stratigraphy of Ginginup #1 corehole and presented its non-calcareous microplankton biostratigraphy. They assigned the Gingin Chalk to the microplanktic local zones of *Deflandrea cretacea* and *Nelsoniella aceras*, which were given a Santonian-Campanian age (based on a coccolith evidence in an unpublished report by the writer). According to Helby & others (1987), the stratigraphic range of *Nelsoniella aceras* is late Santonian to early Campanian.

Coccolith distribution in the Gingin Chalk of the Ginginup #1 corehole is given in Checklist 3, and a biostratigraphic summary is presented in Table 6.

The basal coccolith assemblage from the Gingin Chalk in Ginginup #1 corehole is well preserved and diversified. It contains the index species *Marthasterites furcatus, Kamptnerius magnificus, Micula concava, Broinsonia dentata, Lithastrinus grillii, Eiffellithus trabeculatus, Cribrosphaerella* circula *and* Reinhardtites *anthophorus*. The other key species, *Acuturris scotus, Calculites ovalis, Lucianorhabdus cayeuxii* and *L. maleformis*, make their first up-sequence appearance less than one metre above the base of the chalk; and the lowest occurrence of *Calculites obscurus* is one more metre higher up in the section. Assemblages from the top 9.5 metres

Table 6. Coccolith biostratigraphic summary of Ginginup #1 corehole.

POISON HILL GREENSAND: no coccoliths

------------------------+ALL COCCOLITHS---53.57 m

Assemblages similar to below. Sporadic *Lapideacassis* spp. encountered throughout the chalk.

------------------------+*Marthasterites furcatus*----60 m

Assemblages are highly diversified, including *Broinsonia dentata, B. parca* and related forms, *Eiffellithus eximius, E. trabeculatus, Gartnerago obliquum, Kamptnerius magnificus, Micula concava, M. staurophora, Prediscosphaera* spp., *Reinhardtites anthophorus, Tranolithus orionatus, Zygodiscus deflandrei* and *Z. bicrescenticus*. Also the pentalith *Braarudosphaera bigelowii* and the holococcoliths *Acuturris scotus, Calculites obscurus, C.ovalis, Lucianorhabdus cayeuxii* and *L. maleformis* are present. *Marthasterites furcatus* occurs sporadically.

------------------------***Broinsonia parca*-----------65 m

Assemblages include all key species present below, with the addition of *Calculites obscurus* and *Cribrosphaerella circula*. The hemipelagic species *Munarinus keedyi* and *Ottavianus giannus* are present.

------------------------***Calculites obscurus*--------73 m

Similar to below with the addition of *Acuturris scotus, Calculites ovalis, Lucianorhabdus cayeuxii* and *L. maleformis*. *Eiffellithus trabeculatus* is rare

------------------------***Lucianorhabdus cayeuxii*--74 m

Diversified assemblage including several marker species: *Lithastrinus grillii, Marthasterites furcatus, Micula concava, Reinhardtites anthophorus* and *R. biperforatus*. Several species of *Broinsonia* including *B. dentata* are present. *Eiffellithus trabeculatus* is particularly abundant. Species prefering high latitudes, e.g. *Biscutum coronum* and *Kamptnerius magnificus*, are also present.

--------------------***Reinhardtites anthophorus*-74.75 m

MOLECAP GREENSAND: no coccoliths

***Lowest occurrence** **+Highest occurrence**

contain *Broinsonia bukryi* n.sp., *B. expansa*, *B. parca*, *Eiffellithus eximius* and *Tranolithus orionatus*. *Marthasterites furcatus* ranges up to about 5 metres below the top of the chalk.

SUBSURFACE CARBONATE SEQUENCE IN THE LANCELIN AREA

Lancelin #2B borehole (type section of the Lancelin Beds)

This borehole is located near the coastal town of Lancelin (Fig. 3), at Lat. 31° 04' 00" S - Long. 115° 19' 20" E. Three samples from the type material of the Lancelin Beds were examined. Coccolith distribution in them is given in Checklist 3. Among the species identified, *Acuturris scotus, Biscutum magnum, Broinsonia parca, Eiffellithus eximius, Calculites obscurus, Kamptnerius magnificus, Lucianorhabdus cayeuxii, Misceomarginatus pleniporus, Gartnerago obliquum* and the *Reinhardtites anthophorus/levis* group, are thought be important for correlation. *Biscutum magnum* and *Misceomarginatus pleniporus* are very rare, but the other key species are abundant.

The age is thought to be late Campanian on account of the association of *Biscutum magnum, Broinsonia parca* and *Misceomarginatus pleniporus*.

Breton Bay #1 corehole (type section of the Breton Marl)

Continuous coring at Breton Bay (about 18 Km south of the town of Lancelin, Fig. 3) recovered more than 72 metres of Upper Cretaceous carbonates above the Molecap Greensand in Breton Bay #1 corehole (Lat. 31° 10' 36" S - Long. 115° 24' 06" E), between the 27.5- and 100.1-metre levels. This carbonate section is more than three times the thickness of the Gingin Chalk in its type area (which is about 21 metres in the type section or Ginginup #1 corehole). These carbonates are identified herein as the Gingin Chalk, Lancelin Beds and the (new) Breton Marl at the top.

Coccolith distribution in the carbonate section of Breton Bay #1 corehole is given in Checklist 4 and summaries of biostratigraphic results are presented in Tables 7 and 8.

A) Santonian-Campanian

Coccolith assemblages from the basal part of the Gingin Chalk in the Breton Bay #1 corehole are poorly preserved, showing signs of dissolution and advanced recrystallisation. The assemblage from the 100-metre level already contains the key species *Acuturris scotus, Calculites obscurus, C. ovalis, Broinsonia dentata, Eiffellithus eximius, Gartnerago obliquum, Lucianorhabdus cayeuxii, L. maleformis, Reinhardtites anthophorus, R. biperforatus, Kamptnerius magnificus, Tranolithus gabalus* and *T. orionatus*. Assemblages from only five metres higher up (at the 95-metre level which is at the base of the Lancelin Beds) include the index species *Broinsonia parca, Misceomarginatus pleniporus* and *Monomarginatus quaternarius*; *Lapideacassis* spp. were encountered, but in a few numbers. The key species *Biscutum magnum* occurs at the 87-metre level in very few numbers, but increases in abundance higher up in the section. The other key species *Monomarginatus pectinatus* has its up-sequence

Table 7. Coccolith biostratigraphic summary of Santonian-Campanian carbonates of Breton Bay #1 corehole.

Maastrichtian assemblages (see Table 8).

------------**Cribrosphaerella daniae*---------------51 m

Late Campanian highly variable assemblages: Although *Broinsonia parca* and *Reinhardtites anthophorus/R. levis* group are abundant and persistent, other key species such as *Biscutum magnum, Monomarginatus quaternarius, M. pectinatus, Misceomarginatus pleniporus* and *Quadrum gothicum* are mostly rare and sporadic; *M. quaternarius* is persistent only in lower part. *Ceratolithoides aculeus* occurs at two horizons. *Eiffellithus eximius* is present, though less common than below. *Marthasterites furcatus* occurs (?reworked) at one horizon. Hemipelagic species are common in most levels.

------------**Reinhardtites levis s.l.*-----------------95 m
**Monomarginatus quaternarius*
**Broinsonia parca*
A BIOSTRATIGRAPHIC DISCONTINUITY(1)

----------- +*Tranolithus orionatus*------------------99 m

Late Santonian assemblages including *Acuturris scotus, Calculites obscurus, Eiffellithus eximius, Gartnerago obliquum, Kamptnerius magnificus, Lucianorhabdus cayeuxii,L.maleformis,Reinhardtites anthophorus, R. biperforatus* and *Tranolithus orionatus*. Some forms approaching *Broinsonia parca* are also present.

------------**Calculites obscurus*------------------100 m

top of **Molecap Greensand** is at 100.1 metre

***Lowest occurrence** **+Highest occurrence**

(1) A sampling gap of 4 metres, probably containing early Campanian assemblages with *Broinsonia parca*, may have exaggerated this biostratigraphic discontinuity. The discontinuity lies at the contact between the Gingin Chalk below and the Lancelin Beds above.

appearance at the 84-metre level. Rare specimens of *Quadrum gothicum* appear at several horizons: 80-, 78-, 72-, 66-, 64-, and 59-metre levels; at the 66-, 72- and 78-metre levels, the rare *Q. gothicum* occurs in association with similarly rare *Ceratolithoides aculeus*. The latter also occurs at the 78- and 72 metre levels. *Misceomarginatus pleniporus, Monomarginatus pectinatus, M. quaternarius* are more persistent than either *Quadrum gothicum* or *Ceratolithoides aculeus* over the interval where they occur. Forms referable to *Reinhardtites levis s.l.* first appear at the 95-metre level. The entry of *Cribrosphaerella daniae* is at the 51-metre level.

It is suggested that the lowest occurrence of *Cribrosphaerella daniae* be used as an approximation of the Campanian/Maastrichtian boundary. This event/boundary in Breton Bay #1 corehole was identified within the upper part of the Lancelin Beds.

Remarks. There is evidence for a biostratigraphic discontinuity at approximately the 95-metre level (taken as the base of the Lancelin Beds), where *Misceomarginatus pleniporus, Monomarginatus quaternarius, Reinhardtites levis s.l.* and large *Broinsonia parca* collectively have their lowest occurrences. *Tranolithus orionatus* occurs below the 95-metre level, in the Gingin Chalk, but not above in the Lancelin Beds; this species or a very similar form reappears, however, in the Breton Marl. The age of the assemblages from below this discontinuity is late Santonian, on account of the presence of *Calculites obscurus*, whereas the assemblages from immediately above the discontinuity are probably late Campanian based on the co-occurrence of *Broinsonia parca* and *Monomarginatus quaternarius.*

A correlation can be made between the assemblages from immediately above the postulated hiatus at the 95-metre level in Breton Bay #1 corehole and the assemblages identified from the type Lancelin Beds. The basal assemblage in Breton Bay #1 corehole is correlated with the late Santonian assemblages recovered from several Gingin Chalk outcrops (e.g. Molecap Hill).

The occurrence of the species *Biscutum magnum* and *Misceomarginatus pleniporus* in the upper Campanian of both Lancelin #2B and Breton Bay #1 are highly significant as these species are thought to indicate high-latitude conditions. Hitherto these species were known only from the Falkland Plateau, SW Atlantic Ocean, (Wise & Wind, 1977; Wind & Wise, 1983).

The occurrence of the lower-latitude *Ceratolithoides aculeus* at three horizons within the lower half of the Lancelin Beds in Breton Bay #1 corehole suggests three very short-lived warm episodes during the late Campanian in the Perth Basin.

B) Maastrichtian

The Campanian/Maastrichtian boundary is suggested at the incoming (lowest occurrence) of *Cribrosphaerella daniae*. This is at the 51-metre level in Breton Bay #1 corehole, within the upper part of the Lancelin Beds; a thickness of more than 20 metres for the Maastrichtian section is thus indicated in this corehole. Assemblages with common *C. daniae* were also identified from Breton Bay #5 corehole material.

The overall aspect of the assemblages recovered from the Maastrichtian section in Breton Bay coreholes (see Checklist 4; Table 8) suggests a cold-water regime and/or a location at high latitudes, in a hemipelagic setting. The evidence includes the abundant and persistent occurrence of *Nephrolithus corystus, Cribrosphaerella daniae* and representatives of the genera *Acuturris, Calculites, Kamptnerius,* and *Lucianorhabdus* in most of the upper part of the Lancelin Beds in Breton Bay corehole #1, as well as the occurrence of *Nephrolithus frequens* within the top of the Maastrichtian (Breton Marl) in the same corehole and in the nearby Breton Bay #5 corehole. Species of *Micula* (mainly *M. staurophora* and *M. concava*) are found to be more numerous than *Watznaueria barnesae*; the latter is unknown from high latitude Upper Cretaceous deposits (see Bukry, 1973a), whereas *M. staurophora* is known to be more abundant with increasing palaeolatitudes during the late Maastrichtian (Doeven, 1983).

Nephrolithus frequens is restricted to the top 4.5 to 6 metres of the >20-metre thick Maastrichtian section in Breton Bay #1 corehole indicating that the upper Maastrichtian (Breton Marl) is much thinner than the lower Maatrichtian (upper half of the Lancelin Beds). While *Cribrosphaerella daniae* ranges throughout the entire Maastrichtian section, *Nephrolithus corystus, Monomarginatus quaternarius* and *Misceomarginatus pleniporus* were encountered mostly in the upper part of Lancelin Beds.

The upper Maastrichtian Breton Marl in Breton Bay #1 corehole is separated from the lower Maastrichtian Lancelin Beds below by a biostratigraphic discontinuity (Table 8). The evidence for this discontinuity includes the simultaneous up-section appearance of *Lithraphidites quadratus, Micula murus* and *Nephrolithus frequens* at the 32-

Table 8. Coccolith biostratigraphic summary of Maastrichtian carbonates in Breton Bay #1 corehole.

	levels (m)	Characteristics of assemblages	Key biostratigraphic events
Breton Marl	27.5–29.5	Similar to below but with the exclusion of *Micula murus* and *Ceratolithoides aculeus*. Common *Arkhangelskiella cymbiformis*.	
	30–32	Common to abundant *Nephrolithus frequens, Cribrosphaerella daniae* and *Lithraphidites quadratus*. Frequent *Kamptnerius magnificus*, but *Calculites obscurus* and *Acuturris scotus* are sporadic. Extremely rare *Micula murus, Ceratolithoides aculeus*, and *Eiffellithus eximius*.	⊥ *Nephrolithus frequens* *Micula murus* *Lithraphidites quadratus*
BIOSTRATIGRAPHIC DISCONTINUITY			
Lancelin Beds (upper part)	34–35	Same as below: species of *Acuturris, Calculites, Lucianorhabdus, Kamptnerius* and *Reinhardtites* are present. Abundant *Cribrosphaerella daniae*, and rare *Eiffellithus eximius*, are also present	⊤ *Reinhardtites levis s.l.* *Broinsonia parca* *Nephrolithus corystus* *Biscutum magnum* *Zygodiscus bierescenticus*
	36–51	Consistent *Acuturris scotus, Lucianorhabdus cayeuxii, Kamptnerius magnificus, Calculites obscurus, Broinsonia parca, Cribrosphaerella daniae, Zygodiscus bicrescenticus*..etc.... *Eiffellithus eximius* more frequent than above. Rare *Biscutum magnum, Nephrolithus corystus* and *Monomarginatus quaternarius*, and sporadic *Misceomarginatus pleniporus* are present Rare *Quadrum gothicum* at one horizon.	⊤ *Monomarginatus quaternarius*
	53	Abundant *Broinsonia parca*	⊥ *Cribrosphaerella daniae*

⊥ *Lowest occurrence* ⊤ *Highest occurrence*

20–6/15

metre level, and also the occurrence of *Reinhardtites levis* s.l., *Zygodiscus bicrescenticus, Biscutum magnum* and *Nephrolithus corystus* up to the 34-metre level but not at higher levels. Thus the middle and probably part of the late Maastrichtian are not represented in the Breton Bay #1 corehole. Biostratigraphic events in the missing part of the section would have included the lowest occurrence of *Lithraphidites quadratus* and (possibly) those of *Micula murus* and *Nephrolithus frequens* (compare events in Table 20 with those in Table 8).

Broinsonia parca ranges within the Maastrichtian section of Breton Bay corehole #1, and rare *Eiffellithus eximius* was encountered in the upper Maastrichtian of both Breton Bay coreholes. The extinction level of each of these species has been used elsewhere by other investigators (e.g. Varol, 1983 who used the top of the range of *E. eximius*) to approximate the Campanian/Maastrichtian boundary. These levels could not be used to approximate this boundary in the Perth Basin - though they may be good evidence for the same elsewhere.

Notable in the lower part of the upper Maastrichtian Breton Marl in Breton Bay corehole #1, is the occurrence of rare *Micula murus* and *Ceratolithoides aculeus*, but a similar co-occurrence of these species could not be confirmed in the material studied from the same unit in Breton Bay #5 corehole. This is attributed to inadequate sampling, because of the likelihood that the *murus-aculeus* interval is represented by a thin bed in Breton Bay coreholes. The geographic distribution of *Micula murus* and *Ceratolithoides aculeus*, being mostly at low to mid latitudes, suggests a preference for higher water temperatures than those prevailing at Breton Bay during most of the late Maastrichtian. The brief *murus-aculeus* excursion into Breton Bay (Perth Basin) could have been due to a short-lived event responsible for a rise in water temperature.

The occurrence of several hemipelagic species such as *Acuturris scotus, Brarrudosphaera spp., Calculites obscurus, Lucianorhabdus cayeuxii* and *Kamptnerius magnificus* in the Maastrichtian carbonates of Breton Bay suggests that their deposition was in nearshore or shelf palaeoenvironments.

SUBSURFACE CARBONATE SEQUENCE IN LOWER MOORE RIVER AREA

Gingin Brook #4 borehole

This borehole is located on the Old Gingin Brook Road near the Moore River (Swan Location 946) (approx. Lat. 31° 19' 15" S - 115° 32' 47" E; Fig. 3), about 35 Km west of Gingin and about 38 Km SSW of Lancelin. The Gingin Chalk (39.6-64.6 metres) occurs below a Quaternary to Recent section of coastal limestones and sands, and above the equivalent of the Molecap Greensand (?Osborn Formation). One conventional core was cut from near the base of the Gingin Chalk (core 1: between 61-64 metres). Assemblages recovered from the three samples taken from this core (between 61.5 and 62 metres) are similar (Checklist 3). They include *Acuturris scotus, Ahmuerellela* *octoradiata, Calculites ovalis, Chiastozygus litterrarius, Cylindralithus biarcus, Eiffellithus eximius, Gartnerago obliquum, Kamptnerius magnificus, Micula staurophora, Prediscosphaera cretacea, P. spinosa, Reinhardtites anthophorus, Tranolithus orionatus* and *Watznaueria barnesae*. These assemblages are assigned a mid Santonian age on account of the co-occurrence of *Acuturris scotus* and *Reinhardtites anthophorus* without the association of *Lucianorhabdus cayeuxii* or any other younger marker.

Joondalup #25p borehole

This borehole - about 26 and 6 Km SE of Breton Bay #1 and Gingin Brook #4 respectively - is located 6.8 Km SW of the junction of Lancelin and Old Gingin Brook Roads. (This is about 33 Km west of the town of Gingin; Fig. 3.) The sequence consists of a 38-metre thick section of Cainozoic sands and calcarenites unconformably overlying the Lancelin Beds. Evidently these beds were not totally penetrated in the Joondalup #25p borehole; only 7 metres of the Lancelin beds were drilled. One conventional core was obtained from the bottom of the borehole, at the 45-metre level. A rich and diversified assemblage was identified from a sample (MFN-2159) from this core. The assemblage includes *Acuturris scotus, Arkhangelskiella cymbiformis, Braarudosphaera bigelowii, Broinsonia parca, Calculites obscurus, Chiastozygus litterarius, Cretarhabdus crenulatus, Cribrosphaerella ehrenbergii, Eiffellithus turriseiffeli, E. eximius, Gartnerago obliquum, Kamptnerius magnificus, Lithraphidites carniolensis, Lucianorhabdus cayeuxii, Manivitella pemmatoidea, Marthasterites inconspicuus, Micula staurophora, Misceomarginatus pleniporus, Monomarginatus pectinatus, Petrarhabus copulatus, Prediscosphaera cretacea, P. bukryi, P. spinosa, Placozygus fibuliformis, Quadrum gothicum, Reinhardtites anthophorus, R. levis, Rhagodiscus* sp. *R.* aff. *reniformis, Vekshienella dibrachiata*, and *Zygodiscus bicrescenticus.*

The association of *Broinsonia parca, Misceomarginatus pleniporus, Monomarginatus pectinatus, Quadrum gothicum* and *Reinhardtites levis* is considered to indicate a maximum age of late Campanian age for the Joondalup assemblage. A correlation is made with the assemblages recovered from the type Lancelin Beds and with those from immediately above the biostratigraphic discontinuity (at the 95-metre level) in Breton Bay #1 corehole.

The occurrence of *Misceomarginatus pleniporus* and *Monomarginatus pectinatus* in Joondalup #25p borehole assemblage affirms the cold-water conditions which prevailed in the Perth Basin during the later part of the Campanian, as based on a similar evidence in the Breton Bay #1 corehole.

GINGIN CHALK IN WATHEROO AREA

Agaton #19 borehole

Agaton #19 borehole is located about 17.5 Km west of Watheroo (at Lat. 30° 19' 00" S - Long. 115° 52' 14" E; Fig. 3) about 115 Km north of Gingin. The stratigraphy is the same as in the type area of the Gingin Chalk. Only two cores were cut from the Gingin Chalk: core 1 between 33.5- and 39.6-metre levels and core 2 between 61- and 67-metre levels.

The coccolith evidence suggests that the Molecap Greensand/Gingin Chalk contact was recovered in core 2. The lower part of the core was found to be totally barren of coccoliths, whereas its upper part contains these fossils. Coccolith distribution in Agaton #19 borehole samples is given in Checklist 2, and a biostratigraphic summary is presented in Table 9.

Table 9. Coccolith biostratigraphy of Agaton #19 borehole material.

==================================

POISON HILL GREENSAND: no coccoliths

--26.8 m

NO DATA

--33.5 m

Assemblages similar to below except for the addition of *Lucianorhabdus arcuatus* and *L. cayeuxii.*

--------------------**Lucianorhabdus cayeuxii*----39.6 m

SAMPLING GAP

--61 m

A rich assemblage containing several key species: *Acuturris scotus, Broinsonia dentata, B. orthocancellata, Calculites ovalis, Lucianorhabdus maleformis, Micula concava* and *Reinhardtites anthophorus* and *R. biperforatus. Eiffellithus eximius, E. trabeculatus, Kamptnerius magnificus* and *Marthasterites furcatus* are also present.

--------------------**Acuturris scotus*-----------------62 m

Presevation is poor. *Gartnerago obliquum, Kamptnerius magnificus, Lithastrinus floralis* and *Watznaueria barnesae* are dominating an impervished assemblage. *Lithastrinus grillii* is present.

--------------------**Lithastrinus grillii*---------------63 m

MOLECAP GREENSAND: no coccoliths

==================================

***Lowest occurrence**

figures are approximate levels in metres in the borehole.

Gingin Chalk presumably occurs between 26.8- and 63-metre levels.

A meagre, poorly preserved, coccolith assemblage, from immediately above the greensand in core 2 (sample MFN-2487) is dominated by

Kamptnerius magnificus, *Eprolithus floralis*, *Gartnerago obliquum* and *Watznaueria barnesae*, but also includes the species *Eiffellithus turriseiffeli*, *Lithastrinus grillii* and *Prediscosphaera cretacea*. A richer and better preserved assemblage recovered from the top part of core 2 (sample MFN-2486), includes the key species *Acuturris scotus*, *Broinsonia dentata*, *Calculites ovalis*, *Eiffelithus eximius*, *Lucianorhabdus maleformis*, *Marthasterites furcatus*, *Micula concava* and *Reinhardtites anthophorus*. Both *Lucianorhabdus cayeuxii* and *Calculites obscurus* were not found. However, the assemblages identified from core 1 contain *Lucianorhabdus cayeuxii*, without *Calculites obscurus*.

BASAL COCCOLITH ASSEMBLAGES IN GINGIN CHALK SECTIONS STUDIED

Coccolith assemblages from the base of the Gingin Chalk have particular significance as they represent the base of the calcareous microplanktic sequence in the Upper Cretaceous of the Perth Basin; fully open-marine conditions were envisaged during the deposition of the richly fossiliferous Gingin Chalk by Shafik (1978b). The underlying Molecap Greensand is totally barren of coccoliths (and planktic foraminiferids), indicating conditions hostile to the calcareous microplankton. The occurrence of the occasional bone of the marine reptiles *Ichthyosaurus* and *Plesiosaurus* (Teichert & Matheson, 1944), and of a few belemenites as well as fragments of wood in the Molecap Greensand, especially near its top (Feldtmann, 1963), suggest restricted (or very marginal) marine conditions. Thus at the Molecap Greensand/Gingin Chalk contact a major environmental change occurred (a sharp turn over from restricted to open-marine conditions), heralding a new sedimentation regime, probably caused by a substantial rise in sea level as consequence of a regional subsidence and/or a global rise in sea level. The gradational nature of this contact at McIntyre's Gully (type section of the chalk) is deceiving as the appearance of coccoliths is sudden at the base of the chalk.

Coccolith assemblages from the base of the Gingin Chalk are recorded from the type section of the formation, Molecap Hill outcrops, Agaton #19 borehole, and Ginginup #1 corehole. The basal assemblage in Breton Bay corehole #1 came from 10 cm above the contact with the Molecap Greensand. Age-diagnostic species in the basal assemblages of these sections are not always the same, and the differences are mainly expressions of absences. It is always difficult to determine whether an absence is a true biostratigraphic absence, an exclusion caused by diagenetic processes, or is an impoverishment brought about initially by poor accessibility of the flora to the site of deposition.

The basal assemblage in Agaton #19 borehole includes the potentially age-diagnostic species *Lithastrinus grillii*, *Kamptnerius magnificus*, *Gartnerago obliquum* and *Eprolithus floralis*. This assemblage is not particularly rich and its preservational state is poor. It does not include the key species *Marthasterites furcatus*, *Micula concava*, *Lucianorhabdus maleformis*, *Calculites ovalis*, *Lucianorhabdus cayeuxii*, and *Calculites obscurus* which are found in most of the assemblages identified from the Santonian chalk outcrops in the Gingin area.

That the Agaton basal assemblage could be substantially older than the Santonian assemblages of the chalk outcrops in the Gingin area is unlikely, though its poor preservation coupled with its low diversity leave the question of its dating open. On account of *Lithastrinus grillii*, a maximum age of late Coniacian/early Santonian is adopted: the base of the range of *L. grillii* is within the early Santonian according to Perch-Nielsen (1979e), and is shown at the base of the Coniacian in the range chart of Thierstein (1976). The Agaton basal assemblage may be assigned to the DI:**Lithastrinus grillii*/**Reinhardtites anthophorus* (see Table 22, p.64).

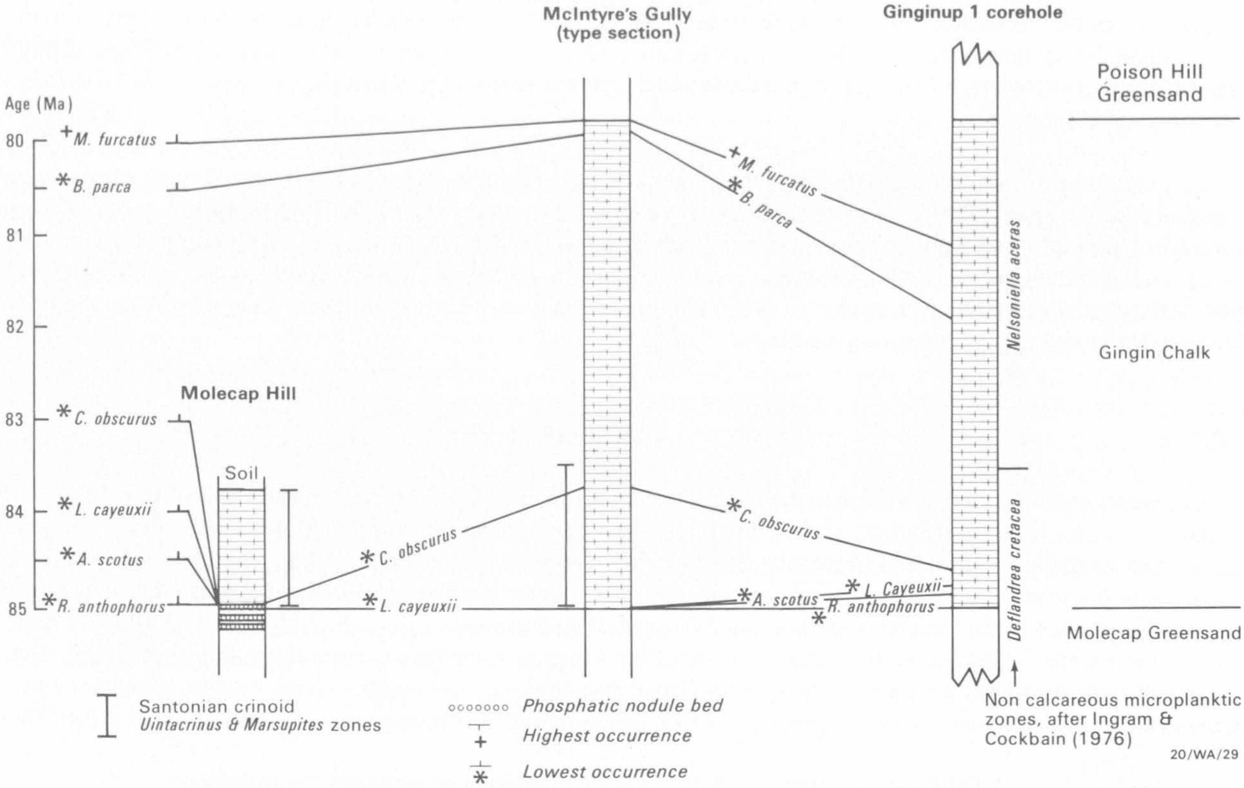
In Ginginup #1 corehole the basal assemblage is richer and better preserved than the Agaton assemblage. In addition to the key species of the Agaton assembage, the Ginginup basal assemblage contains *Marthasterites furcatus*, *Micula concava*, *Broinsonia dentata*, *Eiffellithus trabeculatus*, and *Reinhardtites anthophorus*. This association of key species is assigned an early Santonian age, as it belongs to the DI:**Reinhardtites anthophorus*/**Acuturris scotus* (see Table 22).

The basal assemblage in the type Gingin Chalk section includes the key species *Acuturris scotus*, *Broinsonia dentata*, *Lucianorhabdus cayeuxii*, *Micula concava* and *Reinhardtites anthophorus*, and is assignable to the DI:**Lucianorhabdus cayeuxii*/**Calculites obscurus* (see Table 22).

The assemblage from the base of the chalk at Molecap Hill contains the index species *Calculites obscurus*, and is assignable to the DI:**Calculites obscurus*/**Broinsonia parca* (see Table 22). *Calculites obscurus* prior to the appearance of *Broinsonia parca* is considered to indicate a late Santonian age.

The basal assemblage in Breton Bay #1 corehole, from about 10 cm above the base of the chalk, also contains *Calculites obscurus* in addition to *Acuturris scotus*, *Calculites ovalis*, *Lucianorhabdus cayeuxii*, and *L. maleformis*, similar to the basal assemblage at Molecap Hill; the age is late Santonian.

Figure 5. Correlation between the various sections of the Gingin Chalk in its type area, based on coccolith biostratigraphic events.



The evidence presented above may suggest that the base of the Gingin Chalk is diachronous, ranging in age from late Coniacian/early Santonian to late Santonian. Alternatively, Late Cretaceous carbonate sedimentation in the Perth Basin commencing during the late Coniacian/early Santonian, was very slow until mid to late Santonian when wider geographic accumulation of these carbonates began (i.e. when maximum transgression was reached).

Playford & others (1975) noted the occurrence of a widespread thin phosphatic horizon at the top of the Molecap Greensand, which they considered as indicative of possible hiatus between the deposition of the Molecap Greensand and Gingin Chalk. While a disconformity between the Molecap Greensand and Gingin Chalk is possible, the deposition of the phosphatic nodule bed at the very top of the Molecap Greensand was probably initiated at the start of the sedimentation cycle which produced the Gingin Chalk. As indicated above, only the topmost nodule bed at Molecap Hill contains coccoliths, in contrast with other (lower) nodule beds in the Molecap Greensand, which are totally devoid of these fossils. This nodule bed may have been formed in several stages: initially, a phosphatic blanket was formed towards the end of the regressive phase that deposited the Molecap Greensand; this blanket was subsequently broken up, partly eroded (during the hiatus), and finally redeposited at the advent of a transgression (new sedimentation cycle), when the rates of sedimentation were slow. At the beginning of the transgression the calcareous microplankton had access to the deposition site (contrasting with before, during the deposition of the Molecap Greensand), but not as freely as later on during the course of the transgression when the carbonates started to accumulate. This explains the meagre assemblage in the nodule bed at the base of the Gingin Chalk at Molecap Hill, compared with the much richer assemblages higher up in the same section.

The close stacking of the coccolith events in the basal parts of the Gingin Chalk sections, compared with higher up in the same sections (see Fig. 5), suggests slow rates of sedimentation at the onset of the transgression, consistent with the mechanism proposed for the formation of the nodule bed at the base of the Gingin Chalk. Also, it is not unreasonable to suggest that while the basal part of the Gingin Chalk was being deposited at McIntyre's Gully and Ginginup #1 sites (where the Molecap Greensand/Gingin Chalk contact is seemingly without nodule beds), the nodule bed (at the base of the Gingin Chalk) was formed at the nearby Molecap Hill site. This would make the base of the transgression isochronous, at least (locally) in the Gingin area.

TOP COCCOLITH ASSEMBLAGES IN GINGIN CHALK SECTIONS STUDIED

In both the type section of the Gingin Chalk and in the Ginginup #1 corehole the top coccolith assemblages, from immediately below the Poison Hill Greensand, is early Campanian in age, based on the occurrence of the index species *Broinsonia parca*. This same species ranges over the top 9.5 metres of the Gingin Chalk in Ginginup #1 corehole, whereas it is limited to the top metre in the type section at McIntyre's Gully. Also, the top assemblage in the type section, being assignable to the DI:**Broinsonia parca*/+*Marthasterites furcatus* (see Table 21, p.63), is slightly older than its counterpart in Ginginup #1 corehole which belongs to the DI:+*Marthasterites furcatus*/+*Tranolithus orionatus* (see Table 21).

Assemblages from below the hiatus at the Gingin Chalk/Lancelin Beds contact in Breton Bay #1 corehole are assignable to the broad DI:**Calculites obscurus*/+*Tranolithus orionatus* (see Table 21). *Broinsonia parca* was not found, but the four-metre sampling gap (which is likely to be Gingin Chalk), between the the Gingin Chalk at 100-metre level and the Lancelin Beds at 95-metre level, may contain this early Campanian species, coeval with the top part of the chalk in either its type section or (more likely) the Ginginup #1 corehole. This would narrow the hiatus to between lower and upper Campanian sediments.

DISCUSSION

Based on coccolith distribution in the clastic section below the Upper Cretaceous carbonates in the Perth and Carnarvon Basins (discussed earlier), marine conditions are more evident in the north (Alinga Formation, Carnarvon Basin) than in the south (Molecap Greensand, Perth Basin). Seemingly, connection to the Late Cretaceous open-sea occurred from the north. This together with an evidence related to the deposition of the Beedagong Claystone in the northern Carnarvon Basin (detailed later in the study) suggest that the transgression which produced the Gingin Chalk, subsequent to the deposition of the clastic section of the Molecap Greensand, came from a northerly direction. Evidence indicating that the base of the Gingin Chalk is diachronous is inconclusive. Indeed, there are some indications to suggest that this base is probably isochronous and that sedimentation rates were initially slow. This

Table 10. A summary of the Upper Cretaceous sequence in Perth Basin.

Carbonate cycles	Unit	Some Characteristics and Remarks
CYCLE C	Breton Marl	Late Maastrichtian assemblages. This thin unit can be differentiated by the occurrence of *Lithraphidites quadratus* and *Nephrolithus frequens*.
Biostratigraphic discontinuity/Disconformity		
CYCLE B	Lancelin Beds	Late Campanian and early Maastrichtian with large *Broinsonia parca*, *Reinhardtites levis s.l.*, *Monomarginatus pectinatus*, *Miceomarginatus pleniporus*, *Biscutum magnum* and sporadic *Quadrum gothicum*.
Biostratigraphic discontinuity/Disconformity		
CYCLE A	Gingin Chalk	Santonian and early Campanian assemblages. The Campanian *Broinsonia parca* is usually smaller than in the Lancelin Beds. Lower part of the unit is represented by a condensed section. A phosphatic nodule bed at base.
A possible hiatus (a major change in palaeoenvironmental conditions)		
Molecap Greensand: Barren of calcareous nannofossils.		

means that the transgression was very rapid. A rapid transgression is not inconsistent with the scenario of a low relief (near peneplained surface) of the western margin at the onset of the Senonian transgression; the previous high onshore relief, caused by tectonism during the Jurassic, had been almost entirely eroded away by the Senonian. It is also in agreement with the observation made earlier by Cooper (1977) that marine advances during the Cretaceous were rapid.

The two biostratigraphic discontinuities identified in the Upper Cretaceous carbonate sequence of the Perth Basin, at the Gingin Chalk/Lancelin Beds and the Lancelin Beds/Breton Marl contacts (Table 10), are sharp in the sense that the assemblages from above and below are easily differentiated. This means that the lithostratigraphic units can be characterised by their coccolith assemblages, and thus can be particularly useful in identification of the units in drillholes. The fact that very little sediment material (a few cubic centimetres or even millimetres) is needed to identifiy an enclosed coccolith assemblage, furthers the usefulness of the conclusion. The late Campanian and early Maastrichtian assemblages of the Lancelin Beds are distinct from the Santonian and early Campanian assemblages of the Gingin Chalk by the presence of several key species (see Table 10). The late Maastrichtian assemblages of the Breton Marl at the top of the Upper Cretaceous carbonate sequence of the Perth Basin include the key species *Lithraphidites quadratus* and *Nephrolithus frequens* which do not occur in the other units.

The hiatuses at the Gingin Chalk/Lancelin Beds and Lancelin Beds/Breton Marl contacts are thought to separates three cycles of carbonate deposition (Table 10, also discussed in detail later in the study).

Cold-water conditions prevailed during the late Campanian and Maastrichtian (deposition of the Lancelin Beds and the Breton Marl) probably as a result of a general cooling trend. This is based on the presence of several temperature-indicators such as *Monomarginatus pectinatus, Misceomarginatus pleniporus, Nephrolithus corystus* and *N. frequens.*

The cooling trend during the late Campanian-Maastrichtian was interrupted by several short-lived warm episodes which brought *Ceratolithoides aculeus* to the Perth basin.

UPPER CRETACEOUS CARBONATES IN CARNARVON BASIN

Hitherto, very little was known about the calcareous nannofossils of the Upper Cretaceous carbonates of the onshore Carnarvon Basin. Published results by Thierstein (1977) make use of these fossils to determine the age of a few samples from two Upper Cretaceous carbonate units in this basin.

STRATIGRAPHY

The Upper Cretaceous shelf carbonates crop out in the Carnarvon Basin in its southern parts (mainly Lower Murchison River and Shark Bay areas), and in the Giralia Anticline, to the north (Fig. 6). These carbonates have formally been described as the Toolonga Calcilutite, Korojon Calcarenite and Miria Marl (see Clarke & Teichert, 1948; Condon & others, 1956; Johnstone & others, 1958). In addition, an older calcareous unit previously informally known as the 'upper Gearle Siltstone', is formally described and named herein as the Beedagong Claystone.

Main problems include a) the age of the 'upper Gearle Siltsone' (the Beedagong Claystone of this study) and how does this unit relate to the 'lower Gearle Siltstone' or the undifferentiated Gearle Siltstone; b) misidentification of the Toolonga Calcilutite and Korojon Clacarenite, especially in the subsurface, and their miscorrelation; and c) the age of the Miria Marl with respect to its foraminiferal fauna (late Maastrichtian McGowran, 1962; 1968) and its nannoplankton flora (middle Maastrichtian, Thierstein, 1977). This study attempted solving/clarifying these problems. Other problems related to the nature of the type sections of the Gearle Siltstone, Toolonga Calcilutite and Korojon Calcarenite considered beyond the scope of this study.

BEEDAGONG CLAYSTONE

Coccolith evidence and foraminiferal data cited earlier in this study suggest that the 'lower Gearle Siltstone' is probably coeval with the (undifferentiated) Gearle Siltstone. The name 'lower Gearle Siltstone' is therefore considered as synonymous with the name Gearle Siltstone *sensu stricto*. This leaves the informal name of 'upper

Figure 6. Location map showing the studied localities in the Carnarvon Basin.

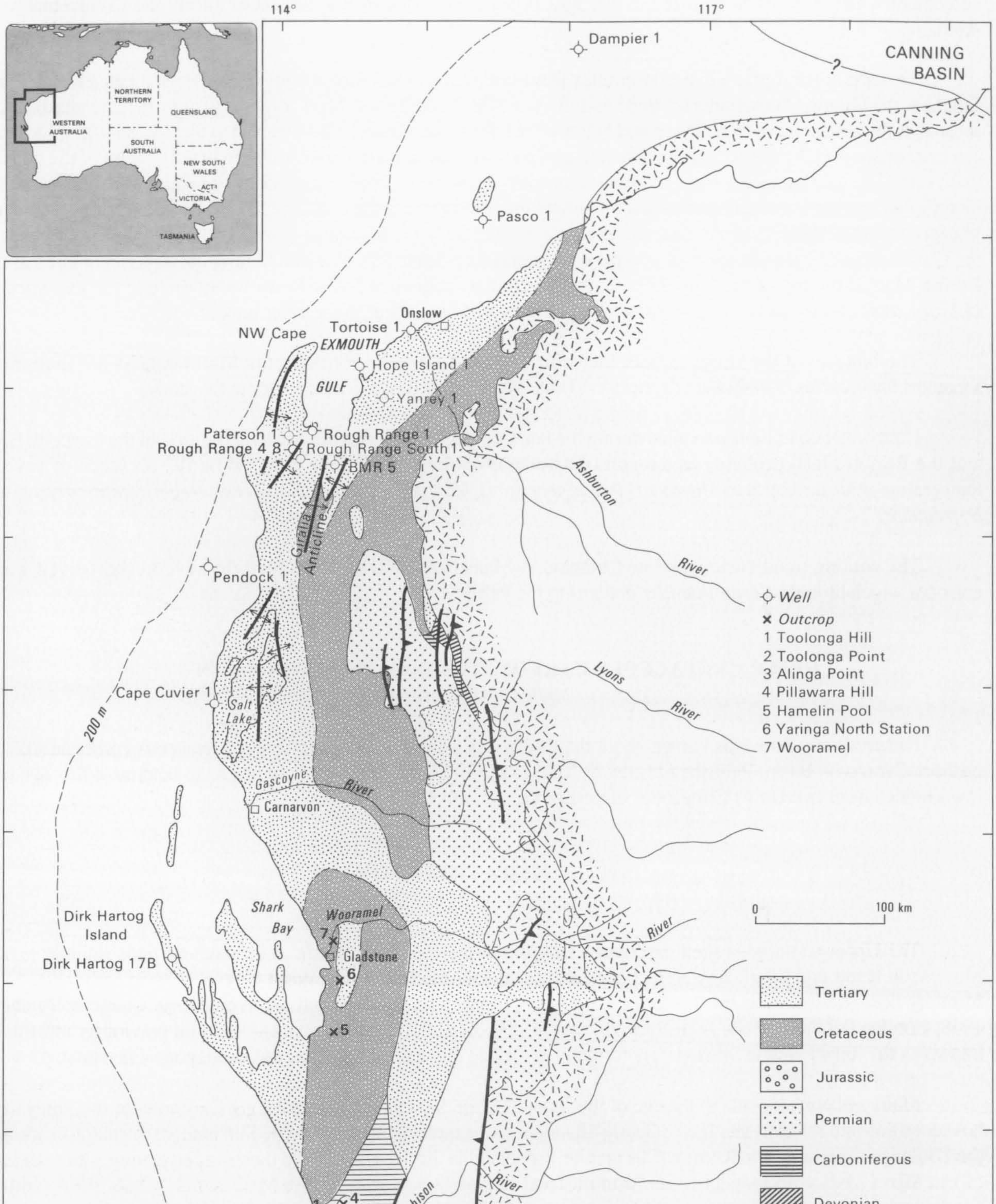
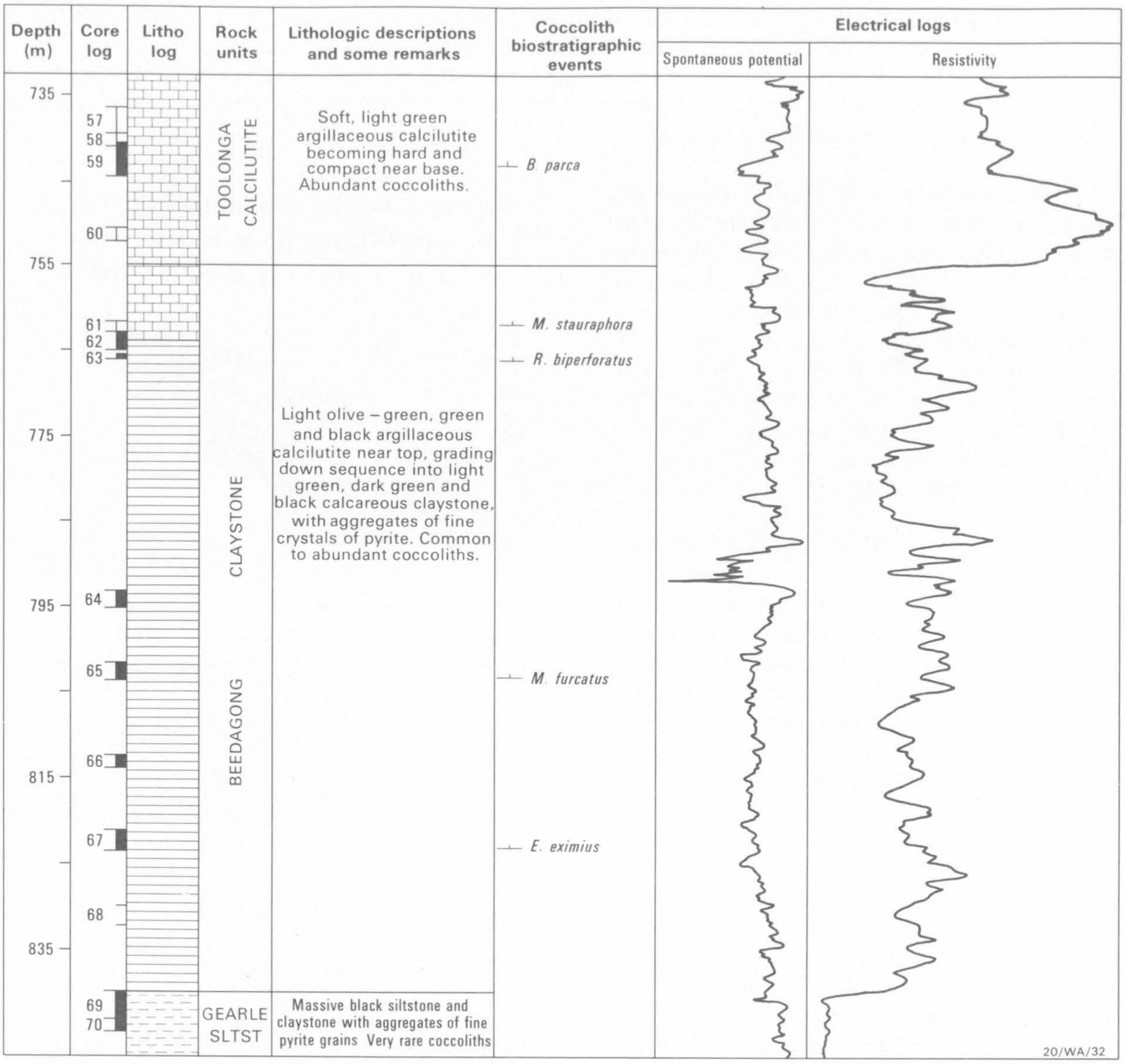


Figure 7. Columnar section of the type Beedagong Claystone, Rough Range South #1 well, Carnarvon Basin.



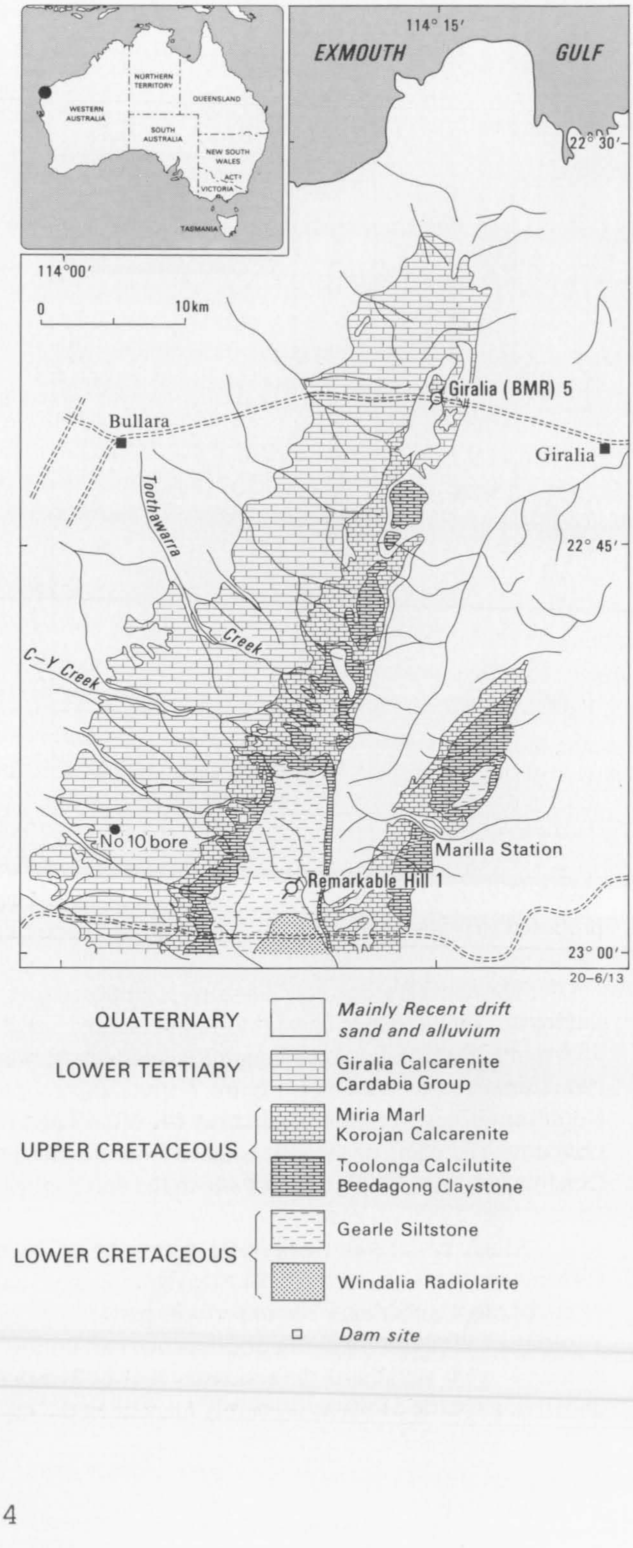
Gearle Siltstone' - representing younger beds - unattended to. In this study the new name Beedagong Claystone is proposed to replace the informal name 'upper Gearle Siltstone'.

The name Beedagong Claystone is proposed for a unit of massive, green to dark grey, calcareous claystone and mudstone, which grades upward to light-coloured calcilutite. The type section is designated as the interval between 755- and 838-metre levels in Rough Range South #1 well (Lat. 22° 37' 17.5" S - Long. 113° 57' 37.6" E; Fig. 6); the type thickness is 83 metres. Figure 7 gives the geophysical logs and other information about the type section. Representatives samples from cores 61, 63, 65 and 68 have been placed in the Bureau of Mineral Resources, Canberra. The name of the unit is taken from the Beedagong Paddock, in the Giralia Anticline (reference map is *in* Condon & others, 1956), north of which the unit has been excavated at a dam site (east of No. 10 Bore; Fig. 8).

Single crystals or fine crystal aggregates of pyrite occur throughout most of the type Beedagong Claystone. (Where the unit is exposed, i.e. an excavation in the Giralia Anticline, gypsum occurs instead, presumably as a result of the pyrite weathering.) The uppermost part of the type Beedagong Claystone resembles the overlying part of the Toolonga Calcilutite in being argillaceous calcilutite. However, the Beedagong Claystone/Toolonga Calcilutite contact is well marked on the resistivity logs of Rough Range South #1 well (Fig. 7). Similarly, the contact with the underlying Gearle Siltstone is sharply marked on the resistivity logs of the same section.

The Beedagong Claystone is restricted to the northern portion of the Carnarvon Basin. It is presently chiefly known from subsurface sections in the Giralia Anticline, Rough Range and Exmouth Gulf areas. It occurs in several Rough Range wells, Hope Island #1, Yanrey #1, Warroora #1, and Giralia (BMR) #5 drillholes. At a dam site in the central Giralia Anticline, a large excavation (east of No. 10 Bore) exposed the Beedagong Claystone which the writer was able to sample in June 1983. Other surface occurrences of the unit in the Giralia Anticline are evidently poorly exposed; the Toolonga Calcilutite below which the Beedagong Claystone lies, is very poorly exposed in the greater part of the northern Carnarvon Basin. In this study, beds referable to the Beedagong Claystone were identified at C-Y Creek, Giralia Anticline (see Fig. 8) between the type Gearle Siltstone below and the poorly exposed Toolonga Calcilutite above.

Figure 8. Geological map of the Giralia Anticline (Carnarvon Basin) showing location of the studied localities.



Belford & Scheibnerova (1971) recorded rich foraminiferal faunas from cores referable here to the Beedagong Claystone in Rough Range #5, Rough Range South #1 and Yanrey #1 wells. These included the planktic forms *Praeglobotruncana stephani stephani* (and allied forms), *P. hagni, P. helvetica, P.* sp. cf. *P. imbricata, Hedbergella hoelzi* and the benthic species *Lingulogavelinella turonica.* They interpreted the age as early and middle Turonian, revising an earlier interpretation (late Cenomanian-early Turonian) by Belford (1958).

The Beedagong Claystone was deposited during a different sedimentation cycle than that of the older Gearle Siltstone. It is allied with the overlying Toolonga Calcilutite: the Beedagong Claystone is considered to represent the onset of the Upper Cretaceous carbonate sedimentation in the 'onshore' northern portion of the Carnarvon Basin.

TOOLONGA CALCILUTITE

The Toolonga Calcilutite (Clarke & Teichert, 1948; amended Johnstone & others, 1958) is widely distributed through most of the Carnarvon Basin, but is particularly well known from its outcrops in the southern parts of the basin. Its type section is in the Toolonga Hills on the north side of the Murchison River (Fig. 6); other important sections are known from outcrops in the Shark Bay-Lower Wooramel River area. The type Toolonga Calcilutite is about 25 metres in thickness, consisting mainly of greenish grey calcilutite with a chalk unit at the base. Fragments of *Inoceramus* occur in the lower half of the type section, and remains of the crinoid genera *Marsupites* and *Uintacrinus* appear in the basal chalk unit (Johnstone & others, 1958); the age of the type material has been firmly established as Santonian on the basis of the crinoid remains. Foraminiferal results by Belford (1958, 1960) agree with this age assignment, but also indicate that outcrops of the formation in Shark Bay area are Campanian in age. The main elements of the foraminiferal fauna of the Santonian Toolonga Calcilutite outcrops include the *Globotruncana lapparenti* group, *G. marginata, G. ventricosa, Bolivinoides strigillata strigillata* and *Rugoglobigerina (R.) pilula*; the Campanian outcrops of the formation was found to include *Globotruncana* sp. cf. *G. arca* and *Neoflabellina praereticulata* (Belford, 1958). Hooper (1977) reported on a foraminiferal fauna from a sample which he believed to be from the base of the Toolonga Calcilutite at C-Y Creek (Giralia Anticline); he considered the fauna to represent the Santonian/Campanian transition, on account of the co-occurrence of *Globotruncana ventricosa* and *G. linneiana*. Thierstein (1977) assigned a Santonian age for samples of Toolonga Calcilutite from the type area.

In its type area, the Toolonga Calcilutite overlies disconformably the Alinga Formation, but its top is usually travertinised at the Tertiary erosion surface (Johnstone & others, 1958). In the northern parts of the basin the stratigraphic setting is remarkably different: the Toolonga Calcilutite occurs between the Gearle Siltstone and Korojon Calcarenite or between the Beedagong Claystone and Korojon Calcarenite.

KOROJON CALCARENITE

The Korojon Calcarenite (Condon, 1954; defined Condon & others, 1956) crops out extensively in the Giralia Anticline (its type area), but it has been traced in drillings from the Exmouth Gulf to Cape Cuvier in the south (Fig. 6). The type section of the Korojon Calcarenite (Fig. 9) - at C-Y Creek (Lat. 22° 24' S - Long. 114° 07' E; Fig. 8) -consists of more than 40 metres of friable calcisiltite, calcarenite, coquinoid calcarenite packed with fragments of giant *Inoceramus*, and soft calcilutite. The exposures along the C-Y Creek are discontinuous, so that gaps (covered intervals) and overlaps cannot be avoided during sampling (see Fig. 9).

In the Giralia Anticline, the contact of the Korojon Calcarenite with the overlying Miria Marl is marked by a bed of phosphatic nodules. The underlying unit has been reported as the Gearle Siltstone (Condon & others, 1956) or as the Toolonga Calcilutite (van de Graaff & others 1977). Where the Korojon Calcarenite directly overlies the Toolonga Calcilutite in the Giralia Anticline, the contact is identifiable at a thin bed of phosphatic nodules.

Based on coccolith evidence in the present study, the bed of phosphatic nodules separating the type Korojon Calcarenite from the underlying Toolonga Calcilutite at C-Y Creek (Giralia Anticline) is considered as the base of the Korojon Calcarenite (discussed in later section of the study).

Foraminiferal evidence indicates that the main part of the Korojon Calcarenite is Campanian in age; the uppermost beds extend into the Maastrichtian (Edgell, 1952, 1954, 1957; Belford, 1958; McGowran, 1968). The main elements of the foraminiferal fauna of the Campanian part of the Korojon Calcarenite include the *Globotruncana linneiana* group, *Bolivina incrassata, Bolivinoides decorata australis* (McGowran, 1968).

Belford (1958) based the Maastrichtian age of the upper part of the Korojon Calcarenite on the occurrence of the foraminiferal species *Bolivinoides draco draco, B. decoratus giganteus, Neoflabellina reticulata* and *Pseudotextularia varians* (see also McGowran, 1962, 1968).

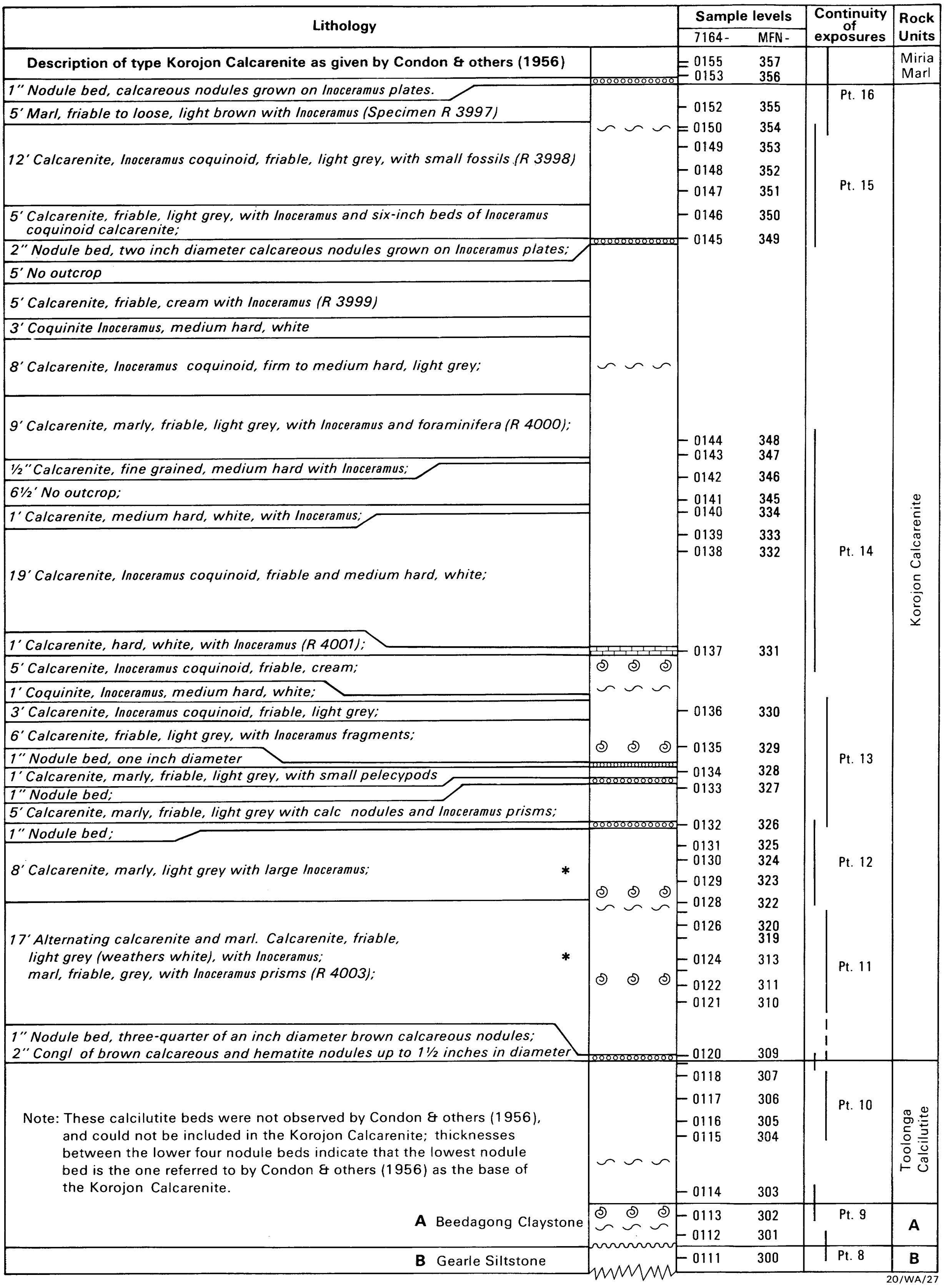
McGowran (1962, 1968, 1969, 1977, *in* Gartner & others, 1974) recorded and reviewed the foraminiferal faunas of the Korojon Calcarenite and the overlying Miria Marl and discussed the Maastrichtian foraminiferal biostratigraphy and biogeography of Western Australia and areas in Pakistan, India, Indian Ocean (Ninetyeast Ridge) and Papua New Guinea. According to McGowran (1977) key elements of the planktic foraminiferal assemblage of the Maastrichtian Korojon Calcarenite include *Rugoglobigerina pennyi/rugosa, Globotruncana lapparenti/linneina/arca, G. elevata* and *Globotruncanella citae*, in addition to *Racemiguembelina* sp. aff. *fructicosa* at the top of the unit.

Toolonga Calcilutite vs Korojon Calcarenite: remarks on a controversy

Johnstone & others (1958) pointed out some similarities between the upper part of the Toolonga Calcilutite in the Lower Murchison River area (southern Carnarvon Basin) and the base of the Korojon Calcarenite in the Giralia Anticline (northern Carnarvon Basin). McWhae & others (1958, p. 113) claimed that, in the central parts of the basin, subsurface Korojon Calcarenite "... appears as a lateral equivalent of the uppermost beds of the Toolonga Calcarenite". Subsequent workers adopted a similar notion: Condon (1968) promoted the concept that the Toolonga Calcilutite grades laterally into the Korojon Calcarenite; Bate (1972) considered the Korojon Calcarenite as "merely" a facies of the Toolonga Calcilutite; and Quilty (1975) suggested that the Korojon Calcarenite interfingers with the Toolonga Calcilutite. Indeed, some investigators (e.g. Bate, 1972; see Table 1) correlated the Campanian Korojon Calcarenite with the upper part of the Toolonga Calcilutite.

Evidence supporting the contention that the Korojon Calcarenite and Toolonga Calcilutite are partly or wholly equivalent has not been outlined by its advocates, and the available biostratigraphic evidence seems to negate this

Figure 9. The Upper Cretaceous sequence at C-Y Creek in the Giralia Anticline, type section of the Korojon Calcarenite.



Vertical scale 1:200. Nodule beds slightly exaggerated.

* Thickness of sequence does not correspond with subsequent field measurements.
Thickness of Korojon Calcarenite is, therefore 40.3 m and not 38.4 m (126 feet) as reported by Condon & others (1956)

Pt. 15	*Sampling location*
∽ ∽	*Interval between outcrops (gap or overlap in sampling)*
⊛	*Inoceramus*
ooooooo	*Nodule bed*
▭	*Hard calcarenite*

contention. Belford (1958) distinguished the Campanian part of the Korojon Calcarenite from that of the Toolonga Calcilutite by the restricted occurrence of the foraminiferal fauna *Bolivina incrassata, Cibicides voltziana, Globotruncana arca, Bolivinoides* sp. cf. *B. decoratus delicatus, B. decoratus australis, Stensioina pommerana* and *Neoflabellina* sp. cf. *N. numismalis* to the Korojon Calcarenite.

The occurrence of the Toolonga Calcilutite in the Giralia Anticline has always been doubtful until recently. Thus McWhae & others (1958, p. 113) stated that "the Korojon Calcarenite thickens to the north at the expense of the Toolonga Calcilutite, which is thin or absent on the Giralia Anticline". On the other hand, Condon (1968, p. 33) explicitly stated that the two formations "...cannot readily be distinguished ..." from each other, but reported a thickness of about 30 metres of Toolonga Calcilutite underlying the type Korojon Calcarenite in the Giralia Anticline! Playford & others (1975) contested that the Korojon Calcarenite conformably overlies the Toolonga Calcilutite, and van de Graaff & others (1977) were able to map the Toolonga Calcilutite -overlying the Gearle Siltstone and underlying the Korojon Calcarenite - in the Giralia Anticline.

Material studied from both the Toolonga Calcilutite and Korojon Calcarenite includes their type sections and other critical sections in areas (such as the Giralia Anticline and Exmouth Gulf) relevant to the above-mentioned controversy.

MIRIA MARL

The younger part of the Upper Cretaceous shelf carbonate sequence in the Carnarvon Basin is well exposed along the flanks of the Giralia Anticline, south of Exmouth Gulf (Fig. 8), where the type section of the Miria Marl (Miria Formation of Henderson & McNamara, 1985) is located (Condon & others, 1956; van de Graaff & others, 1977). There the Miria Marl disconformably overlies the Korojon Calcarenite. The Miria Marl type section, at Toothawarra Creek (Fig. 8), consists of about 1.3 metres of friable calcarenite and soft marl, rich with marine macro- and microfossils including ammonites, foraminifera and coccoliths. The Korojon/Miria contact is marked by a thin bed of phosphatic nodules, easily recognisable in weathered surfaces. The present study includes coccolith evidence to indicate that this nodule bed is best considered as the base of the Miria Marl.

The Miria Marl is overlain disconformably by the Paleocene Boongerooda Greensand. The contact is sharp and is marked by a very thin bed of coarse sands and gravels, which usually include small pieces of reworked Miria Marl as well as ammonite specimens (writer's own field observations).

The foraminiferal assemblage in the Miria Marl includes *Globotruncana mayaroensis* (=*Abathomphalus mayaroensis*), *Globotruncana arca, G. elevata, G. contusa, G.* sp. cf. *falsostuarti, Globotruncanella citae, Rugoglobigerina rugosa/pennyi, Pseudotextularia elegans/deformis, Gublerina cuvillieri, Bolivinoides draco draco, B. decoratus giganteus* and *Neoflabellina reticulata*, indicating a late Maastrichtian age (the *mayaroensis* zone: McGowran, 1962, 1968, 1977). Thierstein (1977) assigned a middle Maastrichtian age for a sample of Miria Marl from C-Y Creek; this probably was based on the presence of the nannofossil taxon *Lithraphidites quadratus*.Reports on ammonites from the Miria Marl suggested an early Maastrichtian (Spath, 1941), late Campanian to early Maastrichtian (Brunnschweiler, 1966) and Maastrichtian age (Henderson & McNamara, 1985) are at odds with the overwhelming foraminiferal evidence for the late Maastrichtian age (McGowran, 1962, 1968, 1977).

McGowran (1977) remarked on the absence of numerous Maastrichtian planktic foraminiferal species from the Korojon Calcarenite and Miria Marl assemblages, and pointed out that the latter were extratropical in contrast to those from Papua New Guinea.

Material studied includes three sets of samples representing the Miria Marl and the uppermost part of the Korojon Calcarenite in three outcrops at the Toothawara and C-Y Creeks in the Giralia Anticline (see Appendix A); these were collected by the writer in June of 1982 and 1983.

MATERIAL EXAMINED, COCCOLITH DISTRIBUTION AND SIGNIFICANCE

A brief description of each of the stratigraphic sections examined is given below; sample levels and other details are given in Appendix A. Coccolith distribution data presented in Cheklists 5-10 (Appendix B) is based chiefly on optical microscopy. Scanning electron microscopic examination of selected assemblages were undertaken mainly for taxonomic consideration.

BEEDAGONG CLAYSTONE "OUTCROPS", GIRALIA ANTICLINE

Excavation east of No. 10 Bore

The Gearle Siltstone/Beedagong Claystone contact is exposed in an excavation at a dam site (east of No. 10 Bore, see Fig. 8) in the central Giralia Anticline. The writer sampled this exposure in 1983. The lowest sample (MFN-2688) taken from the Gearle Siltstone just below its contact with Beedagong Claystone yielded a meagre assemblage (dominated by *Watznaueria barnesae* and *Eprolithus floralis*) typical of the Gearle Siltstone. The base of the Beedagong Claystone yielded a rich assemblage containing the key species *Eiffelithus eximius, Marthasterites furcatus*,*.Eiffellithus trabeculatus* and *Tranolithus orionatus* - which indicate an early Coniacian age -in addition to the other key species *Gartnerago obliquum* and *Quadrum gartneri.*

Lithasterinus grillii and *Reinhardtites biperforatus* first appear in sample MFN-2690 (Checklist 10), a few centimetres above the Gearle/Beedagong contact, in what can be referred to as transitional between Beedagong Claystone and Toolonga Calcilutite.

C-Y Creek outcrop

Among the samples collected by D.J. Belford in 1971 from the C-Y Creek sequence (Fig. 9), the sample MFN-301 was identified in the present study as Beedagong Claystone, and sample MFN-302 as transitional Beedagong Claystone/Toolonga Calcilutite. Sample MFN-301 is from immediately above the type Gearle Siltstone and sample MFN-302 is from below beds referable to the Toolonga Calcilutite. The assemblage recovered from the Beedagong sample (MFN-301) is poorer than the assemblages from higher levels in the Upper Cretaceous carbonates at C-Y Creek (Checklist 7 & Table 12). This assemblage includes the key species *Eiffellithus eximius, Microrhabdulus helicoideus, Marthasterites furcatus* and questionable *Reinhardtites biperforatus*, suggesting a maximum age of early Coniacian. The assemblage from the Beedagong/Toolonga transition (sample MFN-302) includes *Kamptnerius magnificus, Lithastrinus grillii* and *Micula concava*, in addition to *Marthasterites furcatus* and typical *Reinhardtites biperforatus.* This suggests a late Coniacian to early Santonian age.

Remarks. The coccolith evidence from the Beedagong Claystone in the central Giralia Anticline suggests that the unit is represented by a very condensed sequence there: the unit is only a few centimetres east of No. 10 Bore, and is probably less than two metres in thickness at C-Y Creek (to the north), whereas in contrast, its type section in the Rough Range (further to the north) is more than 80 metres thick. Also, it points to a sharp change in the palaeoenvironment: from a restricted (marginal) marine during the deposition of the Gearle Siltstone to open-marine conditions at the onset of the deposition of the Beedagong Claystone. (Nannofossil assemblages of the type Beedagong Claystone are discussed on p. 45.)

TOOLONGA CALCILUTITE OUTCROPS

Several outcrops of the Toolonga Calcilutite (Fig. 10) in the Lower Murchison River area (type area of the formation) and in the Shark Bay-Lower Wooramel River area to the north (Fig. 6) were studied. Also the outcropping Toolonga Calcilutite in the Giralia Anticline is discussed.

Toolonga Point outcrop

Two samples from the lower part of the basal chalk unit of the Toolonga Calcilutite from an outcrop at Toolonga Point, Lower Murchison River area, were examined; there, the Alinga/Toolonga contact is not well exposed. Assemblages recovered are poorly preserved, mainly due to recrystallisation. However, the key species *Kamptnerius magnificus, Eiffellithus eximius, Reinhardtites anthophorus* and *R. biperforatus* could be identified from the lower sample (MFN-364), in addition to *Cyclidralithus biarcus, Gartnerago obliquum, Haqius circumradiatus, Prediscosphaera cretacea* and *Watznaueria barnesae.* The assemblage from the higher sample (MFN-365) is richer, containing *Lucianorhabdus cayeuxii, Tranolithus orionatus, Cribrosphaerella ehrenbergii* and *Micula staurophora.*

The presence of the index species *Reinhartites anthophorus* in the lower assemblage (sample MFN-364) from near the base of the Toolonga Calcilutite suggests that the age of the basal part of the unit is early Santonian. A similar age determination for the chalk unit in the basal part of the Toolonga Calcilutite was reached previously, based on the occurrence of the crinoid genera *Uintacrinus* and *Marsupites.* As discussed earlier in the study, coccoliths from the underlying Alinga Formation in the same section suggest an early Turonian age. A disconformity between the lower Turonian Alinga Formation and the lower Santonian Toolonga Calcilutite is, therefore, suggested at Toolonga Point (Lower Murchison River area), confirming the view held by many authors (e.g. Playford & others, 1975).

Alinga Point outcrops

The lower part of the Toolonga Calcilutite and its contact with the underlying Alinga Formation are well exposed at Alinga Point in the Lower Murchison River area. Abundant coccoliths occur at all levels of the Toolonga Calcilutite in this outcrop, in contrast with their rare and sporadic occurrences in the underlying Alinga Formation. The distribution of coccoliths in the Alinga Point outcrop is given in Checklist 5, and a biostratigraphic summary is presented in Table 11.

Coccolith assemblages from the basal Toolonga Calcilutite show effects of dissolution and signs of overgrowth; coccolith fragments occasionally predominate. Poor preservation is also noted in the upper part of the formation, below the travertinised carbonates. *Gephyrorhabdus coronadventis* and *Kamptnerius magnificus* are persistent in most assemblages, and *Lapideacassis* spp. are particularly prominent in the basal assemblages. The nannoflora recovered from the very base of the formation is somewhat similar to that recovered from the underlying nodule bed. It includes the key species *Ahmuellerella octoradiata, Cyclidrallithus biarcus, Eiffellithus eximius, E. trabeculatus, Gartnerago obliquum, Kamptnerius magnificus, Tranolithus orionatus* and *Quadrum gartneri.*

Several biostratigraphic events are discernible in the Toolonga Calcilutite of Alinga Point (see Table 11). The lowest occurrence of *Reinhardtites anthophorus*, indicative of an early Santonian age, is about 10 cm above the nodule bed.

Table 11. Coccolith biostratigraphic summary of Alinga point section, Lower Murchison River area.

TOOLONGA CALCILUTITE:

travertinised carbonates barren of coccoliths

---12 m

----------------*_Broinsonia parca_--------------------

----------------*_Calculites obscurus_------------4.9 m

----------------*_Lucianorhabdus cayeuxii_-----1.1 m

----------------*_Acuturris scotus_----------------0.7 m

----------------*_Reinhardtites anthophorus_---0.1 m

Peservation is poor. Assemblage similar to that from the nodule bed below.

---0.0 m

nodule bed: poorly preserved but diversified assemblage containing the key species *Eiffellithus eximius, Kamptnerius magnificus, Micula concava* and *Reinhardtites biperforatus*, suggesting a late Coniacian to early Santonian age.

DISCONFORMITY

type ALINGA FORMATION: almost devoid of coccoliths except for rare specimen/fragment of *Watznaueria barnesae*. Signs of severe etching is evident. Coccolith evidence from elsewhere suggests an early Turonian age for the Alinga Formation.

***Lowest occurrence**

figures are levels in metres within the Toolonga Calcilutite, measured from the top of the nodule bed.

Forms approaching typical *Broinsonia parca* occur in the top five metres of the Toolonga Calcilutite below the travertinised carbonates. Typical *B. parca* seems to have its lowest occurrence about 50 cm below the barren travertinised carbonates, but poor preservation of the assemblages of the uppermost part of the Toolonga Calcilutite limits the confidence of identification of the species, particularly *B. parca* which is indicative of early Campanian age.

Remarks. Based on the data discussed above, the outcropping Toolonga Calcilutite at Alinga Point ranges in age from late Coniacian/early Santonian to early Campanian. As indicated earlier in the study, the coccolith evidence from the phosphatic nodule bed, between the Toolonga Calcilutite and the underlying Alinga Formation in the same section, suggests an age of late Coniacian to early Santonian. The virtually identical ages of the nodule bed and the chalk unit of the basal Toolonga Calcilutite suggests that the nodule bed was formed at the beginning of the sedimentation cycle which produced the Toolonga Calcilutite. The evidence for a disconformity (lower Turonian/lower Santonian) between the Alinga Formation and the Toolonga Calcilutite at Toolonga Point supports this conclusion.

The similarities between the Toolonga Calcilutite and Gingin Chalk of the Perth Basin are striking. The stratigraphic setting is the same, both units represent the basal Upper Cretaceous carbonate unit, immediately above a clastic section; the calcareous nannofossil assemblages recovered from the two formations are similar, and their age is early Santonian to early Campanian. The same origin of the phosphatic nodule bed at the base of the Gingin Chalk at Molecap Hill, outlined earlier in this study (p. 29), is also proposed for the phosphatic nodule bed at the base of the Toolonga Calcilutite at Alinga Point.

The Gingin Chalk is thought to have been deposited in a rapidly advancing sea, with the result that the base of the unit is almost isochronous, and it is not unreasonable to suggest the same for the Toolonga Calcilutite.

Toolonga Hills section

The base of the Toolonga Calcilutite is not well exposed in the Toolonga Hills section (Lower Murchison River area), but the chalky basal beds were sampled. Diversified coccolith assemblages were recovered from this section (see Checklist 7). The assemblage recovered from the basal beds (sample MFN-2548) already contains the key species *Acuturris scotus*, *Eiffillithus eximius*, *Lucianorhabdus cayeuxii*, *Reinhardtites anthophorus*, *R. biperforatus* and *Kamptnerius magnificus*, suggesting a mid Santonian age. *Cylindralithus biarcus*, *Gartnerago obliquum*, *Microrhabdulus helicoideus Seribiscutum primitivum* are also present. The marker species *Calculites obscurus* (late Santonian) first appears about 3.6 metres above the base of the chalk unit in this outcrop.

The lower part of the Toolonga Hills outcrop ranges in age from mid to late Santonian, based on coccoliths.

Pillarawa Hill section

The lower part of the Toolonga Calcilutite is well exposed at Pillarawa Hill, Lower Murchison River area. Abundant coccoliths in a moderate state of preservation were recovered. The distribution of these fossils in the samples examined is given in Checklist 6.

An assemblage recovered from about 50 cm above the base of the Toolonga Calcilutite (sample MFN-254) includes *Eiffellithus eximius*, *Kamptnerius magnificus*, *Acuturris scotus*, *Lucianorhabdus cayeuxii*, *L. maleformis*, *Reinhardtites anthophorus*, *Broinsonia pseudoparca* and *Calculites ovalis*, suggesting a mid Santonian age.

The late Santonian marker, *Calculites obscurus*, first appears about 3.5 metres above the base of the formation (sample MFN-257). Forms of *Broinsonia* approaching *B. parca* occur in the top three metres of the Toolonga Calcilutite at Pillarawa Hill.

The Toolonga Calcilutite examined from Pillarawa Hill ranges in age from mid to late Santonian age, with the topmost beds probably being earliest Campanian.

Outcrop at Yaringa North Station

About 5.5 metres of Toolonga Calcilutite are exposed near Yaringa North Homestead. Seven samples were obtained from this exposure. Coccolith assemblage from the base of the outcrop includes *Broinsonia parca*, *Braarudosphaera bigelowii*, *Calculites obscurus*, *C. ovalis*, *Kamptnerius magnificus* and *Lucianorhabdus cayeuxii*. Most of these species uniformly occur throughout the outcrop (Checklist 6).

The association of *Broinsonia parca*, *Eiffellithus eximius* and *Calculites obscurus* suggests an early Campanian age for the entire Toolonga Calcilutite outcrop at Yaringa North Station.

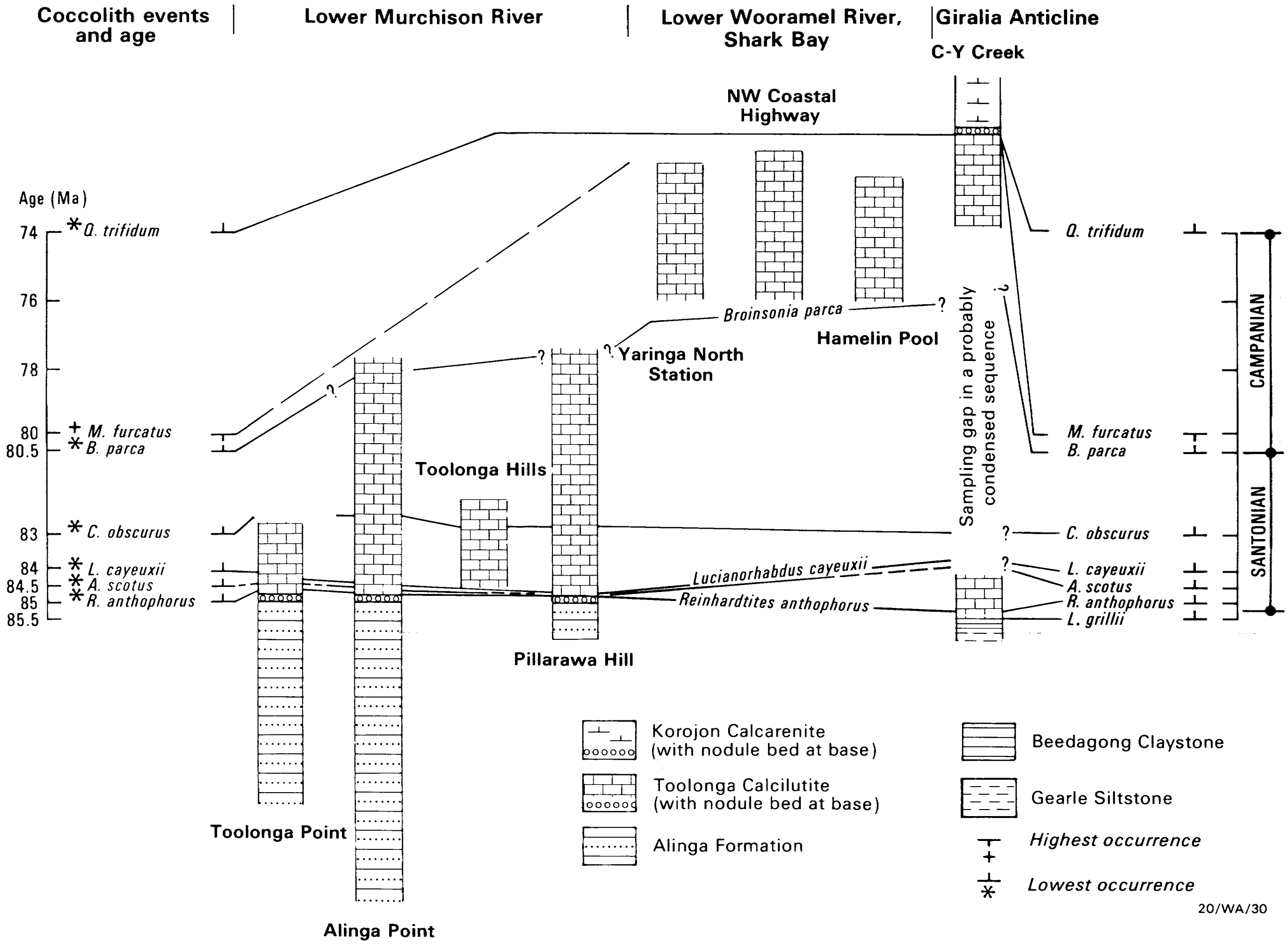
Outcrop on NW Coastal Highway near Wooramel

About 6.75 metres of Toolonga Calcilutite are exposed in an outcrop on the western side of the Northwestern Coastal Highway near Wooramel (Fig. 6). Eight samples from this outcrop were examined. The assemblages recovered from these samples are without significant differences, resembling those from the base of the outcrop. These include *Broinsonia parca*, *Calculites obscurus*, *C. ovalis*, *Kamptnerius magnificus* and *Lucianorhabdus cayeuxii* (Checklist 6), suggesting an early Campanian age.

Coastal outcrop at Hamelin Pool

About 5.20 metres of Toolonga Calcilutite is exposed in the cliffs at Hamelin Pool in the Shark Bay area (Fig. 6). Coccolith distribution in eight samples collected from a section in these cliffs is given in Checklist 6.

Figure 10. Correlation between the various sections of the Toolonga Calcilutite (including the type), based on coccolith biostratigraphic events.



The assemblages were found to be very similar to those recorded from the outcrops near Wooramel and Yaringa North Station in the Lower Woomeral River area. The base of the Hamelin Pool outcrop yielded the key species *Broinsonia parca, Lucianorhabdus cayeuxii, L. maleformis, Eiffellithus eximius, Reinhardtites anthophorus* and *Calculites obscurus*, suggesting an early Campanian age. These species occur uniformly thoughout the outcrop.

Remarks. The coccolith evidence indicates that the outcropping Toolonga Calcilutite in the southern Carnarvon Basin (Lower Murchison River area and Shark Bay-Lower Wooramel River area) ranges in age from late Coniacian/early Santonian (being the age of the nodule bed or early Santonian being the age of the basal chalk) to early Campanian. Outcrops in the Lower Murchison River area are mainly Santonian, with only the very top part ranging into early Campanian. In contrast, the entire outcrops in the Shark Bay-Lower Wooramel River area are early Campanian in age; evidently, in this area the Santonian part of the Toolonga Calcilutite is not exposed.

The disconformity between the Alinga Formation and Toolonga Calcilutite in the Lower Murchison River area, suggested by the coccolith evidence presented above, indicates a period of non-deposition during most of the Turonian and Coniacian. Thus, a new sedimentation cycle began during the late Coniacian/early Santonian and continued into the early Campanian, resulting in the formation of the Toolonga Calcilutite with a phosphatic nodule bed at its base.

The occurrence of the species *Braarudosphaera bigelowii, Acuturris scotus, Calculites obscurus, C. ovalis, Lucianorhabdus cayeuxii, L. maleformis* and *Kamptnerius magnificus* in most of the samples examined from the Toolonga Calcilutite outcrops in the southern Carnarvon Basin suggests deposition in a nearshore or shelf environment.

The small sediment thicknesses between coccolith events in the lowermost part of the Toolonga Calcilutite (Fig. 10), immediately above the Alinga Formation, at Alinga Point, Toolonga Point and Pillarawa Hill sections

(Lower Murchison River area), compared with higher up in the sections suggest slow rates of sedimentation during the early phases of Upper Cretaceous carbonate accumulation in the southern Carnarvon Basin. This is consistent with the proposed origin of the phosphatic nodule bed at the base of the Toolonga Calcilutite.

C-Y Creek outcrops, Giralia Anticline

The Toolonga Calcilutite is poorly exposed in the Giralia Anticline. In 1971, D.J. Belford collected six calcilutite samples from two exposures below the lowest nodule bed (which is at the base of the Korojon Calcarenite) in the C-Y Creek sequence (Fig. 9). Five of these are thought to represent the Toolonga Calcilutite; the sixth sample (MFN-302) is probably transitional Beedagong Claystone/Toolonga Calcilutite, yielding an older coccolith assemblage (see Checklist 7 & Table 12).

Assemblages from the Beedagong/Toolonga transition and basal Toolonga (samples MFN-302 & MFN-303) include the key species *Kamptnerius magnificus, Lithastrinus grillii, Marthasterites furcatus, Micula concava, M. staurophora* and *Reinhardtites biperforatus*, in addition to forms resembling *Reinhardtites anthophorus*. Typical *R. anthophorus* is present, being identifiable with confidence only in the higher assemblage (MFN-303). The assemblages also include *Cylindralithus biarcus, Eiffellithus eximius, Gartnerago obliquum, Gephyrorhabdus coronadventis, Tranolithus orionatus, Quadrum gartneri* and *Zygodiscus bicrescenticus*. These nannofloras are thought to range in age from late Coniacian to early Santonian; the presence of typical *Reinhardtites anthophorus* supports the younger age.

The higher samples (MFN-304 to MFN-307), which were obtained from another exposure (Fig. 9, see Appendix A for details), yielded much younger assemblages including the species *Broinsonia parca, B. dentata, Acuturris scotus, Calculites obscurus, C. ovalis, Eiffellithus eximius, Gartnerago obliquum, Kamptnerius magnificus, Lucianorhabdus cayeuxii, Marthasterites furcatus, Lithastrinus grillii* and *Micula concava*. These are early Campanian in age, on account of the overlap in the ranges of *Broinsonia parca* and *Marthasterites furcatus*.

Remarks. In the C-Y Creek section, the coccolith evidence from the Beedagong Claystone, undifferentiated Beedagong/Toolonga and basal Toolonga Calcilutite (samples MFN-301, MFN-302 & MFN-303), together with the lithological evidence indicate continuous sedimentation between the Beedagong Claystone and Toolonga Calcilutite. This is highly significant, particularly in view of the

Table 12. Coccolith biostratigraphic summary the Upper Cretaceous carbonates of C-Y Creek sequence, Giralia Anticline.

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MIRIA MARL: late Maastrichtian assemblages (see Table 13).

------------------------*_Nephrolithus frequens_------------

Biostratigraphic discontinuity

------------------------+_Broinsonia parca_-----------------

type KOROJON CALCARENITE: late Campanian to early Maastrichtian assemblages. The key species *Petrorhabdus copulatus, Q. gothicum* and *Q. trifidum* are rare and sporadic. *Q. trifidum* more frequent in lower part of the formation, absent from its top part. *Broinsonia parca, Ceratolithoides aculeus* and *Reinhardtites anthophorus/R. levis* group are more abundant and persistent. Hemipelagic species are present. *Misceomarginatus pleniporus* occurs at one horizon.

----

nodule bed: the index species *Ceratolithoides aculeus, Quadrum gothicum , Q. trifidum* and *Reinhardtites anthophorus/levis* are present.

------------------------*_Reinhardtites levis s.l._------------

*_Quadrum trifidum_

Biostratigraphic discontinuity

------------------------+_Tranolithus orionatus_------------

TOOLONGA CALCILUTITE: early Campanian assemblages. *Broinsonia parca, Calculites obscurus, Eiffellithus eximius* and *Marthasterites furcatus* co-occur. *Tranolithus orionatus* is common. Several hemipelagic species are present.

------------------------*_Broinsonia parca_-----------------

Sampling gap

----

basal TOOLONGA CALCILUTITE: early Santonian assemblage similar to below with the addition of *Reinhardtites anthophorus*.

------------------------*_Reinhardtites anthophorus_-------

BEEDAGONG/TOOLONGA transition: late Coniacian to early Santonian assemblages including the key species *Reinhardtites biperforatus, Marthasterites furcatus, Micula concava, Lithastrinus grillii* and *Kamptnerius magnificus*.

BEEDAGONG CLAYSTONE: very condensed sequence with abundant coccoliths including *Eiffellithus eximius, Microrhabdulus helicoideus* and *Marthsterites furcatus* suggesting a Coniacian age.

Hiatus

Gearle Siltstone: mostly barren of coccoliths. Rare coccoliths dominated by *Watznaueria barnesae* and *Lithastrinus floralis*, at one level within the top part of the unit.

==================================

***Lowest occurrence +Highest occurrence**

conclusion reached above (p. 38), that this part of the C-Y Creek section represents a condensed sequence.

The apparent large age-gap between the early Santonian (MFN-303) and early Campanian (MFN-304) assemblages in C-Y Creek, is thought to be a result of inadequate sampling due to poor exposure of the Toolonga Calcilutite, rather than the presence of a sedimentation break. This sampling gap appears to be great because the Toolonga Calcilutite in Giralia Anticline is condensed, when compared with the same formation in the southern parts of the Carnarvon Basin.

The lower Santonian part of the Toolonga Calcilutite at C-Y Creek, Giralia Anticline (sample MFN-303), correlates well with the lowest part of the formation in the Lower Murchison River area (e.g. at Alinga Point, see Fig. 10) based on their coccolith species. Similarly, the lower Campanian part of the Toolonga at C-Y Creek, compares well with outcrops of the formation studied in the Shark Bay-Lower Wooramel River area (e.g. at Hamelin Pool).

TYPE KOROJON CALCARENITE, C-Y CREEK OUTCROPS, GIRALIA ANTICLINE

Sample MFN-309 examined from the phosphatic nodule bed at the base of the type Korojon Calcarenite (C-Y Creek sequence; Fig. 9) yielded a rich coccolith assemblage. Most key species are rare, however. *Quadrum gothicum, Q. trifidum* and *Petrarhabdus copulatus* were encountered, but in low numbers; *Q. trifidum* is particularly very rare. Other key species such as *Broinsonia parca, Ceratolithoides aculeus* and the *Reinhardtites anthophorus/R. levis* group are more abundant. Coccolith distribution in the C-Y Creek outcrops is given in Checklist 7, and coccolith biostratigraphic summaries are given in Tables 12 and 13.

Quadrum trifidum is not only rare but also very sporadic in the type Korojon Calcarenite. The next higher record of the species is in sample MFN-312, about 4 metres above the base of the formation. *Quadrum gothicum* is more persistent than *Q. trifidum*, occurring at more levels.

The key species *Broinsonia parca* ranges throughout the type Korojon Calcarenite section, being present at almost all levels examined. *Misceomarginatus pleniporus* was found at two levels only (samples MFN-311 & MFN-315), in association with rare *Quadrum gothicum* and *Ceratolithoides aculeus*, frequent *Petrarhabdus copulatus*, and common *Broisonia parca*. *Quadrum trifidum* was not found at either levels.

Remarks. The sudden up-section appearance of the key species *Ceratolitoides aculeus, Quadrum gothicum* and *Q. trifidum* at the Toolonga Calcilutite/Korojon Calcarenite contact in the C-Y Creek section suggests a biostratigraphic discontinuity or a disconformity. The index species *Marthasterites furcatus* disappears just below this disconformity. The abundance of the index species *Eiffellithus eximius* declines drastically at the disconformity, and there is a sudden increase in the overall size of *Broinsonia parca* immediately above the Toolonga/Korojon contact.

It is worth noting the similarity in the stratigraphic setting at the Toolonga/Korojon contact with that at the Alinga Formation/Toolonga Calcilutite contact. In both cases, a phosphatic nodule bed is at the base of the younger unit immediately above a disconformity. (The same is true also for the Molecap Greensand/Gingin Chalk contact in the Perth Basin.) A similar origin for the phosphatic nodule bed at the base of the Gingin Chalk, Toolonga Calcilutite and Korojon Calcarenite is, therefore, suggested.

The occurrence of several hemipelagic species, such as *Braarudosphaera bigelowii, Calculites obscurus* and *Lucianorhabdus cayeuxii*, in the type Korojon Calcarenite suggests that its deposition was in a nearshore or shelf environment.

The occurrence of the cold-water indicator *Misceomarginatus pleniporus* in the type Korojon calcarenite at one horizon, suggests a cold spell during the late Campanian to early Maastrichtian interval in the Carnarvon Basin.

Age of Toolonga Calcilutite/Korojon Calcarenite: a discussion.

As can be deduced earlier in this study, the stratigraphic controversy concerning the Toolonga Calcilutite and Korojon Calcarenite lacks solid evidence substantiating the long-standing assertion by several authors (e.g. McWhae & others, 1958; Bate, 1972) that the two units are, at least in part, equivalents (see Table 1). Clark (1979) used foraminiferal evidence to distinguish the Toolonga Calcilutite from the Korojon Calcarenite in the C-Y Creek section of the Giralia Anticline (see also Belford, 1958). The record, in the present study, of hiatus between these formations in the same section confirms that they are discrete units.

The coccolith evidence in the present study indicates that the age of the Toolonga Calcilutite outcrops in its type area, and in the Shark Bay-Lower Wooramel River area, ranges from late Coniacian/early Santonian to early Campanian, whereas the type Korojon Calcarenite is late Campanian to early Maastrichtian. The species *Ceratolithoides aculeus* and *Quadrum gothicum*, frequently found in the Campanian part of the type Korojon, are substantially younger than the coccolith elements from the Campanian Toolonga outcrops. Similarly, several foraminiferal species which were found in the Campanian Korojon but not in the Campanian Toolonga were noted by Belford (1958).

The evidence presented in this study rejects the claims that the Toolonga Calcilutite and Korojon Calcarenite are even partly coeval; instead, they are regarded as two discrete formations of different ages.

MIRIA MARL, GIRALIA ANTICLINE

Coccolith distribution in the uppermost Korojon Calcarenite and Miria Marl in three outcrops in the Giralia Anticline are given in Checklist 8, and a biostratigraphic summary is presented in Table 13; coccoliths from reworked Miria Marl at the base of the Boongerooda Greensand are also included.

Maastrichtian key species (see Tables 2 & 20) are either absent, or rare and sporadic, in the Miria Marl and underlying Korojon Calcarenite. Coccolith species diversity is high in the Miria Marl, but the frequency of most species is low. The significant differences in the recorded coccolith distribution, particularly the stratigraphically important species, between the sections studied (Checklist 8) are basically attributed to the usual extreme rarity of these important species, coupled by highly varied species abundance and states of preservation, at different levels and in the different sections. *Nephrolithus frequens* was encountered more frequently in the type section of the Miria Marl than in a nearby section. Similarly, *Cribrosphaerella daniae* was encountered, though rarely, in the uppermost part of the Korojon Calcarenite at Toothawarra Creek (TOB83 section), and not in the coeval part of the same unit at C-Y Creek (CY83 section); very rare *Nephrolithus corystus* was found in the upper part of the Korojon Calcarenite in both sections.

Cribrosphaerella daniae is extremely rare in the uppermost part of the Korojon Calcarenite, and seems to be absent in the remaining part of this formation, and is therefore of little or no use for delineating the Campanian/Maastrichtian boundary. There is some coccolith evidence in the type Korojon Calcarenite to suggest that its upper part is Maastrichtian in age: *Quadrum trifidum*, although present in small numbers, is more persistent in the lower part of the type Korojon Calcarenite than in its upper part, but is entirely absent in the uppermost part. It is generally accepted that the extinction of *Quadrum trifidum* occurred during the early Maastrichtian.

An hiatus, similar to that indicated at Breton Bay in the Perth Basin, exists in the Giralia Anticline at the Korojon/Miria contact, where some minor reworking may have taken place: *Nephrolithus frequens* and *Lithraphidites*

Table 13. Coccolith biostratigraphic summary of uppermost Korojon Calcarenite and Miria Marl outcrops in Toothawarra and C-Y Creeks, Giralia Anticline.

Formation		Characteristics of assemblages and other
BOONGEROODA GREENSAND (basal part)		Mid Paleocene coccoliths with some reworked late Cretaceous forms. Basal few centimetres usually contain discrete pieces of reworked Miria Marl yielding exclusively latest Maastrichtian coccoliths: *Micula prinsii, M. murus, Nephrolithus frequens* and *Ceratolithoides kamptneri*
DISCONFORMITY		
MIRIA MARL	(main part)	Highly variable late Maastrichtian assemblages. Key taxa such as *Nephrolithus frequens* and *Micula murus* are rare and sporadic; *N. frequens* is somewhat more consistent. *Lithraphidites quadratus* and *Ceratolithoides aculeus* are more frequent and consistent. *Braarudosphaera bigelowii* and other evidence of shelf deposition are prominent. Scarce *Eiffellithus eximius. Cribrosphaerella daniae* is extremely rare and very occasional.
	'nodule bed'	Marking a sharp decrease in sedimentation rates, at the base of the Miria Marl. It includes some evidence of reworking: *Nephrolithus frequens* and *Lithraphidites quadratus* in association with *Broinsonia parca*.
DISCONFORMITY		
KOROJON CALCARENITE (type section)		Late Campanian — early Maastrichtian assemblages. Rare *Quadrum trifidum:* consistent in the lower part, absent in the uppermost part. *Zygodiscus bierescenticus, Reinhardtites anthophorus/R. levis* and consistent *Broinsonia parca* disappear near the top. *Ceratolithoides aculeus* is frequent. *Cribrosphaerella daniae* and *Nephrolithus corystus* are absent or extremely rare at the top.

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quadratus are found together, associated with *Broinsonia parca* in the phosphatic nodule bed at the base of the Miria Marl in an outcrop at Toothawarra Creek (Giralia Anticline) in the immediate vicinity of the type section of the formation. *Nephrolithus frequens* and *Lithraphidites quadratus* are not known from the Korojon Calcarenite, and their simultaneous appearance at the base of the Miria Marl must indicate a biostratigraphic break similar to that in the Perth Basin, i.e. the middle and probably part of the late Maastrichtian are not represented in the Giralia Anticline sequence. The occurrence of *Broinsonia parca* in the nodule bed at the base of the Miria Marl (Toothawarra Creek outcrop) is taken to indicate some minor reworking from the Korojon Calcarenite below: B. *parca* ranges through most of the type Korojon Calcarenite (at C-Y Creek), including those parts of the formation representing the early Maastrichtian, but becomes exceedingly rare or absent near the top. The species is ordinarily absent from the Miria Marl (except for such an occasional reworked occurrence at the base of the formation). Coincident with the biostratigraphic discontinuity are the events marked by the highest occurrences of *Zygodiscus bicrescenticus* and *Reinhardtites levis* s.l.. These events are biostratigraphically important as they can be identified in both the Carnarvon and Perth Basins.

Nephrolithus frequens and *Micula murus* occur together in the Miria Marl: *N. frequens*, although rare, is more frequent than *Micula murus*, and the latter appears to be persistent only at the top of the formation. *Lithraphidites quadratus* and *Ceratolithoides aculeus* occur uniformly throughout the formation, and the former is a reliable indicator for identifying the Miria Marl from the subsurface (as it is unknown in the Korojon Calcarenite). (The middle Maastrichtian age given by Thierstein, 1977, for a sample of Miria Marl is likely to have been based on the presence of *Lithraphidites quadratus* in the absence of both *Micula murus* and *Nephrolithus frequens*, given the usual rarity of the latter two species in the Miria Marl.)

Reworked Miria Marl in the basal few centimetres of the Paleocene Boongerooda Greensand at outcrops in the Giralia Anticline, yielded latest Maastrichtian coccoliths including *Micula prinsii*, *Cribrocorona gallica*, *Nephrolithus frequens*, and *Ceratolithoides kamptneri*. This indicates that deposition of the Miria Marl continued into the latest Maastrichtian, but the resultant sediments were eroded and/or incorporated during the subsequent Paleocene sedimentation.

Deposition of the upper part of the Korojon Calcarenite and the Miria Marl occurred in a nearshore or shelf environment. The coccolith evidence includes the occurrence of species indicative of shallow-water deposition such as persistent *Actinozygus regularis* and *Braarudosphaera bigelowii*, and the occasional *Acuturris scotus*, *Calculites obscurus* and *Lucianorhabdus cayeuxii* (Checklist 8).

Remarks. The coccolith evidence of minor reworking detected in the phosphatic nodule bed at the base of the Miria Marl in the Giralia Anticline supports the envisaged mechanism for the formation of this nodule bed, as being similar to the mechanism outlined for the formation of the phosphatic nodule bed at the base of the Gingin Chalk (on p. 29).

ROUGH RANGE SOUTH #1 WELL: TYPE SECTION OF BEEDAGONG CLAYSTONE

This well is located on the Rough Range, north of the Giralia Anticline (at Lat. 22° 37' 17.5" S - Long. 113° 57' 37.6" E). It was drilled by WAPET during 1956. It penetrated a Cainozoic - Cretaceous sequence of more than 853.4 metres (2800 feet). The Korojon Calcarenite was identified as occurring between 680.3- and 725.4-metre levels (2232-2380 feet), and the Toolonga Calcilutite was thought to extend below the Korojon Calcarenite to the 755.9-metre level (2480 feet). The Beedagong Claystone type section, which was originally known as the "upper Gearle Siltstone", occurs in the Rough Range South #1 well between 755.9- and 838.2-metre levels (2480-2750 feet) (Fig. 7). The Gearle Siltstone (originally identified as the "lower Gearle Siltstone") extends below the Beedagong Claystone down to the bottom of the well at 873.5-metre level (2866 feet). The Korojon Calcarenite and the Toolonga Calcilutite are represented in this study by three conventional cores each. The Beedagong Claystone is well represented by eight conventional cores, and the Gearle Siltstone is represented by three cores.

Coccolith distribution in the cores examined from Rough Range South #1 well is given in Checklist 9, and a biostratigraphic summary is given in Table 14.

The key species *Ceratolithoides aculeus*, *Petrarhabdus copulatus*, *Quadrum gothicum*, *Q. trifidum*, *Broinsonia parca*, and the *Reinhardtites anthophorus*/*R. levis* group, occur in the Korojon Calcarenite in Rough Range South #1 well. *Quadrum trifidum* is sporadic, but is present in core 55 (719.9- 722.9 metres) (MFN-278) taken from near the base of the formation. *Quadrum gothicum*, though also rare, is more frequent than *Q. trifidum*. *Acuturris scotus*, *Calculites obscurus*, *C. ovalis*, and *Lucianorhabdus cayeuxii* are also present in the Korojon Calcarenite.

Assemblages recovered from the Toolonga Calcilutite cores include *Broisonia parca, Calculites obscurus, Eiffellithus eximius, Marthasterites furcatus* and *Tranolithus orionatus*. Specimens of *Broinsonia parca* are smaller (and the ratio of its central area to rim width is larger) than those occurring in the overlying Korojon Calcarenite.

The type Beedagong Claystone cores yielded rich coccolith assemblages which contrast sharply with the meagre assemblages from the Gearle Siltstone below. The upper half of the Beedagong Claystone may be characterised by the occurrence of the key species *Marthasterites furcatus*. The first up-sequence occurrence of *Lithastrinus grillii* is in core 61 (MFN-1990), and *Reinhardtites biperforatus* first occurs in core 63 (MFN-4429), above the lowest occurrence of *Marthasterites furcatus*. Forms assignable to *Micula staurophora* occur near the top of the Beedagong Claystone in core 61 (762-763.5 metres) (MFN-1990).

The lowermost part of the Beedagong Claystone contains the key species *Ahmuellerella octoradiata* and *Kamptnerius magnificus* and *Eiffellithus* sp. aff. *eximius*. Typical *E. eximius* occurs slightly higher in core 67 (819.3-821.7 metres) (MFN-1981).

Remarks. The expanded sequence of the Beedagong Claystone in the Rough Range area sharply contrasts with the very condensed sequence of the formation in the central Giralia Anticline.

Assemblages recorded from the exposures comprising the basal Beedagong Claystone and the overlying undifferentiated Beedagong Claystone/Toolonga Calcilutite (Checklists 7 & 10) in the central Giralia Anticline, fit well within the biostratigraphic sequence of events recognised in the type Beedagong Claystone (Table 14), at least partly confirming it.

OTHER SUBSURFACE SECTIONS

The Upper Cretaceous coccolith biostratigraphy of several wells is discussed below; the order of presentation is mainly geographic, from south to north.

Table 14. Coccolith biostratigraphic summary of the Upper Cretaceous of Rough Range South #1 well.

GIRALIA CALCARENITE equivalent: Eocene calcareous nannofossils.

--680.3 m

KOROJON CALCARENITE: key species include persistent *Ceratolithoides aculeus, Quadrum gothicum, Broinsonia parca* and *Reinharditites levis s.l.*; *Petrorhabdus copulatus* and *Q. trifidum* are sporadic but occur in the lower part. *Cribrosphaerella circula, Gartnerago obliquum, Markalius astroporus* and *Micula* sp. resembling *M. praemurus* are present. Several hemipelagic species are also present.

--------------------**Quadrum trifidum*---------725.4 m

Sampling gap

TOOLONGA CALCILUTITE: *Broinsonia parca, Eiffellithus eximius* and *Marthasterites furcatus* are present; *B. parca* is smaller than in above, and *E. eximius* is more common than above. *Tranolithus orionatus, Kamptnerius magnificus, Reinhardtites anthophorus* and a host of holococcoliths such as *Calculites obscurus, C. ovalis, Lucianorhabdus cayeuxii* and *L. maleformis* are frequent.

-------------**Broinsonia parca*-----------745.8 m

------------------Sampling gap------------------755.9 m

--762.0 m

BEEDAGONG CLAYSTONE:

-------------**Reinhardtites biperforatus*-768.0 m

-------------**Marthasterites furcatus*-----801.6 m

-------------**Eiffellithus eximius*----------821.7 m

-------------**Kamptnerius magnificus*---830.6 m

Sampling gap

--838.2 m

GEARLE SILTSTONE: very rare coccoliths mainly *Watznaueria barnesae* and *Eprolithus floralis*.

***Lowest occurrence**

figures are levels in metres in the well.

Dirk Hartog wells

A synthesis of the biostratigraphy of the Upper Cretaceous carbonate sequence studied in the Dirk Hartog wells is presented in Table 15. Individual Dirk Hartog wells are discussed in detail below, beginning with the section with the older Upper Cretaceous cores.

Dirk Hartog #17B. This well is located at Lat. 25° 51' 58" S - Long. 113° 04' 40.5" E (Fig. 6). Three cores were studied from the Toolonga Calcilutite section in Dirk Hartog #17B. Rich assemblages were identified, though preservation is only moderate with signs of recrystallisation being evident. Core 1 (533.4-539.5 metres) (1750-1770 feet) (MFN-415) contains the index species *Broinsonia parca, Eiffellithus eximius, Lucianorhabdus cayeuxii, L. maleformis, Micula concava, M. staurophora, Kamptnerius magnificus, Reinhardtites anthophorus, Tranolithus orionatus* and *Zygodiscus bicrescenticus*. The assemblage identified from core 2 (563.8-569.3 metres) (1850-1868 feet) (MFN-416) is similar to that from core 1. However, *Broinsonia parca* is not as typical as in core 1, being essentially much smaller. *Biscutum coronum, Calculites obscurus* and *C. ovalis* were found among the coccoliths of core 2 and not core 1. The age of these cores is early Campanian, based on the occurrence of *Broinsonia parca*; these cores can readily be correlated with the outcropping Toolonga Calcilutite in the Shark Bay-Wooramel River area. The assemblage recovered from core 3 (600.4-605.9 metres) (1970-1988 feet) (MFN-417) lacks *Broinsonia parca, Calculites obscurus* and *Biscutum coronum*, but includes the other key species, *Calculites ovalis, Eiffellithus eximius, Gartnerago obliquum, Kamptnerius magnificus, Lucianorhabdus cayeuxii, L. maleformis, Micula staurophora, Reinhardtites anthophorus* and *R. biperforatus*, an association that suggests a mid Santonian age, and a correlation with the Toolonga Calcilutite in its type area (Lower Murchison River area).

Dirk Hartog #4. Five cores were examined from Dirk Hartog #4. Cores 1 and 2 (304.8-306.9 metres; 342.2-345.3 metres respectively) (1000-1007 feet; 1123-1133 feet) (MFN-411 & MFN-412) contain early Paleocene and late Maastrichtian coccolith assemblages respectively (see Table 15). The absence (or extreme rarity) of several key species (such as *Micula murus, Nephrolithus frequens, Reinhardtites levis* and *Zygodiscus bicrescenticus*) in the late Maastrichtian assemblage contrasts with the common occurrence of *Lithraphidites quadratus*. This evidence suggests the presence of the Miria Marl or equivalent in the southern Carnarvon Basin. (In its type area, the Miria Marl contains common *L. quadratus* and lacks *Reinhardtites levis* and *Zygodiscus bicrescenticus*; *Micula murus* and *Nephrolithus frequens* are usually rare and sporadic, or may be absent from the Miria Marl in the Giralia Anticline.) Core 3 (424.6-427 metres) (1393-1401 feet) (MFN-413) yielded an assemblage containing large specimens of common *Broinsonia parca* in association with very rare (short specimens of) *Quadrum gothicum*, suggesting a correlation with the type Korojon Calcarenite. Other key species found in the same assemblage include *Markalius astroporus, Calculites obscurus, Lucianorhabdus cayeuxii*, the *Reinhardites anthophorus/R. levis* group and *Zygodiscus bicrescenticus*.

Table 15. Synthesis of coccolith biostratigraphy in Dirk Hartog wells.

Early Paleocene calcareous nannofossils in #1 and #4 wells

a possible biostratgraphic discontinuity

Miria Marl equivalent:
late Maastrichtian assemblages in #1 and #4; *Lithraphidites quadratus* is prominent. *Broinsonia parca* and *Zygodiscus bicrescenticus* are absent.

a possible biostratigraphic discontinuity

KOROJON CALCARENITE equivalent:

early Maastrichtian assemblage in #1 (core 18) containing the key species *Cribrosphaerella daniae, Reinhardtites anthophorus R. levis* group, *Teichrhabdus ethmos* and *Zygodiscus bicrescenticus*.

late Campanian assemblage in #4 (core 3) containing common *Broinsonia parca* and *Reinhardtites anthophorus/R. levis* group, and are *Quadrum gothicum. Tranolithus orionatus* is absent.

a possible biostratigraphic discontinuity

TOOLONGA CALCILUTITE:

early Campanian assemblages in #4 (cores 4 & 5) and in #17B cores 1 & 2), characterised by the presence of *Biscutum coronum, Broinsonia parca, Eiffellithus eximius, Kamptnerius magnificus, Reinhardtites anthophorus, Tranolithus orionatus* and several holococcoliths.

mid Santonian assemblage in #17B (core 3), containing *Calculites ovalis, Kamptnerius magnificus, Lucianorhabdus cayeuxii, L. maleformis, Reinhardtites anthophorus* and *Tranolithus orionatus*.

The assemblage identified from sample MFN-414 (cores 4 & 5: 454.1-45.2 metres; 1490-1500 feet) contains smaller *Broinsonia parca* and lacks *Quadrum gothicum*, suggesting a correlation with the lower Campanian Toolonga Calcilutite of Shark Bay area. Other key species identified from MFN-414 include *Calculites obscurus, Kamptnerius magnificus, Lucianorhabdus cayeuxii, Reinhardtites anthophorus, Acuturris scotus* and *Zygodiscus bicrescenticus*.

Dirk Hartog #1. Four cores were examined from Dirk Hartog #1. Cores 15 and 16 (234.8-246.9 metres; 274.3-277.4 metres respectively) (800-810 feet; 900-910 feet) (MFN-407 & MFN-408) contain Paleocene coccoliths. Late Maastrichtian coccoliths indicative of the Miria Marl or equivalent were recovered from core 17 (1000-1010 feet) (MFN-409). Neither *Micula murus* nor *Nephrolithus frequens* were found, though *Lithraphidites quadratus* abounds; *Reinhardtites levis, Zygodiscus bicrescenticus* are also absent.

Forms tentatively assignable to *Cribrosphaerella daniae* are found among the assemblage of core 18 (335.3-338.3 metres) (1100-1110 feet) (MFN-410), which also includes *Teichorhabdus ethmos*, the *Reinhardtites anthophorus/R. levis* group and *Zygodiscus bicrescenticus*. This core is thought to equate with the top part of type

Korojon Calcarenite (Giralia Anticline), though the species *Quadrum gothicum, Q. trifidum, Ceratolithoides aculeus* and *Broisonia parca* are lacking.

Cape Cuvier #1 well

This drillhole, situated at Cape Cuvier about 19.2 Km north of Quobba Homestead (Fig. 6), penetrated an Upper Cretaceous carbonate sequence that was identified by Pudovskis (1955) as undifferentiated Korojon Calcarenite and Toolonga Calcilutite (121.9-315.20 metres; 401-1034 feet). The coccolith assemblages recovered from the few cores taken from this sequence are readily correlatable with those of the Miria Marl, Korojon Calcarenite (or equivalents) and Toolonga Calcilutite (Checklist 10; Table 16), nevertheless.

The assemblage from the top part of the Cretaceous sequence in Cape Cuvier #1 well (core 5: cut between 121.9 & 125 metres; 400-410 feet) (MFN-1213) is characterised by the presence of *Lithraphidites quadratus*, and large forms of *Arkhangelskiella cymiformis, A. orthocancellata*, and the absence of *Broinsonia parca, Micula murus, Nephrolithus frequens, Reinhardtites levis* and *Zygodiscus bicrescenticus*. It is regarded here as late Maastrichtian in age, coeval with the type Miria Marl.

Core 6 cut from between 155.4 and 158.5 metres (510-520 feet) (MFN-1214) is regarded as Korojon Calcarenite by virtue of its coccolith assemblage, being of early Maastrichtian (pre-Miria) age. The assemblage is characterised by very rare *Cribrosphaerella daniae, Monomarginatus quaternarius* and *Quadrum gothicum* together with frequent *Broinsonia parca* and common specimens of the *Reinhardtites anthophorus/levis* group. It also contains the species *Braarudosphaera bigelowii, Arkhangelskiella cymbiformis, A. specillata, Lucianorhabdus cayeuxii, Calculites obscurus, Lapideacassis cornuta* and *Lapideacassis simplex*, n. sp., among others.

Table 16. Coccolith biostratigraphic summary of the Upper Cretaceous carbonates in Cape Cuvier #1 well.

NO COCCOLITHS

122 m

MIRIA MARL equivalent: Late Maastrichtian assemblage containing *Lithraphidites quadratus* and large forms of *Arkhangelskiella cymbiformis*. *Broinsonia parca* and *Zygodiscus bicrescenticus* are absent.

125 m

SAMPLING GAP

155.4 m

KOROJON CALCARENITE equivalent: Early Maastrichtian rich assemblages with rare *Cribrosphaerella daniae, Lapideacassis* spp., *Monomarginatus quaternarius* and *Quadrum gothicum*. Frequent *Kamptnerius magnificus, Reinhardtites levis s.l.* and several hemipelagic species. *Broinsonia parca* and *Zygodiscus bicrescenticus* are present. *Tranolithus orionatus* is absent.

158.5 m

SAMPLING GAP

195 m

TOOLONGA CALCILUTITE equivalent:

early Campanian assemblage containing the key species *Broinsonia parca, Eiffellithus eximius, Gartnerago obliquum, Reinhardtites anthophorus* and *Tranolithus orionatus*.

198.1 m

SAMPLING GAP

256 m

late Santonian assemblage containing the marker species *Calculites obscurus, C. ovalis, Gartnerago obliquum, Lucianorhabdus arcuatus, L. cayeuxii, Reinhardtites anthophorus, R. biperforatus* and *Tranolithus orionatus*. *Eiffellithus eximius* is particularly abundant.

figures are levels in metres in the well.

The coccolith assemblages in cores 7 and 8 are Campanian and Santonian in age, coeval with those of the Toolonga Calcilutite outcrops of the Lower Murchison River and Shark Bay areas, respectively. The Campanian assemblage of the Toolonga Calcilutite recovered from core 7 (195-198.1 metres) (640-650 feet) (MFN-1215) includes *Broinsonia parca, Eiffellithus eximius, Reinhardtites anthophorus* and *Tranolithus orionatus*. The Santonian assemblage recovered from core 8 (256-259 metres) (840-850 feet) (MFN-1218) lacks *Broinsonia parca*, but contains *Calculites obscurus, Lucianorhabdus cayeuxii, Reinhardtites biperforatus* and *R. anthophorus*.

Remarks. The early Maastrichtian assemblage of the Korojon Calcarenite (MFN-1214) and the Campanian assemblage of the Toolonga Calcilutite (MFN-1215) are easily differentiated from each other, notwithstanding the restricted occurrence of the key species *Cribrosphaerella daniae, Monomarginatus quaternarius* and *Quadrum gothicum* to the former (MFN-1214). The species *Broinsonia parca, Eiffellithus eximius* and *Kamptnerius magnificus* are important members of the Campanian Toolonga assemblage, being usually abundant. The same species may be present in the Korojon assemblages, but are never abundant. Another difference is the presence of forms approaching *Reinhardtites levis* (as well as the typical form, i.e. appreciable evolutionary advance is notable in the *Reinhardtites anthophorus/R. levis* group) in the Korojon Calcarenite assemblages, and their absence from the Toolonga Calcilutite Campanian assemblages.

A comparison between the Korojon Calcarenite assemblages in Cape Cuvier #1 and Rough Range South #1 wells supports the observation made above that the species *Cribrosphaerella daniae* and *Monomarginatus quaternarius* have preferred high-latitude locations such as Falkland Plateau (SW Atlantic) and Perth Basin (Western Australia). These species occur, though in a few numbers, in the southerly location of Cape Cuvier #1 and not to the north in Rough Range South #1.

The rare occurrences of scarce *Cribrosphaerella daniae* in the lower Maastrichtian Korojon Calcarenite (or equivalent) in the Dirk Hartog #1, Cape Cuvier #1 and Toothawarra Creek section (Giralia Anticline) is consistent with a global late Campanian-Maastrichtian cooling trend documented elsewhere (references on p. 74). This conclusion is strengthened further by similarily rare occurrences of *Monomarginatus quaternarius* in the lower Maastrichtian of Cape Cuvier #1 and of *Nephrolithus corystus* in the uppermost part of the type Korojon Calcarenite in the Giralia Anticline.

Giralia (BMR) #5

This drillhole is located on the northern tip of the Giralia Anticline (Fig. 8). The Korojon Calcarenite, Toolonga Calcilutite and Beedagong Claystone are identified from core samples from Giralia (BMR) #5, based partly on their coccoliths (Checklist 10). Samples from core 1 (30.5-33 metres) (100 feet-108 feet 4 inches) (Korojon Calcarenite) yielded rich assemblages containing the species *Calculites obscurus* and *Lucianorhabdus cayeuxii* and *Braarudosphaera bigelowii*, which suggest deposition in nearshore or shelf environment. The age-diagnostic species *Broinsonia parca, Ceratolithoides aculeus, Quadrum gothicum* and *Q. trifidum* are present in the samples of core 1.

Samples from core 2 (58.8-61.9 metres) (193-203 feet) yielded assemblages characteristic to the Toolonga Calcilutite on account of the presence *Lucianorhabdus cayeuxii, Reinhardtites anthophorus, Kampnerius magnificus* and *Micula staurophora*. Two assemblages, characteristic to the Beedagong Claystone, were recovered from core 3 (89.9-92.4 metres) (295 feet-303 feet 4 inches). The younger assemblage was identified from samples MFN-519 and MFN-520. These included *Eiffellithus eximius, Gartnerago obliquum, Kamptnerius magnificus, Micula staurophora, Microrhabdulus helicoideus, Lithastrinus grillii, Reinhardtites biperforatus* and *Marthasterites furcatus*. The older assemblage, from sample MFN-521, *Eiffellithus eximius, Kamptnerius magnificus, Gartnerago obliquum, Eprolithus floralis* and *Quadrum gartneri*.

The rich assemblages of cores 2 and 3 (Toolonga Calcilutite and Beedagong Claystone) are in sharp contrast with the meagre or no coccoliths of cores 4 and 5 (Gearle Siltstone and probably older sediments).

Remarks. Coccolith evidence from occurrences of the Beedagong Claystone in the Giralia Anticline suggests that this unit thickens rapidly in a northerly direction: The condensed sequence of the Beedagong Claystone in the central parts of the anticline (exposures east of No. 10 Bore and at C-Y Creek) contrasts with the relatively expanded sequence of the unit at the northern tip of the Giralia Anticline (Giralia #5); further north the Beedagong Claystone is represented by a more expanded sequence in the Rough Range (Rough Range South #1 well), its type area.

Rough Range #8 well

Core 1 taken from between 466.3 and 471.8 metres (1530-1548 feet) from the Beedagong Claystone in Rough Range #8 well recovered a rich coccolith assemblage from the Beedagong Claystone which included the species *Eiffellithus eximius, Eprolithus floralis, Corollithion* sp., *Haqius circumradiatus, Kamptnerius magnificus, Marthasterites furcatus, Quadrum gartneri, Gartnerago obliquum, Ahmuerellerela octoradiata* and *Gephyrorhabdus coronadventis*. This assemblage correlates well with those from the upper half of the type Beedagong Claystone in Rough Range South #1 well.

Rough Range #4 well

The Korojon Calcarenite in Rough Range #4 well was cored between 411.5 and 423 metres (1350-1388 feet). Two samples (MFN-275 & MFN-276) were examined from this unit; their coccolith content is given in Checklist 9. The assemblages are characterised by rare *Quadrum gothicum, Q. trifidum* and *Ceratolithoides aculeus*, frequent *Petrarhabdus copulatus* and *Broinsonia parca*, and common specimens of the *Reinhardtites anthophorus/R. levis* group, besides *Acuturris scotus* and *Lucianorhabdus cayeuxii*.

Remarks. *Quadrum trifidum* is a widespread species in the northern Carnarvon Basin occuring usually in small numbers, in the Korojon Calcarenite in both the Giralia Anticline, and the Rough Range [e.g. Giralia (BMR) #5, Rough Range South #1 and Rough Range #4 wells]. In contrast, it is absent from the upper Campanian - Maastrichtian section at Breton Bay in the Perth Basin. Equally contrasting, is the occurrence of *Cribrosphaerella daniae*, *Nephrolithus corystus*, *Monomarginatus quaternarius* and *Misceomarginatus pleniporus* in the lower Maastrichtian of Breton Bay #1 corehole, Perth Basin, and the absence or extreme rarity of these species at coeval levels in the northern Carnarvon Basin.

Hope Island #1 well

This well is situated on Hope Island in the Exmouth Gulf at Lat. 27 09 34 S - Long. 114 28 35 E (Fig. 6). The Upper Cretaceous carbonate sequence in this well, identified by Bowering (1968) as Toolonga Calcilutite, was sampled by six sidewall cores. Coccolith distribution in these cores is given in Checklist 9. A coccolith rich section represented by sidewall cores 6, 7 and 8 is separated from a similarly coccolith-rich section below (represented by sidewall cores 10 and 11) by a coccolith-free segment indicated by sidewall core 9 at the 411.5 metre level. Coccolith assemblages in the younger section (above the 411.5 metre level) included the key species *Ceratolithoides aculeus*, *Arkhangelskiella speciallata*, *Broinsonia parca*, *Calculites obscurus*, and *Quadrum gothicum*, which are absent from below the barren interval. This coccolith association suggests a correlation with assemblages from the type Korojon Calcarenite in C-Y Creek section of the Giralia Anticline.

The key species of the assemblage (in sidewall core 10 at 426.7 metre) below the barren segment included *Calculites ovalis*, *Lucianorhabdus cayeuxii*, *L. maleformis*, *Marthasterites furcatus*, and *Reinhardtites anthophorus*, suggesting a correlation with the Santonian Toolonga Calcilutite of the Lower Murchison River area. The older assemblage (in sidewall core 11 at 442 metre), below the barren segment, lacks these key species, but it includes *Eprolithus floralis*, *Gartnerago obliquum*, *Kamptnerius magnificus*, *Lithastrinus grillii*, *Quadrum gartneri*, *Eiffellithus eximius* and *Haqius circumradiatus*. This older assemblage correlates well with assemblages recovered from the lower half of the type Beedagong Claystone in Rough Range South #1 well.

Remarks. There is some confusion regarding the identification of the Toolonga Calcilutite and Korojon Calcarenite in subsurface sections in the northern portion of the Carnarvon Basin. The criteria for differentiating between these two units are mainly based on differences in their grain size and the abundance of the *Inoceramus* fragments present. Although these criteria have been applied successfully in most outcrops, the practice of identification of the units in the subsurface sections has relied mainly on geophysical methods. The coccolith evidence presented below suggests that these geophysical methods were often unreliable for discriminating between the Korojon Calcarenite and Toolonga Calcilutite.

Case 1. Based on geophysical data, Bowering (1968) identified the entire Upper Cretaceous sequence, occurring between 365.7 (1154 feet) and 435.2 metres (1428 feet), in Hope Island #1 well as the Toolonga Calcilutite, although the upper part of this sequence consists of fine-grained limestone, calcarenite and calcilutite with abundant *Inoceramus* fragments. The present study identified the fossiliferous section in Hope Island #1 well above the barren segment (at 411.5 metre; 1350 feet) as the Korojon Calcarenite (sidewall cores 6-8 between 565.7-396.2 metre; 1200-1300 feet), and the section below the same barren segment as the Toolonga Calcilutite (sidewall core 10 at 426.7 metre; 1400 feet) and the Beegagong Claystone (sidewall core 11 at 442 metre; 1450 feet); the Toolonga/Beedagong contact is probably at 435.2-metre level (1428 feet).

Ceratolithoides aculeus and *Quadrum gothicum*, identified in the core material (sidewall cores 6-8) above the barren segment in Hope Island #1 well, were not found in any of the outcrop samples examined in this study from the Toolonga Calcilutite, whereas these two key species were identified in the type section of the Korojon Calcarenite (C-Y Creek, Giralia Anticline) and several subsurface samples of the Korojon Calcarenite (see, e.g. Rough Range South #1 well). This evidence together with the lithological evidence of dominantly fine-grained limestone with abundant *Inoceramus* fragments above 411.5-metre level indicate the Korojon Calcarenite in Hope Island #1 well.

Case 2. Mainly on geophysical grounds, Pudovskis (1964) identified the section between 596- and 606-metre levels in Paterson #1 well (in the northern Carnarvon Basin; Fig. 6) as Korojon Calcarenite even though only occasional *Inoceramus* fragments are present; this carbonate section consists of only 10 metres of calcarenite grading downward into calcilutite. The uppermost part of the section (sidewall core sample at 597.4-metre level = 1960 feet) yielded an admixture of Paleocene and late Maastrichtian nannofossil species, suggesting an interval of mixing at the Cretaceous/Tertiary boundary (characteristic of either the very top of the Miria Marl, or of the reworked Miria Marl at base of the Paleocene). The coccolith assemblage from three metres below (at 600-metre level) is readily assignable to the biostratigraphic interval DI:**Lucianorhabdus cayeuxii*/**Calculites obscurus*, and can thus be correlated with the Santonian Toolonga Calcilutite of the Lower Murchison river area.

In view of the paucity of the *Inoceramus* fragments in the calcilutites of Paterson #1 well and the coccolith evidence indicating a Santonian age, it is concluded that the main part of the 10-metre carbonate section (between 596- and 606-metre levels) in that well is identifiable as the Toolonga Calcilutite. The uppermost part of the Cretaceous carbonates of Paterson #1 well probably represents the Miria marl, which is consistently thin in outcrops. The Korojon Calcarenite is either extremely thin or totally absent in Paterson #1 well.

Tortoise #1 well

This well is situated on Tortoise Island which lies 27 Km N80W of the Town of Onslow, in the Exmouth Gulf (Fig. 6) at Lat. 21 35 08 S - Long. 114 51 11 E. The Toolonga Calcilutite in this well occurs between 227.7 and 390.1 metres (747-1280 feet) (Johnson, 1967). It was sampled by six sidewall cores. Coccolith distribution in these cores - given in Checklist 9 - suggests a correlation with the lower Campanian Toolonga Calcilutite of Shark Bay-Lower Wooramel River area, and with the Santonian Toolonga Calcilutite of the Lower Murchison River area. The key species *Arkhangelskiella specillata*, *Broinsonia parca*, *Eiffellithus eximius*, *Kamptnerius magnificus* and *Marthasterites furcatus* occur constantly in the upper four sidewall cores. Both *Arkhangelskiella cymbiformis* and *Broinsonia parca* increase in size up-section, being smallest at 281.9 metre (925 feet) (MFN-94). Assemblages from the lowest two sidewall cores lack *B. parca*, but include *Lucianorhabdus cayeuxii* and *Marthasterites furcatus* and other key species.

Pasco #1 well

Two sidewall cores were examined from the Upper Cretaceous carbonates of Pasco #1 well in the Exmouth Gulf (Fig. 6). The younger core (sidewall core 11 at 288.9 metres; 948 feet) (MFN-87) yielded late Maastrichtian coccoliths, including *Lithraphidites quadratus* and *Micula murus*, indicative of the Miria Marl. The other core (sidewall core 12 at 303.6 metre; 996 feet) (MFN-88) yielded an assemblage which includes the species *Broinsonia parca, Ahmuellerella octoradiata, Arkhangelskiella specillata, Cretarhabdus surirellus, Cyclindralithus spp., Cribrosphaerella ehrenbergii, Eiffellithus turriseiffeli, Lithraphidites carniolensis, Manivitella pemmatoidea, Placozygus fibuliformis, Prediscosphaera cretacea, P. spinosa, Reinhardtites anthophorus, Vekshinella imbricata, Watznaueria barnesae* and *Tetrapodorhabdus decorus*. This assemblage suggests a correlation with the lower Campanian Toolonga Calcilutite of the Shark Bay-Lower Wooramel River area.

Remarks. The late Maastrichtian key species, *Nephrolithus frequens*, which is usually rare and sporadic in the type Miria Marl, is absent in Pasco #1 well to the north, but the other late Maastrichtian key species, *Micula murus*, which is even rarer and more sporadic in the Miria Marl at its type area, is relatively common in Pasco #1 well material. Neither *Micula murus*, nor *Nephrolithus frequens* were found among the late Maastrichtian assemblages recovered from Cape Cuvier #1, Dirk Hartog #1 and #4, in the southern Carnarvon Basin . In all of these late Maastrichtian assemblages (in Pasco #1, type Miria Marl, Cape Cuvier #1 & Dirk Hartog wells), *Lithraphidites quadratus* abounds, but *Reinhardtites levis* and *Zygodiscus bicrescenticus* are absent.

Trimouille #1 well

The Upper Cretaceous carbonate sequence in Trimouille #1 well is represented in this study by a conventional core (core 3 cut between 1130.8 and 1134.2 metres; 3710-3721 feet). A moderately preserved coccolith assemblage recovered (MFN-126) from this core is dominated by *Arkhangelskiella cymbiformis, Biscutum melaniae, Cretarhabdus conicus, C. surirellus, Cribrosphaerella ehrenbergii, Eiffellithus turriseiffeli, Micula staurophora* and *Watznaueria barnesae*. It also includes *Ahmuellerella octoradiata, Broinsonia parca, Calculites ovalis, Microrhabdulus belgicus, M. decoratus, Placozygus fibuliformis*, and *Quadrum gothicum*. The occurrence of *Quadrum gothicum* suggests a correlation with the type Korojon Calcarenite.

Remarks. The evidence from the Hope Island #1, Tortoise #1, Pasco #1 and Trimouille #1 wells indicates the presence in the Exmouth Gulf area of the Beedagong Claystone and Toolonga Calcilutite sequence below the other carbonate sequence of Korojon Calcarenite and Miria Marl. The evidence from Paterson #1 and Pasco #1 wells suggests that the Korojon Calcarenite in parts of the northern sector of the basin is much thinner than its type section in the Giralia Anticline.

DISCUSSION

The biostratigraphic discontinuities identified within the Upper Cretaceous carbonate sequence of the Carnarvon Basin coincide with the formational contacts (Table 17). Because these biostratigraphic discontinuities are sharp, in the sense that assemblages from below and above these breaks are easily distinguishable, the lithostratigraphic units can be equally easily identified by their nannofossil assemblages. This is significant particularly in view of the difficulties in identification of the Toolonga Calcilutite and Korojon Calcarenite in the subsurface. The underlying principle is that a very small sample (a few cubic millimetres) is needed to identify the enclosed nannofossil assemblage, and consequently, the unit itself.

Table 17. A summary of the Upper Cretaceous sequence in the Carnarvon Basin.

Carbonate cycles	Unit	Some Characteristics and Remarks
CYCLE C	Miria Marl	Late Maastrichtian assemblage. This thin unit can be differentiated by the occurrence of *Lithraphidites (a majorquadratus*. A nodule bed at base, with evidence of reworking. Displaced Miria at the base of the Paleocene Boongerooda Greensand includes the latest Siltstone Maastrichtian *Micula prinsii*.
		Biotratigraphic discontinuity/Disconformity
CYCLE B	Korojon Calcarenite	Late Campanian and early Maastrichtian assemblages with *Broinsonia parca*, *Reinhardtites levis s.l.*, and sporadic *Quadrum gothicum* and *Q. trifidum*. The last three species are absent from units below. Lower part of the type Korojon with several phosphatic nodule beds, suggesting slow rates of sedimentation. Base marked by a nodule bed.
		Biotratigraphic discontinuity/Disconformity
CYCLE A	Toolonga Calcilutite	Santonian and early Campanian assemblages similar to those in Gingin Chalk (Perth Basin). The Campanian *Broinsonia parca* is usually smaller than in the Korojon Calcarenite. A phosphatic nodule bed at base where the unit overlies the highly clastic Alinga Formation. In the Giralia Anticline this unit and the underlying Beedagong are represented by a condensed sequence, the contact separating them being transitional.
	Beedagong Claystone	Late Turonian to late Coniacian/early Santonian assemblages; no counterparts in the Perth Basin. This unit thickens rapidly in a northerly direction: condensed section of a few centimetres in the central Giralia, more than 30 m at the northern tip of the anticline, to more than 80 m in Rough Ranges.
		Hiatus (a major change in palaeoenvironmental conditions)
	Gearle Siltstone	Mostly barren of coccoliths. Assemblages are are poor, *Watznaueria barnesae* and *Eprolithus floralis* dominating.

During the late Campanian and Maastrichtian, surface waters were warmer in the Carnarvon Basin than in the Perth Basin. This is based on the distribution of several temperature-indicators such as *Ceratolithoides aculeus, Cribrosphaerella daniae, Monomarginatus pectinatus, Micula murus, Misceomarginatus pleniporus, Nephrolithus corystus, N. frequens* and *Quadrum trifidum.* A 'latitudinal' temperature gradient could be detected in the Carnarvon Basin, as the cold-water indicators (e.g. *Cribrosphaerella daniae* and *Monomarginatus quaternarius*) are more prominent in the southern sections (e.g. at Dirk Hartog) than in the northern sections (e.g. at Giralia Anticline or Rough Range), and the warm-water indicators (e.g. *Ceratolithoides aculeus, Cribrocorona gallica* and *Quadrum trifidum*) having a reversed order of prominence.

On a gross scale, the Upper Cretaceous carbonates were laid down along the Australian western margins in wedges, thickening offshore. This can be demonstrated on the smaller scale by the Beedagong Claystone which thickens rapidly in a northerly direction towards the sea. The implications are that effects of changes in sea-level would be easily detectable in the onshore sections than in their offshore counterparts. Thus the hiatuses at the Gearle/Beedagong, Alinga/Toolonga, Toolonga/Korojon, and Korojon/Miria contacts, represent possible major falls in sea-level, separating three cycles of carbonate deposition (Table 17, discussed in detail later in the study).

UPPER CRETACEOUS COCCOLITH BIOSTRATIGRAPHIC EVENTS

GLOBAL TURONIAN-MAASTRICHTIAN COCCOLITH BIOSTRATIGRAPHY

OVERVIEW

Late Cretaceous coccoliths were first described by Ehrenberg (1836, 1854), whom is generally credited with the discovery of calcareous nannofossils. Arkhangelsky (1912) was the first worker to investigate the systematics of these fossils; his work probably is the only reference to Late Cretaceous coccoliths during the first half of this century. Investigations of Late Cretaceous coccoliths were resumed in the early 1950's. Notable early contributions include Deflandre (*in* Grasse, 1952, *in* Piveteau, 1952), Deflandre & Fert (1952, 1954), Gorka (1957), Vekshina (1959), Stradner (1961, 1963), Martini (1961), Bramlette & Martini (1964), Reinhardt (1965, 1966a, b) and Stover (1966).

A rapid increase in the number of published studies of Cretaceous coccoliths occurred in the late 1960's, partly due to the successful application of electron microscopy, and to improvements in optical microscopy, and partly due to the availability of enormous amount of material through the DSDP and later ODP. Key references include Black (1967, 1971a, b, 1972, 1973, 1975), Gartner (1968), Perch-Nielsen (1968, 1972, 1973, 1977, 1979e, 1985b), Bukry (1969, 1973b, c), Bukry & Bramlette (1970), Noel (1970), Cepek (1970), Forchheimer (1968), Hoffmann (1970a-d, 1972a, b), Roth & Thierstein (1972), Roth (1973, 1978), Reinhardt (1970a, b, 1971), Shafik & Stradner (1971), Shumenko (1971), Thierstein (1971a, b, 1973, 1974, 1976), Martini (1976), Verbeek (1976, 1977), Sissingh (1977), Wise & Wind (1977), Crux (1982) and Stradner & Steinmetz (1984).

Zonations

Calcareous nannofossil zonation of the Upper Cretaceous was first attempted by Stradner (1963), who proposed a biostratigraphic framework based on associations or assemblages. The first comprehensive zonal scheme was published by Cepek & Hay (1969a, b), based on sections in Alabama (U.S.A.). Because of some weaknesses in this scheme, indicated by subsequent investigators (Gartner *in* Cita & Gartner, 1971; Smith, 1975), a need for its modification became soon apparent. This coincided with a considerable increase in the biostratigraphic data becoming available through the Deep Sea Drilling Project. Several new zones and zonal schemes were then proposed (e.g. Bukry & Bramlette, 1970; Roth & Thierstein, 1972; Bukry, 1973b; Roth, 1973). However, some of these schemes were based mainly on zones previously described by Cepek & Hay (1969a, b) (see, e.g. Manivit, 1971).

Because of the proven value of coccoliths as tools for rapid age-determination, activities in the field of coccolith biostratigraphy continued to increase during the later part of the last decade; as material from more areas was investigated, modifications or emendations of previously published zones became necessary (see, e.g. Martini, 1976; Perch-Nielsen, 1977; Roth, 1978). Also, more complete stratigraphic sections were investigated, and more detailed zonations were published (e.g., Verbeek, 1976; Sissingh, 1977).

Sissingh (1977) gave his zones numbers, and Roth (1978) suggested a numberical system for a Cretaceous zonation which he promoted as being drawn largely from published results of other investigators; the credit of introducing numberical system to nannofossil biostratigraphy goes to Martini and to Worsley (see Martini & Worsley, 1970; Martini, 1970).

Table 3 presents previously proposed Turonian-Maastrichtian coccolith zones, arranged alphabetically. Tables 4A-4B represent an attempt to correlate most of the widely used zonal schemes. Reviews of the various Cretaceous zonations have been given by Thierstein (1976), Gartner (1977), Sissingh (1977), Verbeek (1977), and Perch-Nielsen (1979e).

Problems in coccolith biostratigraphy

Shafik (1978b) discussed several problems of Late Cretaceous coccolith biostratigraphy: A) a species originally described using only electron microscopy is likely to be of little biostratigraphic utility for studies where only optical microscopy is used; B) relative stratigraphic ranges of some of key species have not been well established; and C) provincial distribution, and selective elimination by post-depositional processes of some of the markers have serious biostratigraphic consequencies.

A) Identification of species

Initially, optical microscopy was used for the identification of coccolith species, but later, advantage was taken of the more revealing electron microscopy. Species originally described and illustrated by one of these techniques, are usually difficult to identify using the other technique. This problem was overcome by developing procedures combining the two techniques to view the same coccolith specimen (see, e.g. Shafik, 1984). Such procedures have not been widely adopted in routine examination of samples, even though they have been applied successfully.

Diagenetic effects such as overgrowth and partial dissolution (accidents of preservation) may obliterate the species beyond recognition or produce conspecific morphotypes. Several such morphotypes from the Cretaceous have been discussed and illustrated by Thierstein (1974, 1976). Some of these morphotypes have been utilised in superjacent zones (e.g. *Kamptnerius punctatus* and *K. magnificus* zones *in* Cepek & Hay, 1969a, b).

It is difficult to consistently identify a number of biostratigraphically important Cretaceous species, such as some species of the genera *Broinsonia*, *Gartnerago*, *Micula*, *Quadrum*, *Vekshienella* and *Reinhardtites*, because they are presently fraught by taxonomic problems. This causes uncertainties and difficulties in their biostratigraphic use. A broad species concept is usually the result of inadequate original description/illustration, and can câuse problems in correlation. Moreover, the evolutionary appearance of a species in phyletic series (e.g. *Micula murus* in *M. staurophora/M. concava/M. murus/M. prinsii* series) is usually not easily utilised as a sharp/precise event in a biostratigraphic sequence, even though the species may be originally narrowly defined.

B) Stratigraphic range

An alphabetical list of the key species utilised in the definitions of the various zones presented in Table 3 and correlated in Tables 4A-4B is given below:

(1) *Acuturris scotus (Eurhabdus)*
(1) *Arkhangelskiella ethmopora*
(2) *Arkhangelskiella specillata*
(1) *Biscutum coronum*
(2) *Broinsonia lacunosa*
(12) *Broinsonia parca (Aspidolithus)*
(4) *Calculites obscurus (Tetralithus)*
(1) *Calculites ovalis (Tetralithus)*
(12) *Ceratolithoides aculeus (Tetralithus)*
(2) *Chiastozygus initialis*
(3) *Corollithion exiguum*
(1) *Cribrosphaera circula*
(8) *Eiffellithus eximius (E. angustus)*
(3) *Gartnerago obliquum (G. obliquus)*
(1) *Heliorthus concinnus*

(6) *Kamptnerius magnificus (K. punctatus)*
(1) *Liliasterites angularis*
(1) *Lithraphidites acutum*
(14) *Lithraphidites quadratus*
(1) *Eprolithus floralis (Lithastrinus)*
(6) *Lucianorhabdus cayeuxii*
(3) *Lucianorhabdus maleformis*
(15) *Marthasterites furcatus*
(1) *Microrhabdulus helicoides (Lithraphidites helicoides)*
(3) *Micula concava*
(13) *Micula murus (Tetralithus; M. mura)*
(9) *Micula staurophora (M. decussata)*
(1) *Munaris lesliae*
(10) *Nephrolithus frequens*
(1) *Ottavianus giannus*
(1) *Prediscosphaera stoveri*
(9) *Quadrum gartneri (Tetralithus pyramidus)*
(9) *Quadrum gothicum (Tetralithus gothicus; Tetralithus nitidus; Uniplanarius gothicus)*
(14) *Quadrum trifidum (Tetralithus gothicus trifidus; T. nitidus trifidus; Uniplanarius trifidus)*
(1) *Ramsaya swanseana*
(5) *Reinhardtites anthophorus*
(1) *Reinhardtites levis*
(2) *Rucianolithus hayii*
(1) *Thiersteinia ecclesiastica*
(1) *Tranolithus orionatus (T. phacelosus)*
(1) *Zygolithus spiralis*

The figures between brackets indicate the number of zonal schemes (in Table 3) in which the particular taxon has been used; names between brackets are synonyms used in Table 3. The species *Bronisonia parca, Ceratolithoides aculeus, Eiffllethus eximius, Lithraphidites quadratus, Marthasterites furcatus, Micula murus, M. staurophora, Nephrolithus frequens, Quadrum gartneri, Q. gothicum*, and *Q. trifidum*, have been used by many investigators as zonal markers, and so have high scores. The vertical ranges of these species with high scores are better known than those species with very low scores (3 or less). Those with low scores include some only recently proposed as zonal guides, e.g. *Biscutum coronum* used by Wise (1983), *Liliasterites angularis* introduced by Stradner & Steinmetz (1984) (*L. angularis* was first described by Svabenicka & Stradner *in* Stradner & Steinmetz, 1984). A zonation, based on a few closely-spaced stratigraphic sections, that uses a newly described species may result in miscorrelation elsewhere. For example, *Eurhabdus scotus* Risatti, 1973 (=*Acuturris scotus*), first used as a Maastrichtian zonal marker in Mississippi, U.S.A. (Risatti, 1973), occurs in the Santonian Gingin Chalk in Western Australia (present study).

No doubt that uncertainties about the stratigraphic ranges of key species are automatically translated into poor biostratigraphy, i.e. doubtful stratigraphic order of events. A firm ordinal system of biostratigraphic events is undoubtedly basic to a precise correlation.

C) Geographic distribution

The distribution of modern coccoliths is primarily controlled by temperature (McIntyre & Be, 1967; Okada & Honjo, 1973; Ruddiman & McIntyre, 1976): at low-latitudes where surface-water temperatures are high, species diversity is high though productivity (abundance) may be low, and at higher latitudes the reverse is true i.e., greater abundance of much fewer coccolith species (see, e.g. McIntyre & others, 1970 who recorded monospecific nannoplankton populations in the Subarctic and Subantarctic regions). Coccolith distribution throughout the Cainozoic shows a similar dependancy on temperature: warm periods equate with peaks in coccolith species diversity, and cold episodes correlate with periods of very low species diversity. Although they were not evident during the Early Cretaceous, pronounced latitudinal patterns of coccolith distribution developed during the later Cretaceous.

Provincialism among Late Cretaceous coccoliths has been known since Worsley & Martini (1970) outlined the palaeogeographic limits of the late Maastrichtian species *Nephrolithus frequens* and *Micula murus* (reported as *Tetralithus murus*), but, until recently, its relevance to biostratigraphic correlation was not always fully acknowledged. Originally it was generally thought that coccoliths were cosmopolitan, with few concomitant problems in correlation. This study demonstrates that evaluation of the temporal distribution of late Campanian - Maastrichtian coccolith species (biostratigraphy and biostratigraphic correlation) becomes more reliable when due consideration is given to their spatial distribution (biogeography).

Most coccolith species occur in both oceanic and nearshore (hemipelagic) sediments. A few groups, including holococcoliths and pentaliths, are restricted to nearshore sediments because they are susceptible to dissolution in the oceanic realm. (This distribution pattern is very evident in the Cainozoic, and for the Eocene in particular.) The occurrence of holococcoliths (Wind & Wise, 1978), pentaliths and other hemipelagic species (in the sense of Gartner, 1977) in Upper Cretaceous sediments has already been noted by many investigators, including Shafik (1978b). Some of these nearshore species (e.g. *Lucianorhabdus cayeuxii* see Sissingh, 1977; Shafik 1978b; this study) have been used successfully in biostratigraphic subdivision of nearshore or shelf sequences, even so, they are of little or no biostratigraphic use for most deep-sea sections.

D) Biostratigraphic standard

At present there is no standard Late Cretaceous coccolith biostratigraphic zonation, although at least one zonation (Sissingh's 1977) seems to be widely used. As indicated above, the stratigraphic and/or the geographic ranges of some of the key Late Cretaceous species are not yet well established, but as more Cretaceous sections are studied, these ranges will be better known. The biostratigraphic approach adopted in this study (biohorizons/datum levels instead of formal zones, as discussed earlier) is one of presenting a biostratigraphic scheme readily amenable to improvements. Thus, biostratigraphic sequences of events suitable for mid to high latitudes (e.g. Table 23), and mid to low latitudes (e.g. Table 24), could be separately developed and repeatedly tested. From such a study, standard Cretaceous coccolith biostratigraphic system, based on lowest and highest occurrences of cosmopolitan (oceanic) and hemipelagic species, and is suitable for most palaeolatitudes, could be eventually assembled.

E) Zonal names

The current practice of using previously adopted names for newly described or emended zones (e.g. *Marthasterites furcatus* zone in Table 3), has been a source of confusion. As shown in Table 3, zones having the same names are not necessarily based on the same coccolith events.

The numberical notation of Cretaceous zones (see, e.g. Sissingh, 1977), bearing otherwise, names that are cumbersome and difficult to spell, is an easy way of communicating biostratigraphic results. However, it has spurious finality about it, and is not easily amenable to incorporation of new data.

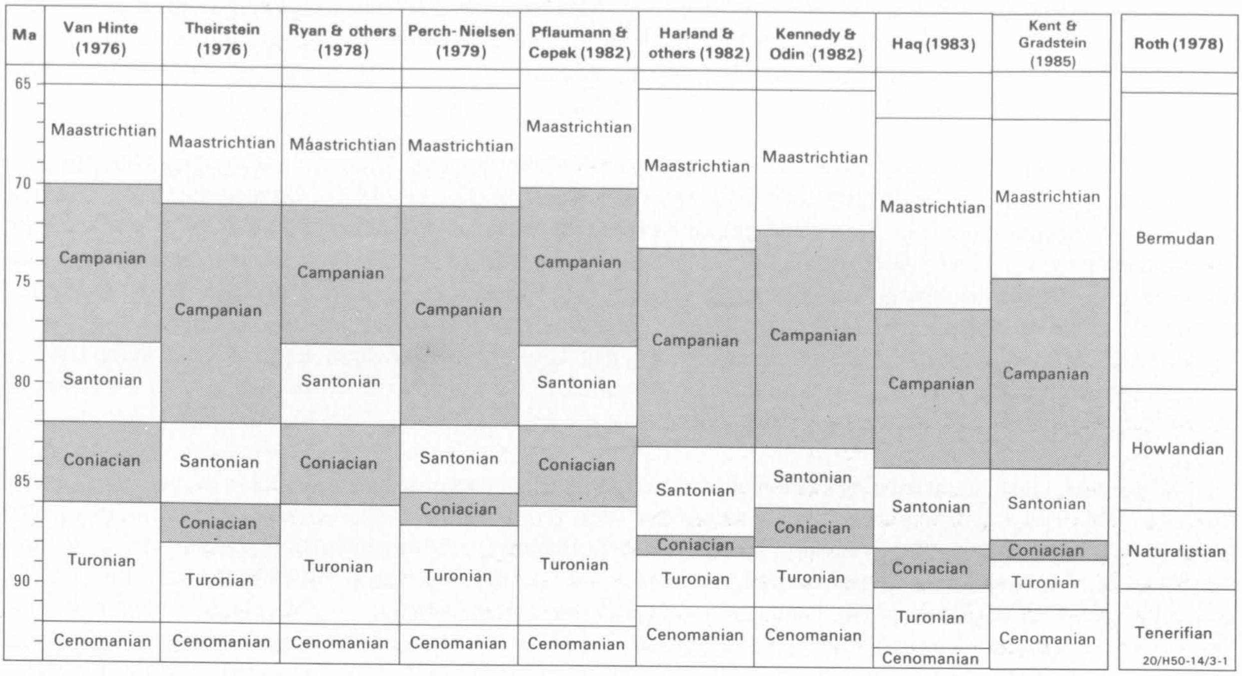
Coccolith biochronology

The major tools for dating sediments are radiochronology (rates of decay of unstable isotopes), biochronology (ordinal framework of fossil events in time), and to a much lesser degree, stable-isotope stratigraphy (oxygen and carbon isotopic fluctuations), and magnetostratigraphy (magnetic polarity reversals). Biochronology computes geologic time with greater resolution than radiochronology, though less accurately in absolute terms. The concept of biochronology was throroughly discussed by Berggren & van Couvering (1978) and more recently by Haq & Worsley (1982). According to these authors, a biochronologic scale is an organisation of geological time based on the irreversible process of organic evolution, as distinct from a biostratigraphic sequence which is an observed superpositional sequence of fossils without inherent chronologic significance.

A) Correlation with European Stages

The terms Turonian and Senonian were proposed by d'Orbigny (1842, 1852), and the Coniacian, Santonian, Campanian and Dordonian Stages were originally named as substages of the Senonian by Coquand (1857). As ponted out by Arnaud (1879), the Dordonian is synonymous with the Maastrichtian Stage, which had been introduced earlier by Dumont (1849). The Coniacian, Santonian and Campanian stratotypes were designated in France by Coquand (1856, 1857, 1858). The stratotype of the Maastrichtian occurs in the vicinty of Maastricht in South Holland. The Maastrichtian and to a lesser degree the Campanian Stages were discussed at length by Berggren (1964); in addition, Harland & others (1982) gave a brief account of the stages of the Phanerozoic including the European Cretaceous Stages. The Turonian-Maastrichtian interval represents most of the Late Cretaceous, approximately 26 million years, from 91 to 65 Ma according to Kennedy & Odin (1982) (see estimates by others, Table 18).

Table 18. Span of European Upper Cretaceous stages, according to various authors (million years).



In spite of several attempts at studying coccolith distribution in the classical Upper Cretaceous stage stratotype sections (e.g. Manivit, 1971; Sissingh, 1977; Verbeek, 1977), no coccolith biostratigraphic scheme firmly linked to these stages has emerged. At best, *tentative* correlation with coccolith zones recognisable elsewhere could be made with coccoliths of the Turonian, Coniacian and Santonian stratotype sections. The situation with the Campanian and Maastrichtian stratotypes is much better, with coccolith zones being identifiable there. However, because of controversies surrounding the limits of these stratotypes, biostratigraphic schemes published by different investigators are difficule to reconcile.

Coccolith evidence from the Turonian stratotype does not permit an accurate biostratigraphic assessment. Sissingh (1977) indicated that the type Turonian probably belongs to his *Tetralithus pyramidus* zone and/or lowest part of his *Lucianorhabdus maleformis* zone. Verbeek (1977) tentatively correlated the type Turonian with his *Quadrum gartneri* and *Eiffellithus eximius* zones (see Table 3 for zonal definitions).

The Coniacian stratotype section is almost barren, and on the basis of a very poor assemblage with *Quadrum gartneri*, and questionable forms of *Micula staurophora*, Sissingh (1977) suggested an approximate correlation with his *Marthasterites furcatus* zone. Similarly, Verbeek (1977) tentatively correlated the Coniacian Stage with his *Marthasterites furcatus* zone, on the basis of a meagre assemblage in a sample from a nearby section.

Sissingh (1977) identified the holococcolith *Lucianorhabdus cayeuxii* among a few other calcareous nannofossils from the type Santonian beds, and a correlation with his *L. cayeuxii* zone seemed possible. Verbeek (1977) identified a large number of poorly preserved coccolith species from the Santonian stratotype, including the *Calculites obscurus* group and the index species for his *Zygodiscus spiralis* zone. He correlated the Santonian Stage with his *Broinsonia lacunosa*, *Micula concava* and *Rucinolithus hayii* zones, despite the apparent absence of the nominate zonal markers. Three coccolith zones were recognised by Verbeek (1977) in the Campanian stratotype: his *Ceratolithoides aculeus*, *Quadrum gothicum* and *Q. trifidum* zones. In this he agrees with Martini (1976) who identified the equivalents of the first two zones in the same section, but disagrees with Manivit (1971) regarding the level of the lowest occurrence of *C. aculeus*. Sissingh (1977) correlated the Campanian Stage with several zones, extending from his *Calculites obscurus* zone to his *Tranolithus phacelosus* zone (see Tables 3 & 4A-4B for zonal limits). Thus, the lower part of the type Campanian has been assigned to two different zones (the *Calculites obscurus* zone of Sissingh, 1977; and the *Ceratolithoides aculeus* zone of Verbeek, 1977) usually considered as representing two well-spaced time slices.

Bramlette & Martini (1964) identified several calcareous nannofossil species from type material of the

Maastrichtian, including the index species *Nephrolithus barbarae (=N. frequens)* and *Lithraphidites quadratus*. Instead of *N. frequens*, Verbeek (1977) identified *Micula murus*, a species of equal biostratigraphic importance. Van Heck (1979) recored both *Nephrolithus frequens* and *Micula murus* together with other index species such as *Lithraphidites quadratus* and *Reinhardtites levis* in the type Maastrichtian. Verbeek (1986) found neither *N. frequens* nor *M. murus*, but recorded the other markers from the Maastrichtian Formation.

B) Correlation with numerical time scale

Refinement of the microplanktic biostratigraphy of the classical Upper Cretaceous stratotypes has not been forthcoming in spite of renewed work in this field (e.g. Verbeek, 1976; Sissingh, 1977). On the other hand, available Late Cretaceous coccolith and foraminiferal zonations (for coccoliths, examples in Tables 3 & 4A-4B; or foraminiferids e.g. van Hinte, 1976; Caron, 1985) have been widely applied to marine sediments, with high resolution results. Roth (1978) argued that a zonal system, based on microplanktic forms, would represent a better standard of reference for global marine Cretaceous stratigraphy, than the problem-ridden European stage stratotypes. A microplanktic biostratigraphic system with radiometrically dated events (i.e. a biochronological system in the sense of Berggren & van Couvering, 1978), would be more valuable for worldwide correlations than a system of chronostratigraphic units based on ambiguous stage stratotypes.

However, the numerical dating (radiometric or isotopic ages) of coccolith biostratigraphic events is in a state of flux (see Table 19), and different numerical dates have been given to the same biostratigraphic event; this partly because boundaries of stage stratotypes have been correlated differently to the numerical time scale by various authors (see Table 18). For example, the lowest occurrence of *Broinsonia parca* is given an age of 78 Ma by van Hinte (1976), 82 Ma by Thierstein (1976), 80 Ma by Roth (1978) and 84.5 Ma by Haq (1983) (see Table 19); this event marks the base of the Campanian according to many investigators. The base of the Campanian is at 78 Ma according to van Hinte (1976), at 82 Ma according to Thierstein (1976), at 80 Ma according to Roth (1978) and at 84 according to Haq (1983) (see Table 18).

Most radiometric ages are based on K/Ar ratios in glauconites, which are susceptible to argon losses or could have been reworked (in lag deposits, and immediately above sedimentary breaks). Loss of argon will produce ages which are too 'young', and reworked glauconites will result in ages too 'old'. Acceptable ages should be around the main clusters of age determinations for a particular event (Roth, 1978).

The choice of any particular published set of numerical dates for the coccolith biostratigraphic events (Table 19) would appear arbitrary. The writer adopted, with some reservations, the generally accepted numerical scale given by Perch-Nielsen (1979e) for Upper Cretaceous coccolith biostratigraphic events.

C) Oceanic chronostratigraphy

Oceanic stages, based on stratotypes whose boundaries are defined on the basis of calcareous nannofossil biostratigraphic events in sections drilled by the Deep Sea Drilling Project, was first proposed by Bukry (1973c) for the Cainozoic and uppermost Cretaceous. Roth (1978) extended this oceanic chronostratigraphy back into the Cretaceous and uppermost Jurassic. Four oceanic stages covering the Late Cretaceous were proposed: the Tenerifian, Naturalistian, Howlandian and Bermudan, in an ascending order (see Table 18).

The Tenerifian Stage is bounded by the lowest occurrences of *Lithraphidites acutum* and of *Micula staurophora* (probably *Quadrum gartneri* of his study), and is loosely correlated with the Cenomanian and the lower Turonian. The Naturalistian is bracketed by the lowest occurrences of *Micula staurophora* (probably *Quadrum gartneri* of this study) and of *Marthasterites furcatus*, and is correlated with most of the Turonian. The Howlandian Stage, which is an approximate correlative with the combined Coniacian and Santonian Stages, is marked by the lowest occurrences of *Marthasterites furcatus* and of *Broinsonia parca*. The youngest Cretaceous oceanic stage, the Bermudan, was defined by Bukry (1973c) as between the lowest occurrence of *Broinsonia parca* and the highest occurrence of Cretaceous nannofossils. The Bermudan Stage is an approximate equivalent of the combined Campanian and Maastrichtian Stages.

Abreviations used in Table 19 (opposite page).

A.=Arkhangelskiella; As.=Aspidolithus; B.=Broinsonia; Bu.=Bukryaster; C.=Ceratolithoides; Ca.=Calculites; Co.=Corollithion; E.=Eiffellithus; G.=Gartnerago; K.=Kamptnerius; L.=Lithraphidites ; Ls.=Lithastrinus; Lu.=Lucianorhabdus; M.=Micula; Ma.=Marthasterites; N.=Nephrolithus; P.=Phanulithus; Q.=Quadrum; R.=Reinhardtites; T.=Tetralithus

Table 19. Age assignement of coccolith biostratigraphic events in million years according to various investigators.

Ma	van Hinte (1976)	Thierstein (1976)	Roth (1978)	Ryan & others (1978)	Perch-Nielsen (1979e)	Pflaumann & Cepek (1982)	Haq (1983)	Haq&others (1987)
65.5					*M. prinsii*			
66.		*M. mura *N. frequens	*M. mura *N. frequens		*N. frequens			
66.5					*M. murus			
67.	*M. mura			*M. mura	*L. quadratus	*M. mura		*M. mura
67.5		*L. quadratus						
68.		+T.trifidus	*L. quadratus	*L. quadratus	*A. cymbiformis	*L. quadratus	*M. mura	
68.5								*L. quadratus
69.	+T. trifidus				+R. levis	+T. trifidus	*N.frequens	
70.					+Q. trifidum		*L.quadratus	
70.5				+ T. trifidus				+T. trifidus
71.	*T. trifidus		+T. trifidus		+A. pacus	*T. trifidus		
72.5					+R. anthophorus +E. eximius			
73.		*T.trifidus	*T. trifidus		+R. levis		+T.trifidus	
73.5					+Ls. grillii			
74.	+E. eximius			*T. trifidus	*Q. trifidum	*T. gothicus		
75.5						*T. aculeus		*T. trifidus
76.		*T.aculeus						
76.5					*Q. nitidum			
77.			*T. aculeus			+Ma. furcatus		
77.5					*C. aculeus			
78.	*B. parca			*B. parca		*B. parca		
79.					+Bu. hayi		*T.trifidus	
80.			*B. parca		+M. furcatus			*C. aculeus
80.5					*As. parcus			
81.	+Ma. furcatus				*Bu. hayi			
82.		*B. parca	*T. obscurus *M. concava *L. helicoideus					*B. parca
83.					*P. obscurus		*C.aculeus	
83.5								*Ca. obscurus
84.	*Ma. furcatus		*B. lacunosa		*Lu. cayeuxii			
84.5							*B.parca	
85.				*Ma. furcatus	*R. anthophorus *Ls. grillii			
85.5								*Lu. cayeuxii
86.		*T. obscurus	*Ma. furcatus *E. eximius		*M. decussata	*Ma. furcatus	*Lu.cayeuxiii	
87.		*Ma. furcatus			*Ma. furcatus		*R.anthophorus	
87.5								*R. anthophorus
88.	*M. decussata		*K. magnificus		*E. eximius		*M.staurophora	
89.							*Ma.furcatus	*Ma. furcatus
90.		*M. staurophora	*M. staurophora *T. pyramidus			*M. staurophora		
90.5								*E. eximius
91.		*G. obliquum					*E.eximius	
92.	*Co. exiguum		+L. acutum		*Q. gartneri	+L. acutum		*E. gartnerii
93.						*Q. gartneri		

*Lowest occurrence

+Highest occurrence

Roth (1978) correlated the Cretaceous oceanic stages with the magnetic reversal scale, and assigned radiometric ages for their boundaries. So far, the use of these stages has been limited.

BIOSTRATIGRAPHIC EVENTS

Turonian

Caratini's (1960) study of the Turonian sediments of the Rouen Region in France showed that *Gartnerago obliquum* (reported by Caratini as *Discolithus ornamentus*) and *Micula staurophora* (probably *Quadrum gartneri* of this study) are among the important mid Cretaceous key species, for they first occur in sediments of this age. Stradner (1963) termed the Turonian coccolith assemblages the "Staurophora-association". Stover (1966) included *Gartnerago obliquum* in his list of Turonian first appearances, which also included the species *Eiffellithus eximius* (described as *Clinorhabdus eximius*) and *Kamptnerius magnificus*. Thierstein (1974) identified several coccolith stratigraphic events for the mid Cretaceous. Those for the Turonian are listed below in a stratigraphic order.

last *Gartnerago striatum* at Turonian/Coniacian boundary
first *Kamptnerius magnificus*
first *Micula staurophora* (?*Quadrum gartneri* of other authors)
first *Ahmuellerella octoradiata*
last *Podorhabdus albianus*
last *Lithraphidites alatus* at Cenomanian/Turonian boundary.

Thierstein (1976) described the lowest appearances of *Gartnerago obliquum* and *Micula staurophora* as biohorizons for the early and middle Turonian respectively, but also showed in his range chart that other species such as *Ahmuellerella octoradiata*, *Kamptnerius magnificus* and *Microrhabdulus decoratus* are potentially important for the biostratigraphy of the Turonian. However, Manivit & others (1977) threw some doubts about the age assingment of the lowest occurrences of *Ahmuellerella octoradiata*, *Cribrosphaerella ehrenbergii* and *Lucianorhabdus maleformis* as being late Turonian. These authors used the lowest occurrences of *Quadrum gartneri* and *Eiffellithus eximius* (as an early and late Turonian events respectively) to define a biostratigraphic zone (see the *Quadrum gartneri* zone in Tables 3 & 4A-4B).

Conard & Manivit (1979) showed that *Ahmuellerella octoradiata* first appears in the upper Cenomanian, above the lowest occurrence of *Gartnerago obliquum.* The range chart given by Manivit (1981) shows that the lowest occurrences of *A. octoradiata*, *Quadrum gartneri* and *Cyclindrallithus biarcus* are at the same level. The lowest occurrence of both *Eiffellithus eximius* and *Kamptnerius magnificus* are about the same level within the upper Turonian according to the data presented by Conard & Manivit (1979) and Manivit (1981). Recently, Hill & Bralower (1987) recorded forms very similar to *E. eximius* from upper Albian and lower Cenomanian of northern Texas and southern Oklahoma (U.S.A.), and cautioned that previously reported post-Albian appearance datums of *E. eximius* are abundance acmes. They reasoned that low abundance, spotty occurrence and palaeogeographic restriction within the lower stratigraphic range of the species, mask its true lowest occurrence. Curiously, Hill & Bralower (1987) indicated that there are no reports of middle to late Cenomanian occurrences of *E. eximius.*

Recent attempts at integrating mid Cretaceous zones, based on various groups of fossils (including calcareous nannofossils), in relation to the European stages (e.g. Robaszynski, 1983; Salaj & Gasparikova, 1983; Marks, 1984) have shown that the lowest occurrence of *Gartnerago obliquum* and *Microrhabdulus decoratus* are within the upper Cenomanian. Marks (1984) concluded that the lowest occurrence of *Quadrum gartneri* is at the base of the Turonian, and the lowest occurrence of *Marthasterites furcatus* at the base of the Coniacian, and noted a disagreement between Manivit and Verbeek regarding the placement of the lowest occurrence of *Eiffellithus eximius* within the Turonian.

A synthesis of coccolith biostratigraphic events recognised by various investigators for the late Cenomanian-early Coniacian interval is included in Table 2. As most investigators place the lowest occurrence of *Marthasterites furcatus* at the base of the Coniacian, this event is taken as a good reference horizon for compilation of other events. The sequential order of events in Table 2 is by no means definite, because the vertical ranges of some of the species are not well established.

Coniacian-Campanian

The pioneering work of Cepek & Hay (1969a, b) has identified several Upper Cretaceous coccolith events, two of which, namely the first up-section appearance of *Marthasterites furcatus* and the much younger event at the lowest occurrence of *Ceratolithoides aculeus* (reported as *Tetralithus aculeus*), are particularly important within the Coniacian-Campanian interval. Other pioneering biostratigraphic works such as by Bukry & Bramlette (1970), Manivit (1971), Roth (1973) and Thierstein (1976), introduced most of the other widely-used coccolith events for the Coniacian-Campanian interval: the up-section appearances of *Calculites obscurus* (reported as *Tetralithus obscurus*), *Broinsonia parca*, and *Quadrum trifidum* (reported as *Tetralithus nitidus trifidus*). Most of the newly described coccolith zonations (e.g. Sissingh, 1977) incorporate most of these events in a similar sequential order.

The sequence of events presented in Table 2 is based on various sources, including those mentioned above. The relative positions of the lowest occurrences of *Calculites obscurus*, *Broinsonia parca* and *Quadrum trifidum* are firm, but this can not be said about some of the other events in Table 2 as they are frequently placed differently by different authors. On the other hand, some of the key species, such as *Lithastrinus grillii*, are excluded from Table 2 because of greater uncertainty related to the relative positions of their lowest or highest occurences. Wind & Wise (1983) have identified the problem of where the highest occurrence of *Marthasterites furcatus* and of *Lithastrinus grillii* relative to the lowest occurrence of *Broinsonia parca*. Similar problems do exist: the relative positions of the highest occurrence of *Eprolithus floralis*, and of the lowest occurrences of *Lucianorhabdus cayeuxii* and *Lithastrinus grillii* in the sequence. The dating of the lowest occurrence of *Calculites obscurus* and other index species is another problem though of different type. Thierstein (1976) assigned a Santonian age for the lowest occurrence of *Tetralithus obscurus* (=*Calculites obscurus*), but Sissingh (1977, 1978) considered it as early Campanian. Shafik (1978b) recorded *C. obscurus* (as *Tetralithus obscurus*) from Gingin Chalk outcrops where the European Santonian zones of the pelagic crinoides *Uintacrinus* and *Marsupites* were identified; the Santonian age is confirmed in this study. Earlier, however, Forchheimer (1972) described a nannolith very similar to *C. obscurus* (her *Lucianorhabdus quadrifidus*) from the Aptian-Cenomanian of a borehole in Sweden; see also Barrier (1980) who stated that this species occurs first in Texas, U.S.A., in the lower Turonian.

Smith (1981) cited evidence suggesting that the lowest occurrence of *Lucianorhabdus cayeuxii* in the Austin Group (Texas, U.S.A.) is early Coniacian in age, but earlier Sissingh (1977) correlated the same event with a level within the Santonian.

Thierstein (1976) assigned the highest occurrence of *Marthasterites furcatus* to the late Santonian, but other investigators (Manivit, 1968; Gartner, 1968; Bukry, 1969) found the species in Campanian sediments.

Maastrichtian

Published work by Cepek & Hay (1969a, b), Martini (1969) and Bukry & Bramlette (1970) includes the basic coccolith biostratigraphic framework for the Maastrichtian: 1) the lowest occurrence of the key species *Nephrolithus frequens* being above that of the other key species *Lithraphidites quadratus* (Cepek & Hay, 1969a, b); 2) the lowest occurrence of *Micula murus* as a zonal marker in the uppermost Maastrichtian (Martini, 1969, footnotes pp.122-123 as *Tetralithus murus*); and 3) the extinction of *Quadrum trifidum* within the lower Maastrichtian (Bukry & Bramlette, 1970, reported as *Tetralithus nitidus trifidus*). These biostratigraphic events were incorporated in subsequent zonations (e.g. Manivit, 1971; Roth, 1973; Bukry, 1973b; Thierstein, 1976; Verbeek, 1976; see also Table 20). Some have not always been identified, and in more recent zonations, these have been approximated using other key species. For example, Martini (1976) used the highest occurrence of *Broinsonia parca* to approximate the highest occurrence of *Quadrum trifidum* in the type Maastrichtian Gulpen Chalk, because the latter species was not found there. Other investigators used the same evidence where a good top (highest occurrence) for *Q. trifidum* could not be identified, but Perch-Nielsen (1977) used the highest occurrence of *Reinhardtites anthophorus* instead.

Attempts made by some investigators (e.g. Risatti, 1973; Sissingh, 1977) to substantially refine Maastrichtian coccolith biostratigraphy have not been without problems. Risatti (1973) proposed several new Maastrichtian zones, based on newly-described species from Mississippi (U.S.A.). Most of these zones, however, could not be verified elsewhere because their key species were found to be either very rare or longer ranging. On the other hand, Sissingh (1977) described a number of biostratigraphic units (zones and subzones), which were used subsequently by other investigators. Sissingh (1977) identified several Maastrichtian events below the base of the range of *Lithraphidites quadratus* (Table 20): 1) a set of up-section sequential extinctions: a) of *Broinsonia parca* (reported as *Aspidolithus* ex gr. *parcus*), b) of *Tranolithus orionatus* (reported as *T. phacelosus*), and c) of *Reinhardtites levis*, and 2) still a higher event, the lowest occurrence of *Arkhangelskiella cymbiformis*. The criteria for identification of some of the key species used by Sissingh (1977), in particular *Tranolithus phacelosus* (*T. orionatus* of this study), *Reinhardtites levis* and *Arkhangelskiella cymbiformis*, are not uniformly adhered to by the majority of coccolith investigators - often resulting in a sequence of events different from that of Sissingh. For instance, a wider concept of *A. cymbiformis* adopted by Perch-Nielsen, can probably be related to her record of an overlap in the ranges of this species and *Reinhardtites levis* in Denmark (Perch-Nielsen, 1979a). The occurrence of *Reinhardtites levis* with *Nephrolilthus frequens* in the type Maastrichtian has been thought as a result of reworking (see van Heck, 1979; Verbeek, 1986).

An outline of the Maastrichtian coccolith biostratigraphy currently in use by most European investigators (e.g. Perch-Nielsen, 1979e) is largely incorporated in Table 20. Other newly recognised late Campanian-Maastrichtian events, not included in Table 20, are the lowest and highest occurrences of *Biscutum coronum*, and the highest occurrence of *Biscutum magnum* (Wise, 1983; Wind & Wise, 1983). These events, however, have not been tested outside the Falkland Plateau (South Atlantic), the present study notwithstanding.

In Table 20, the relative position of the lowest occurrences of *Nephrolithus frequens* and *Micula murus* in the sequence are uncertain, and only rarely are these species found together. On geographic distribution, *N. frequens* can be regarded as austral/boreal, and *M. murus* as tropical (Worsley & Martini, 1970; Shafik & Stradner, 1971). Gartner (*in* Cita & Gartner, 1971) equated the lowest occurrences of both species. Manivit (1971) indicated that *Micula murus* appears in the Aquitaine Basin in France slightly **above** the lowest occurrence of *Nephrolithus frequens.* A similar order of appearance is shown by Thierstein (1976) who assigned the lowest occurrence of *Nephrolithus frequens* to the middle Maastrichtian, and the lowest occurrence of *Micula murus* (reported as *Tetralithus murus*) to the late Maastrichtian. On the other hand, Sissingh (1977, p. 56) remarked that *Micula murus* first appears in the record **below** the lowest occurrence of *Nephrolithus frequens* (see also Verbeek, 1976). Earlier Worsley & Martini (1970, p. 1242) commented that "*murus* is always restricted to the latest Maastrichtian", whereas *frequens* appeared during the latest Maastrichtian "only toward the limits of its province". Recently, Perch-Nielsen (1979e) described *Micula prinsii*, a closely related species to *Micula murus*, and indicated that its lowest occurrence is above the lowest occurrence of *Nephrolithus frequens*. The lowest occurrence of *Micula murus* is below that of *Nephrolithus frequens*, according to Perch-Nielsen (1979e). Earlier, Perch-Nielsen (1977) indicated the reverse, i.e. the lowest occurrence of *N. frequens* being older than the lowest occurrence of *M. murus* (see also Perch-Nielsen & others, 1974, p. 343). (Indeed, she described a zone based on the range of *N. frequens* prior to the appearance of *M. murus* which marked her youngest Cretaceous zone (Perch-Nielsen, 1977).) The absence of *M. murus* from high-latitude Maastrichtian deposits has been interpreted by Perch-Nielsen (1977; 1979b) as evidence for the absence of the youngest Cretaceous in the section or, in the case of chalk facies, the dissolution of the species itself. Stradner & Steinmetz (1984) believed that *N. frequens* appears in the record below the lowest occurrence level of *M. murus*.

In the type Maastrichtian, both *Nephrolithus frequens* and *Micula murus* are rare, and *N. frequens*

Table 20. Framework of the Maastrichtian coccolith biostratigraphy, based on results of Cepek & Hay (1969a, b), Martini (1969), Bukry & Bramlette (1970), Manivit (1971), Thierstein (1976), Sissingh (1977), Perch-Nielsen (1979e), among others.

Age	Important biostratigraphic events
MAASTRICHTIAN	
	*Micula prinsii
Late	
	*Nephrolithus frequens(1)
------------	*Micula murus(1)
	*Lithraphidites quadratus
	*Arkhangelskiella cymbiformis(2)
Middle	
	+Reinhardtites levis(2)
	+Tranolithus orionatus
-----------	+Quadrum trifidum(3)
Early	+Broinsonia parca(4)
------------	*Cribrosphaerella daniae(5)
CAMPANIAN	

***Lowest occurrence +Highest occurrence**

(1) Relative timing uncertain, see text.

(2) Strict species definition is not commonly adopted, hence possible unreliability in correlation using independent investigators' results.

(3) This event is identifiable in both Extratropical and Tropical Provinces, but particularly reliable in correlation within the Tropical Province.

(4) This event may approximate the Campanian/Maastrichtian boundary within the Tropical Province; *B. parca* ranges into Maastrichtian in the Extratropical Province.

(5) The species is particularly common in the Austral Province, where the event can be used to approximate the Campanian/Maastrichtian boundary.

appears earlier than *M. murus* according to data given by van Heck (1979).

It has already been acknowledged by other investigators, that the Campanian/Maastrichtian boundary is difficult to delineate using coccoliths; it falls within the vertical range of the key species *Quadrum trifidum*. Criteria for the identification of this boundary have varied from one investigator to another; none of the criteria has been shown to be applicable everywhere.

Correlation between biostratigraphic results based on late Maastrichtian foraminiferids and coccoliths shows that the vertical range of the foraminiferal index *Abathomphalus mayaroensis* approximates the vertical range of the coccolith *Micula murus* (see, e.g., Thierstein, 1976). However, according to Sissingh (1978) and Perch-Nielsen (1979e) the range of *Abathomphalus mayaroensis* seems to encompass several coccolith stratigraphic events including some older than the lowest occurrence of *Micula murus*.

EVENTS IN THE PERTH AND CARNARVON BASINS

SANTONIAN-CAMPANIAN IN PERTH BASIN

Table 21 summarises the Santonian-Campanian coccolith biostratigraphic events that are recognisable in the Perth Basin, and Table 22 is an attempt at their correlation with the European and oceanic Cretaceous stages.

Probably, the oldest coccolith biostratigraphic event discernible in the Gingin Chalk is the lowest occurrence of *Lithastrinus grillii* in Agaton #19 borehole, immediately above the barren Molecap Greensand. The basal assemblage in Agaton #19 borehole is impoverished and lacks *Marthasterites furcatus*, *Eiffellithus eximius*, *Reinhardtites biperforatus*, *Micula concava*, *Lucianorhabdus maleformis*, *Calculites ovalis*, *Lucianorhabdus cayeuxii*, *Acuturris scotus* and *Reinhardtites anthophorus*, the key species for the base of the type Gingin Chalk. It also lacks *Calculites obscurus* which characterises the assemblages of most of the outcropping Gingin Chalk in the type area. It is not known whether the absence of these species is biostratigraphic (i.e. a true absence), a result of diagenesis or due to environmental factors (e.g. an impoverishment brought about initially by poor accessibilty of the flora) at the Agaton site. The assemblage represents an initial stage in a marine transgression and therefore may not be representative of the total flora.

Table 21. Santonian-Campanian(1) coccolith biostratigraphic events as recognised in the Upper Cretaceous carbonates of Perth Basin.

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---------**Cribrosphaerella daniae*(1)

LANCELIN BEDS

---------**Reinhardtites levis s.l.*------------------------------

**Monomarginatus quaternarius*

(a biostratigraphic discontinuity)

---------*+Tranolithus orionatus*------------------------------

+Marthasterites furcatus

**Broinsonia parca*

**Calculites obscurus*

**Lucianorhabdus cayeuxii*

GINGIN CHALK

**Acuturris scotus, Calculites ovalis*

**R. anthophorus, M. concava, B. dentata*

**Lithastrinus grillii* (Impoverished assemblage at base of Upper Cretaceous microplanktic sequence.)

=====================================

***Lowest occurrence** **+Highest occurrence**

R.=Reinhardtites; M.=Micula; B.=Broinsonia

(1)This event is suggested as a good approximation of the Campanian/Maastrichtian boundary.

The absence of *Acuturris scotus*, *Calcultites obscurus*, *C. ovalis*, *Lucianorhabdus cayeuxii* and *L. maleformis* from the Agaton assemblage may not be due to their destruction by post-depositional agents, because the relatively diagenetically susceptible *Kamptnerius magnificus* is present in large numbers. Other species, more resistant to diagenesis, such as *Marthasterites furcatus*, *Eiffellithus eximius*, *Micula staurophora*, *M. concava*, *Reinhardtites anthophorus* and *R. biperforatus*, are absent, probably because of unfavourable palaeoenvironmental conditions.

The association of *Eprolithus floralis*, *Lithastrinus grillii*, *Kamptnerius magnificus* and *Gartnerago obliquum* in the Agaton basal assemblage suggests a late Coniacian/early Santonian age, i.e. an age not substantially different from the age of the basal assemblages of the Gingin Chalk outcrops in the Gingin area.

Later events, the first up-sequence appearances (a cluster of lowest occurrences) of *Broinsonia dentata*, *Micula concava* and

Table 22. Correlation of selected coccolith biostratigraphic events from Table 21 with the Upper Cretaceous stages.

MAASTRICHTIAN	**Cribrosphaerella daniae*	
	**Monomarginatus quaternarius*	
CAMPANIAN	+*Marthasterites furcatus*	BERMUDAN
	**Broinsonia parca*	
	**Calculites obscurus*	
	**Lucianorhabdus cayeuxii*	
SANTONIAN	**Acuturris scotus*	HOWLANDIAN
	**Reinhardtites anthophorus*	
	**Lithastrinus grillii*	
CONIACIAN		

***Lowst occurrence   +Highest occurrence**

Reinhardtites anthophorus have been identified in the basal assemblage in Ginginup #1 corehole, immediately above the barren Molecap Greensand; this assemblage already has *Kamptnerius magnificus*, *Gartnerago obliquum*, *Marthasterites furcatus*, *Eiffellithus eximius* and *Micula staurophora*. The basal assemblage in Ginginup #1 corehole represents the base of the transgression, similar to the basal assemblage in Agaton #19 borehole. But unlike the Agaton assemblage, it is rich and diversified.

The first up-sequence appearance of *Reinhardtites anthophorus* may be a more reliable biostratigraphic event than other events represented by the lowest occurrences of *Micula concava* or *Broinsonia dentata*. *R. anthophorus* is more readily identifiable than *B. dentata*, and is less readily altered by diagensis than is *M. concava*.

The next higher events are the lowest occurrences of *Acuturris scotus* and *Calculites ovalis* as illustrated by the assemblages from Gingin Brook #4 and Agaton #19 boreholes (sample MFN-2486). These assemblages also include the biostratigraphically important species *Eiffellithus eximius*, *Marthasterites furcatus*, *Micula staurophora*, *M. concava*, *Lucianorhabdus maleformis*, *Reinhardtites anthophorus* and *Broinsonia dentata*.

The lowest occurrence of *Acuturris scotus* is a more reliable event than the lowest occurrence of *Calculites ovalis* because the former species is more distinctive.

The sequence of events marked by the lowest occurrences of the key species *Lucianorhabdus cayeuxii*, *Calculites obscurus* and *Broinsonia parca* (Tables 21 & 22) is well documented in the Ginginup corehole #1 and also in the type Gingin Chalk (Tables 5 & 6).

The next higher event, above the lowest occurrence of *Broinsonia parca*, is the highest occurrence of *Marthasterites furcatus* - based on the Ginginup #1 corehole sequence (see Table 6).

Other coccolith biostratigraphic events occurring above the highest occurrence of *Marthasterites furcatus* (Table 22) and below the intra-Maastrichtian hiatus, in the Upper Cretaceous carbonate sequence of the Perth Basin, are those identified in the Lancelin Beds in the Breton Bay #1 corehole sequence. These are above the intra-Campanian hiatus (see Tables 7 & 21) which is at the lowest occurrences of *Monomarginatus quaternarius* and *Reinhardtites levis s.l.* in that corehole. The lowest occurrence of *Quadrum gothicum* in Breton Bay #1 corehole sequence is unreliable because of the scarcity and sporadic distribution of the species; *Q. gothicum* was encountered in the Joondalup #25p core but not in the type Lancelin Beds.

TURONIAN-CAMPANIAN IN CARNARVON BASIN

The lower part of the biostratigraphic sequence given in Table 23 is based on the coccolith successions in the type Beedagong Claystone section (Rough Range South #1 well), supplemented by events recognisable in exposures of Beedagong/Toolonga transition in the central Giralia Anticline. The lowest occurrence of *Eiffellithus eximius* in Table 23 may not correspond with the first appearance of the species in the world ocean; *E. eximius* or forms very similar to it have been recorded from upper Albian deposits elsewhere (see Hill & Bralower, 1987).

The lowest discernible coccolith biostratigraphic event in the Toolonga Calcilutite proper is represented by the lowest occurrence of *Reinhardtites anthophorus*, a few centimetres above the phosphatic nodule bed marking the disconformity between the Alinga Formation and the Toolonga Calcilutite in the Alinga Point section (Lower Murchison River area). The older event, marked by the lowest occurrence of *Lithastrinus grillii*, is identifiable in the Beedagong/Toolonga transition section in the central Giralia anticline, but not in the type Beedagong Claystone (Rough Range). This event could not be detected at the base of the Toolonga Calcilutite in the Lower Murchison River sections, in the southern portion of the basin. This may be due to poor preservation in the nodule bed and inadequate sampling of the basal few centimetres of the Toolonga Calcilutite.

The sequence of events from the lowest occurrence of *Reinhardtites anthophorus* up to the highest occurrence of *Marthasterites furcatus* inclusive is documented from sections of the Toolonga Calcilutite in the Lower Murchison River-Shark Bay area and in the Giralia Anticline.

Several key species have their lowest occurrence simultaneously in the phosphatic nodule bed at the base of the type Korojon Calcarenite (Tables 12 & 23). Of these only the lowest occurrence of *Quadrum trifidum* is thought to be relevant to the biostratigraphy of this part of the Cretaceous in the Carnarvon Basin (Table 24). The event marked by the lowest occurrence of *Quadrum gothicum* is more reliable, but *Q. trifidum* is younger. The event marked by the lowest occurrence of *Reinhardtites levis* is slightly younger than the lowest occurrence of *Quadrum trifidum* (see Table 2; Perch-Neilsen, 1979e), but the lowest occurrence of typical *R. levis* is difficult to recognise because of forms transitional between *R. anthophorus* and *R. levis*. The highest occurrence of *Broinsonia parca* relative to the highest occurrence of *Quadrum trifidum* in the type Korojon Calcarenite (Table 23) is reversed in Table 24 in keeping with the sequential order of these events elsewhere (see Tables 2 & 20). *Quadrum trifidum* is rare and sporadic in the Korojon Calcarenite, and the event marking its highest occurrence in highly unreliable, compared with that of the highest occurrence of *Broinsonia parca*; *B. parca* is more persistent in the Korojon Calcarenite.

Quadrum trifidum was not encountered in the Korojon Calcarenite equivalent in Cape Cuvier #1 well (southern Carnarvon Basin), instead *Monomarginatus quaternarius* was found in association with *Quadrum gothicum*.

CORRELATION OF EVENTS IN PERTH AND CARNARVON BASINS

Coccolith events older than the late Coniacian/early Santonian lowest occurrence of *Lithastrinus grillii* in the Carnarvon Basin have no

Table 23. Turonian-Campanian coccolith biostratigraphic events as recognised in the Upper Cretaceous carbonates of Carnarvon Basin.

+*Broinsonia parca*(2)	
+*Quadrum trifidum*(1)	
	KOROJON CALCARENITE
---*_Reinhardtites levis s.l._---	
*_Quadrum trifidum_	
*_Quadrum gothicum_	
*_Ceratolitoides aculeus_	
(disconformity at the Toolonga/Korojon contact)	
---+*Tranolithus orionatus*---	
+*Marthasterites furcatus*	
*_Broinsonia parca_	
*_Calculites obscurus_	**TOOLONGA CALCILUTITE**
*_Lucianorhabdus cayeuxii_	
*_Acuturris scotus_	
*_Reinhardtites anthophorus_	
(continuous sedimentation across the Beedagong/Toolonga contact)	
*_Lithastrinus grillii_	
*_Reinhardtites biperforatus_	
*_Marthasterites furcatus_	**BEEDAGONG CLAYSTONE**
*_Eiffellithus eximius_	
*_Kampnerius magnificus_	

***Lowest occurrence** **+Highest occurrence**

(1) This event is unreliable because the species is usually rare and sporadic in the Korojon Calcarenite. The age of this event is commonly regarded as early Maastrichtian.

(2) This event, is above the highest occurrence of *Quadrum trifidum*, and therefore within the early Maastrichtian.

(1-2) These events are reversed in Table 24, in keeping with Table 2 which is based on results from elsewhere.

Table 24. Correlation of selected coccolith biostratigraphic events from Table 23 with the Upper Cretaceous stages.

UPPER CAMPANIAN/ LOWER MAASTRICHTIAN	+_Quadrum trifidum_(1)	BERMUDAN
	+_Broinsonia parca_(2)	
	*_Quadrum trifidum_	
LOWER CAMPANIAN	+_Marthasterites furcatus_	
	*_Broinsonia parca_	
SANTONIAN	*_Calculites obscurus_	
	*_Lucianorhabdus cayeuxii_	
	*_Acuturris scotus_	
	*_Reinhardtites anthophorus_	
	*_Lithastrinus grillii_	HOWLANDIAN
CONIACIAN	*_Reinhardtites biperforatus_	
	*_Marthasterites furcatus_	
UPPER TURONIAN	*_Eiffellithus eximius_	NATURALISTIAN
	*_Kamptnerius magnificus_	

***Lowest occurrence** **+Highest occurrence**

(1-2) The order of these events is the reverse of that in Table 23.

counterparts in the Perth Basin where conditions were hostile to the calcareous microplankton.

Santonian and early Campanian coccolith biostratigraphic events are similar in the Perth and Carnarvon Basins (compare Tables 22 & 24). This differs from the events of the younger part of the Cretaceous. The lowest occurrence of _Monomarginatus quaternarius_ is useful for differentiating a younger Campanian in the Perth Basin, but the species was encountered in only one section (Cape Cuvier #1 well) in the Carnarvon Basin, in lower Maastrichtian sediments. Its probable coeval event in the Carnarvon Basin is the lowest occurrence of _Quadrum trifidum_, an event not recognised in the Perth Basin.

Monomarginatus quaternarius is sporadic in the Lancelin Beds of the Perth Basin, particularly in the upper part of the unit. The same is more so for _Quadrum trifidum_ in the Korojon Calcarenite in the Carnarvon Basin. However, these species are used in the biostratigraphies of these basins because of the absence of other equally important marker species: The key species _Quadrum gothicum_ is rare and sporadic in the Perth Basin sequence, and its lowest occurrence (in Breton Bay #1 corehole) is unreliable. The index species _Ceratolithoides aculeus_ is more uniform in its distribution than _Quadrum trifidum_ in the upper Campanian-lower Maastrichtian of the Carnarvon Basin, but its lowest occurrence is known to occur below that of _Q. trifidum_ elsewhere (see Table 2).

The biostratigraphic discontinuity indicated between the Gingin Chalk and the Lancelin Beds in Breton Bay #1 corehole, Perth Basin, is likely to be coeval with that recorded between the Toolonga Calcilutite and Korojon Calcarenite at C-Y Creek in the Giralia Anticline, Carnarvon Basin (Tables 21 & 23). The age of the top of the Gingin Chalk (in Breton Bay #1 corehole) is likely to be early Campanian, judging from occurrences of the Gingin Chalk in its type area (e.g. Ginginup #1 corehole). The age of the top of the Toolonga Calcilutite (in C-Y Creek section) is also early Campanian, having similar coccolith assemblages as those from the top part of the Gingin Chalk in Ginginup #1 corehole. Thus the lower surface of the biostratigraphic discontinuity in Breton Bay #1 corehole and C-Y Creek section may be isochronous, within the early Campanian. Determination of the age of the upper surface of this discontinuity is not simple. The key species at the base of the Lancelin Beds are different from those at the base of the Korojon Calcarenite. _Monomarginatus quaternarius_ is thought to have first appeared during the late Campanian, based on its occurrence on the Falkland Plateau (SW Atlantic, see Wind & Wise, 1983); _M. quaternarius_ occurs at the base of the Lancelin Beds in Breton Bay #1 corehole. The age of the base of the range of _Quadrum trifidum_ is generally accepted as late Campanian (see, e.g. Thierstein, 1976; Perch-Nielsen, 1979e); this species occurs at the base of the Korojon Calcarenite in C-Y Creek section. A maximum age limit of late Campanian age seems plausible for either the base of the Lancelin Beds or the Korojon Calcarenite. It is difficult, however, to assign a minimum age limit for these horizons. _Tranolithus orionatus_ disappears at or below the discontinuity in both cases, but this species is thought to have its highest occurrence within the Maastrichtian (see Table 2), above the highest occurrence of _Quadrum trifidum_ according to investigators (e.g. Perch-Nielsen, 1979e). That _T. orionatus_ disappeared from the Australian sections earlier than the early Maastrichtian seems plausible in view of its similar stratigraphic range in the Falkland Plateau sequence (DSDP Hole 327A data _in_ Wise & Wind, 1977; DSDP Hole 511 data _in_ Wise, 1983).

AUSTRALIAN MAASTRICHTIAN COCCOLITH BIOSTRATIGRAPHIC EVENTS

Several significant coccolith biostratigraphic events are recognisable in the Australian Maastrichtian sections (Tables 8 & 13). The oldest is the lowest occurrence of _Cribrosphaerella daniae_, an event recognisable in the Perth Basin but not in the Carnarvon Basin where the species is extremely rare and sporadic. The other events are marked by the lowest and highest occurrences of _Nephrolithus corystus_, and the highest occurrences of _Monomarginatus quaternarius, Zygodiscus bicrescenticus, Broinsonia parca, Biscutum magnum_ and _Reinhardtites levis_ s.l., as well as the lowest occurrences of _Lithraphidites quadratus, Nephrolithus frequens_, and _Micula murus_. Of these events, only the highest occurrences of _Zygodiscus bicrescenticus, Reinhardtites levis_ s.l. and _Broinsonia parca_, and the lowest occurrence of _Lithraphidites quadratus_ are easily recognisable, and seem to be useful in both the Perth and Carnarvon Basins. The sequential order of these events could not, however, be determined because they occur too close to each other, i.e. at about the same level - suggesting an hiatus which is about the same time in both basins (discussed earlier in this study).

Other events are tenable for one basin but not for the other (see Table 25). Thus, while the lowest occurrences of _Cribrosphaerella daniae_ and _Nephrolithus corystus_, and the highest occurrences of _Monomarginatus quaternarius, Nephrolithus corystus_ and _Biscutum magnum_ are easily discernible as reliable events in the Perth Basin, they are either unrecognisable or unreliable in the Carnarvon Basin. The lowest occurrences of _Micula murus_ and _M. prinsii_

Table 25. Australian Maastrichtan sequences of coccolith events.

PERTH BASIN	CARNARVON BASIN
	*_Micula prinsii_(1)
*_Nephrolithus frequens_	*_N. frequens_/*_Micula murus_
HIATUS	HIATUS
+_Z. bicrescenticus_/_B. parca_	+_Z. bicrescenticus_/_B. parca_
+_Monomarginatus quaternarius_	
*_Nephrolithus corystus_	
*_Cribrosphaerella daniae_	

__*Lowest occurrence__ __+Highest occurrence__

(1) found only in reworked Miria Marl at base of Paleocene Boongerooda Greensand.

N. =Nephrolithus, Z. =Zygodiscus, B. =Broinsonia are difficult to identify in both basins. *Micula murus* is more likely to be identified in the Carnarvon Basin because it is more frequent in there than in the Perth Basin. *M. prinsii*, not found in the Perth Basin, occurs only in the reworked Miria Marl at the base of the Paleocene Boogerooda Greensand, in the Carnarvon Basin. *Nephrolithus frequens* is more common in the Perth Basin, hence its lowest occurrence is more readily recognisable in the Perth rather than the Carnarvon Basin. Table 25 shows that the biostratigraphic resolution achievable for the Maastrichtian in the Perth Basin is finer than that in the Carnarvon Basin (see Remarks on p. 76).

UPPER CRETACEOUS COCCOLITH BIOGEOGRAPHIC PROVINCES

Provincialism among Maastrichtian coccoliths was first acknowledged by Worsley & Martini (1970), who outlined the geographic limits of the two most cited examples, *Nephrolithus frequens* and *Micula murus.* Of later published reports, few have addressed the subject of Late Cretaceous coccolith provincialism and biogeography. Worsley (1974) believed that the Maastrichtian *Micula murus*, *Ceratolithoides kamptneri* and *Cyclindralithus gallicus* (=*Cribrocorona gallica*), and the long-ranging *Rhagodiscus splendens*, *Thoracosphaera operculata* and *T. imperforata* were tropical, whereas *Markalius astroporus* and *Nephrolithus frequens* preferred higher latitudes; Roemin (1977) later added *Cyclagelosphaera reinhardtii* (=*Cyclagelosphaera margereli*) and *Crepidolithus neocrassus* (=*Neocrepidolithus neocrassus*) to the species restricted to higher latitudes. Thierstein (1976) noted that *Kamptnerius magnificus*, *Lucianorhabdus cayeuxii*, *Nephrolithus frequens*, *Gartnerago obliquum*, *Micula staurophora*, *Vagalapilla octoradiata* (=*Ahmuellerella octoradiata*), *Tetralithus obscurus* (=*Calculites obscurus*) and *Braarudosphaera bigelowii* become more abundant with increasing palaeolatitudes. In an abstract by Thierstein & Haq (1977) two conclusions relating to the Maastrichtian were given (1) the relative abundance distribution at any particular site remains remarkably constant, suggesting relatively stable ecologic conditions, and (2) the biogeographic boundaries roughly parallel latitudes: tropical assemblages are dominated by *Micula staurophora* and *Watznaueria barnesae* and include common *Micula murus* and *Tetralithus aculeus* (=*Ceratolithoides aculeus*), while higher latitude assemblages contain abundant *Nephrolithus frequens*, *Arkhangelskiella cymbiformis*, *Kamptnerius magnificus*, *Lucianorhabdus cayeuxii* and *Zygodiscus anthophorus* (=*Reinhardtites anthophorus s.l.*). Roth (1978) stated that many latest Cretaceous coccolith species show a latitudinally controlled distribution: *Nephrolithus frequens* and *Lithraphidites quadratus* being absent from tropical oceanic sites, whilst *Micula murus*, *Tetralithus trifidus* (=*Quadrum trifidum*) and *Tetralithus gothicus* (=*Quadrum gothicum*) being confined to mid and low latitudes.

MATERIAL STUDIED FROM NEARBY AREAS AND SW PACIFIC

To assess the palaeogeographic distribution of key coccolith species in the Australian and SW Pacific region, material from the Naturaliste Plateau, Australian NW corner, Papua New Guinae, Ontong Java Plateau, Nineyeast Ridge, Kerguelen Plateau and New Zealand was examined. Results obtained were compared with those from the Perth and Carnarvon Basins.

NATURALISTE PLATEAU, DSDP SITE 264

Two samples from core 11 taken at DSDP site 264 were examined. Coccolith assemblages recovered from both samples (264-11-1, 147-150 cm; 264-11-2, 17-20 cm) are rich, although poorly preserved, with some evidence of dissolution. *Reinhardtites anthophorus*, *Kamptnerius magnificus*, *Gartnerago obliquum*, *Watznaueria barnesae*, *Prediscosphaera cretacea*, *Biscutum coronum* and *Lucianorhabdus cayeuxii* are particularly abundant. *Broinsonia parca*, *Reinhardtites biperforatus*, *Micula staurophora*, *Quadrum gartneri* as well as several species of *Arkhangelskiella* and *Broinsonia* are important members of the assemblages, although less abundant. Species which are found to be rare or restricted to one sample, include *Eiffellithus eximius*, *E. turriseiffeli*, *Ahmuellerella octoradiata*, *Microrhabdulus belgicus*, *Tranolithus orionatus*, *Lapideacassis sp.*, *Cyclagelosphaera spp.*, *Actinozygus regularis* and ? *Tetrapodorhabdus decorus.*

The association of *Broinsonia parca*, *Biscutum coronum* and *Reinhardtites biperforatus* suggests an early Campanian age, and a correlation is made with the lower Campanian Gingin Chalk in Ginginup #1 corehole (Perth Basin) and the lower Campanian Toolonga Calcilutite outcrops in the Shark Bay-Lower Woramel River area (Carnarvon Basin).

Remarks. Early Campanian coccolith assemblages recovered from the Naturaliste Plateau, Gingin Chalk and Toolonga Calcilutite correlate well with assemblages recorded from the offshore central Scott Plateau to the NNW of Australia (Shafik, 1978c). The Scott Plateau assemblages lack several species, such as *Acuturris scotus, Biscutum coronum, Calculites obscurus, C. ovalis, Kamptnerius magnificus, Lucianorhabdus cayeuxii* and *L. maleformis*, which are mostly present in the other assemblages. This association suggests deposition in nearshore or shelf environment at higher latitudes (compared with palaeolatitudes of Scott Plateau). The lower Campanian chalk of the central Scott Plateau was probably deposited in deeper oceanic settings (Shafik, 1978c).

Biscutum coronum, first described from the Falkland Plateau, is regarded as an indicator for cold-water conditions, having a preference for high latitudes. In the present study, this species has been recorded from the lower Campanian of three areas, though with differing abundance. *B. coronum* is common in the Naturaliste Plateau material, frequent in the Gingin Chalk of the Perth Basin, and relatively rare in the Toolonga Calcilutite of the Dirk Hartog area, southern Carnarvon; this species is not known elsewhere in the Carnarvon Basin. Its abundance in the early Campanian of the Naturaliste Plateau and Perth Basin suggests cooler-water conditions than in the Carnarvon Basin, where *B. coronum* is absent in most occurrences of the contemporaneous Toolonga Calcilutite. Occasional cold spells did occur in the Carnarvon Basin during the early Campanian, evident in the basinal southern sector (Dirk Hartog area).

The rarer occurrence of both cold-water indicators *Biscutum coronum* (in the lower Santonian Gingin Chalk of Ginginup #1 corehole) and *Seribiscutum primitivum*, (in the middle Santonian Toolonga Calcilutite at Toolonga Hills) suggests minor climatic oscillations during the Santonian, probably related to an overriding cooling trend during the Late Cretaceous.

OFFSHORE AUSTRALIAN NORTHWEST

Australian Northwest Shelf, Delambre #1

The late Maastrichtian is represented in Woodside Delambre #1 by a thick carbonate section (approximately 25 metres) - based on foraminiferal faunas (Heath, in Delambre #1, Woodside, 1981-Completion Report). Coccolith preservation is poor in this section, and evidence based on absence of species may not be reliable. Important members of the assemblages include *Micula staurophora, M. concava*, the *Ceratolithoides aculeus* group (declining in numbers near the top of the section), *Cribrosphaerella ehrenbergii* (*C. daniae* was not found), *Prediscosphaera cretacea*, and related species such as *P. majungae* and *P. grandis* which become more numerous near the top of the section. Also present are *Cribrocorona gallica* and *Markalius astroporus* which increase in numbers up the section, and *Arkhangelskiella cymbiformis* which increases in size up the section.

The age diagnostic species, *Micula murus* and *Nephrolithus frequens* are extremely rare and were encountered together only at the top of the section at the 2070-metre level (MFN-2241); *Micula murus* was also found at the 2072-metre level (MFN-2242). Typical *Lithraphidites quadratus*, with broad blades, are restricted to the upper 15 metres of the upper Maastrichtian section in Delambre #1.

Remarks. The distribution of the late Maastrichtian key species *Nephrolithus frequens* and *Micula murus* on the Australian western margin (Perth and Carnarvon Basins) and the Northwest shelf seems to follow a regular trend: an increase in abundance and constancy of the already rare *M. murus* northward concomitantly with a diminishing abundance of *N. frequens*. This confirms earlier results based on distributions of planktic foraminiferids in the Maastrichtian of the Carnarvon Basin, Papua New Guinea and Australian Northwest Shelf (McGowran, 1977; Apthorpe, 1979), suggesting a gradient of increasing water temperature northward.

Apthorpe (1979) suggested the occurrence of a widespread middle Maastrichtian disconformity on the Australian Northwest Shelf, to account for the absence of key foraminiferal species in many wells. In Delambre #1 a similar disconformity between the lower and upper Maastrichtian was recorded by Heath (in Delambre #1, Woodside, 1981- Completion Report). This break may be correlated with the disconformity at the Korojon/Miria contact in the Giralia Anticline (Carnarvon Basin), and with the hiatus at the contact Lancelin Beds/Breton Marl in Breton Bay (Perth Basin).

Apthorpe (1979) saw no evidence for a regression below the upper Maastrichtian, but documented that the underlying lower Maastrichtian is eroded in some wells. She showed a transgressive deepening up the section during the late Maastrichtian. In the Carnarvon and Perth Basins the upper Maastrichtian section is thin, compared with the lower Maastrichtian, and evidence for deepening in the upper Maastrichtian part is equivocal. In the very thin Miria

Marl (less than 1.5 metres) of the Carnarvon Basin, no apparent trend could be detected in the distribution of species with palaeodepth significance (such as *Braarudosphaera bigelowii*) to suggest deepening/shoaling during the late Maastrichtian. However, the levels of erosion and reworking, evidenced by the nodule bed at the Korojon/Miria contact (where the hiatus is detected), are likely to have occurred during the very early stages of the Miria transgression. In Breton Marl of the Perth Basin, the hemipelagic species *Acuturris scotus*, *Calculites obscurus*, and *Kamptnerius magnificus* are less common than in the underlying Lancelin Beds, and decrease in abundance up the section to disappear completely near the top. This pattern of distribution could be related to various factors which include those resulting from depth increases up the section.

Bonaparte Gulf Basin, Ashmore Reef #1

The Maastrichtian part of the "Woodbine Beds" contains abundant and well preserved coccolith assemblages. These include *Arkhangelskiella cymbiformis, Biscutum melaniae, Calculites obscurus, Cretarhabdus surirellus, C. conicus, Cylindralithus serratus, Cribrosphaerella ehrenbergii, Eiffellithus turriseiffeli, Lithraphidites carniolensis, L. quadratus, Microrhabdulus belgicus, M. decoratus, Micula* spp. (including *M. murus* and *M. staurophora*), *Prediscosphaera cretacea, Watznaueria barnesae, Zygodiscus sigmoides and Z. spiralis.*

Remarks. *Nephrolithus frequens*, encountered on the Australian NW shelf and in areas to the south along the western margin, is absent from Ashmore Reef #1. Forms of *Micula*, frequent to common in the Carnarvon Basin and on the NW shelf, but insignificant in the Perth Basin, are common to abundant in Ashmore Reef #1 material.

PAPUA NEW GUINEA (PAPUAN BASIN)

The upper Campanian - Maastrichtian sequence of the Papuan Basin is represented by isolated spot-samples from outcrops in the Wabag and Lai River areas in the north (for localities, see Owen, 1973) and the Mendi area in the south (Fig. 1). Coccolith assemblages recovered are arranged in a chronological order in Table 26.

Lai (Gai) River area

Three samples from this area (20NG-1593, 20NG-1594 and 20NG-1596 from Waia Creek, southwest of Linganas: Owen, 1973) yielded abundant *Quadrum trifidum*, and other key species including *Broinsonia parca*, the *Reinhardtites anthophorus*/R. *levis* group, *Ceratolithoides aculeus* and *Quadrum gothicum*. The assemblages are latest Campanian. Owen (1973) argued for a possible early Maastrichtian age, based on the benthic foraminiferal fauna in 20NG-1593 and on a planktic foraminiferal form, described as intermediate between *Globotruncana fornicata* and *G. contusa*, in 20NG-1594.

Wabag area

Two samples (F229 and F202 - the Lagaip River: Owen, 1973) from the Lagaip Beds (Dow *in* Belford, 1967) were examined. The coccolith assemblage of sample F229 included *Ceratolithoides aculeus*, *Cretarhabdus conicus*, *Cribrosphaerella ehrenbergii*, *Cylindralithus* sp., *Eiffellithus turriseiffeli*, *Micula concava*, *M. staurophora*, *Microrhabdulus decoratus*, *Quadrum gothicum*, Q. *trifidum*, the *Reinhardtites anthophorus*/R. *levis* group, *Rhagodiscus reniformis*, *Tetrapodorhabdus decorus*, and questionable *Tranolithus orionatus*. *Quadrum trifidum* is particularly abundant, and in the absence of *Broinsonia parca*, is evidence for an early Maastrichtian age, supporting Owen's (1973) age assignment, based on a rich foraminiferal fauna. The assemblage recovered from sample F202 included *Lithraphidites quadratus*, *Cribrocorona gallica*, the *Ceratolithoides aculeus* group, and forms of *Micula* intermediate between *M. concava* and *M. murus* (some resembling *Tetralithus* sp. of Lambert, 1980); typical *Micula murus* was not found. It is significant that Lambert's (1980) *Tetralithus* sp. zone, in the Kef section of Tunisia and the Charentes section of France, contains *Lithraphidites quadratus*, and is older than *Micula murus*. The coccoliths in sample F202 confirm Owen's (1973) age determination, based on foraminiferal evidence (*Globotruncana contusa*, *G. stuarti*, *Racemiguembelina fructicosa*, and *Pseudotextularia elegans*) of a middle Maastrichtian age.

Mendi area

Of the six samples studied, three (KRC-6, KRC-7 and KRC-22, location *in* Campbell & Herrara, 1968) contained the latest Campanian - early Maastrichtian key species *Quadrum trifidum*, and are restricted to the latest Campanian by the presence of *Broinsonia parca*. Other diagnostic species included *Ceratolithoides aculeus*, *Quadrum gothicum* and the *Reinhardtites anthophorus*/*R. levis* group. McGowran (*in* Campbell & Herrara, 1968) dated the

Table 26. Main elements of the late Campanian and Maastrichtian coccolith sequence in the Papuan Basin, Papua New Guinea.

Area	Main elements of assemblages
Mendi	Latest Maastrichtian assemblage containing common *Micula prinsii, M. murus, Lithraphidites quadratus, Cribrocorona gallica, Ceratolithoides aculeus* (mainly advanced forms) and *C. kamptneri.*
	Late Maastrichtain assemblage including common *Micula murus* (some specimens recall *M. praemurus*), *M. concava, M. staurophora*, intermediates between *M. concava* and *M. murus, Lithraphidites quadratus, Ceratolithoides aculeus* and *Cribrocorona gallica.*
Wabag	Middle Maastrichtian assemblage containing common *Lithraphidites quadratus, Ceratolithoides aculeus* 'group', *Cribrocorona gallica*, and intermediates between *Micula concava* and *M. murus.*
	Early Maastrichtain assemblage containing abundant *Quadrum trifidum, Ceratolithoides aculeus, Micula concava, M. staurophora* and *Reinhardtites anthophorus/R.levis.* Frequent *Quadrum gothicum.*
Lai River	Late Campanian assemblages (also in Mendi) include abundant *Quadrum trifidum, Ceratolithoides aculeus, Reinhardtites anthophorus/R. levis, Quadrum gothicum* and *Broinsonia parca.*

foraminiferids of samples KRC-6 and KRC-7 as late Campanian to early Maastrichtian, and sample KRC-22 as late Campanian.

Sample KRC-3 (MFN-3941B) yielded an assemblage which may be characterised by the prominent presence of large *Arkhangelskiella cymbiformis*, in association with *Ceratolithoides aculeus, Lithraphidites praequadratus* and *L. quadratus.* The age is thought as early to middle Maastrichtian. McGowran (*in* Campbell & Herrara, 1968) regarded the foraminiferids of this sample as early Maastrichtian in age. Sample KRC-4 (MFN-3942) yielded common *Micula murus* (including some specimens resembling *Micula praemurus*), *M. concava, M. staurophora*, forms intermediate between *Micula concava* and *M. murus*, and slightly less common *Ceratolithoides aculeus, Cribrocorona gallica, Lithraphidites praequadratus, L. quadratus* and *Rhagodiscus reniformis.* This assemblage is late Maastrichtian in age. Sample KRC-2 (MFN-3941A) yielded *Micula prinsii, M. murus, Lithraphidites quadratus, Ceratolithoides kamptneri, C. aculeus* (mainly advanced forms approaching *C. kamptneri*) and *Cribrocorona gallica.* The occurrence of *Micula prinsii* suggests latest Maastrichtian.

The coccoliths of samples KRC-2 and KRC-4 confirm the age determined by McGowran (*in* Campbell & Herrara, 1968) based on his identification of the foraminiferal index species *Abathomphalus mayaroensis*; being late Maastrichtian.

Remarks. The latest Campanian - Maastrichtian biostratigraphic sequence in Papua New Guinea (Table 26) seems to be more complete than the coeval sequence on the Australian western margin. Evidence for this conclusion rests on: a) the middle Maastrichtian assemblage with *Lithraphidites quadratus*, recorded from the Wabag area in the Papuan Basin, is absent from the sequence in the Carnarvon and Perth Basins, and b) the latest Maastrichtian assemblage with *Micula prinsii*, identified from the Mendi area of Papua New Guinea, was encountered in the Australian material only in reworked pieces of Miria Marl at the base of the Paleocene Boongerooda Greensand in the Giralia Anticline of the Carnarvon Basin.

Micula murus is more abundant in the upper Maastrichtian material from Papua New Guinea than in coeval material from the Australian Northwest Shelf and western margin - in keeping with the trend of northward increase in the abundance of this species in the Australian region. The same is true for the *Ceratolithoides aculeus* group and *Quadrum trifidum.* Thus *Ceratolithoides aculeus* and *Quadrum trifidum* are virtually absent from the Perth Basin section (Breton Bay #1 corehole), but abundant in the Papua New Guinea material. In the intervening Carnarvon Basin and Northwest shelf of Australia, the *Ceratolithoides aculeus* group is frequent to common, but *Quadrum trifidum* is rare, though widespread in the Carnarvon Basin.

ONTONG JAVA PLATEAU (SOUTHWEST PACIFIC OCEAN)

Upper Cretaceous sediments on the Ontong Java Plateau (SW Pacific Ocean) were recovered during Deep Sea Drilling Project Leg 30 at sites 288 and 289. Coccolith distribution in the Maastrichtian parts of the sections of these sites is given in Checklist 11.

DSDP site 288

Saito (*in* Andrews, Packham & others, 1975) assigned core 288A-9 to the (middle Maastrichtian) foraminiferal *Globotruncana gansseri* subzone, on account of the presence of the nominate species with *Globotruncana contusa, Racemiguembelina fructicosa, Rugotruncana subpennyi* and the abundant occurrence of *Globotruncana elevata.* Shafik (*in* Andrews, Packham & others, 1975) indicated that the top part of the same core (288A-9-1) contains late Maastrichtian coccoliths, and dated the remainder of the core as middle Maastrichtian. A re-examination of additional material from core 288A-9 has revealed the occurrence of the late Maastrichtian index species *Micula murus* in assemblages throughout most of the core (Checklist 11). Forms intermediate between the *Micula staurophora/concava* group and the *M. murus/prinsii* group are particularly abundant. Evidence of selective dissolution is strong, with most specimens lacking their central structures. Even so, species diversity is moderately high.

DSDP site 289

Results published independently by Shafik and Saito (*in* Andrews, Packham & others, 1975) record the late Maastrichtian *Micula murus* in core 289-122, though the coeval foraminiferal index, *Abathomphalus mayaroensis,* was not found. Re-examination of other Upper Cretaceous cores of the site has revealed the presence of *Micula murus* ranging from core 289-126-1, 148-149 cm to core 289-122-2, 138-140 cm inclusive, indicating the presence of more than 35 metres of upper Maastrichtian section. Coccolith distribution in this section is given in Checklist 11. Core 289-122-1, 138-140 cm contains a few Paleocene species, including a species of *Cruciplacolithus.* The Cretaceous/Tertiary boundary is placed accordingly within the top section of core 289-122. The late Campanian - early Maastrichtian key species *Quadrum trifidum* occurs in core 289-127-1 at 131-132 cm.

Coccolith preservation in the upper Maastrichtian section at the site is generally poor, mainly due to recrystallization; the highly resistant species, such as *Watznaueria barnesae* and species of *Micula* including *M. murus,* are particularly abundant. Specimens of *Micula,* other than those referable to *M. murus,* are difficult to differentiate, and some, very similar to *Micula praemurus,* are common in core 289-123-1, 134-135 cm.

Notable in the late Maastrichtian assemblages of this site is the extreme rarity or absence of *Eiffellithus turriseiffeli, Lithraphidites quadratus,* and other species of *Lithraphidites.* Because *Eiffellithus turriseiffeli* is moderately resistant to destruction, its absence may be the result of factors other than poor preservation. Species of *Lithraphidites,* in particular *L. quadratus,* are known to be either rare or absent from the Pacific region.

Remarks. The overwhelming evidence for the late Maastrichtian at DSDP sites 288 and 289 from the coccolith flora contrasts with the total absence of the late Maastrichtian foraminiferal key species *Abathomphalus mayaroensis.* Hemipelagic species such as *Braarudosphaera bigelowii, Acuturrus scotus, Calculites obscurus, Lucianorhabdus cayeuxii* and *Kamptnerius magnificus,* frequent in the Miria Marl of the Carnarvon Basin and the Breton Bay of the Perth Basin, are absent in the Ontong Java assemblages. They are prone to dissolution in the oceanic realm, and most of them may have lived in higher palaeolatitudes than the Maastrichtian latitudes of the Ontong Java Plateau.

NINETYEAST RIDGE (EASTERN INDIAN OCEAN)

The upper Maastrichtian section on the Ninetyeast Ridge was cored at sites 216 and 217 during DSDP Leg 22. Gartner (1974) presented tables of coccolith distributions in the sequences penetrated at these and other sites occupied during Leg 22. McGowran (1974) recorded foraminiferids, including the index species *Abathomphalus* *mayaroensis* from the upper Maastrichtian section at both sites.

DSDP site 216

An assemblage recovered from core 216-24, core catcher suggests shallow depositional depth and a cold-water influence. This conclusion is based mainly on the presence of *Braarudosphaera bigelowii*, *Kamptnerius magnificus*, *Cribrosphaerella daniae* and *Nephrolithus frequens*. The assemblage is moderately diversified, and also includes *Arkhangelskiella cymbiformis*, *Ceratolithoides aculeus*, *Biscutum melaniae*, *Ahmuellerella octoradiata*, *Cribrosphaerella ehrenbergii*, *Actinozygus regularis*, *Micula* spp. (similar to *M. praemurus* and including specimens approaching *M. murus*), *M. staurophora*, forms intermediate between *M. concava* and *M. murus*, *Cretarhabdus conicus*, *C. surirellus*, *Heterorhabdus sinuous*, *Microrhabdulus decoratus*, *Placozygus fibuliformis*, *Tetrapodorhabdus decorus*, *Zygodiscus lacunatus*, *Prediscosphaera cretacea*, *P. spinosa*, *Chiastozygus fessus*, *Watznaueria barnesae*, *Lithraphidites carniolensis*, *L. praequadratus*, *Cylindralithus* sp., *Eiffellithus turriseiffeli*, and *Markalius* sp. aff. *M. astroporus*.

Lithraphidites quadratus, typical *Micula murus* and *Cribrosphaerella daniae* are absent.

DSDP site 217

An assemblage recovered from core 217-20, core catcher contains *Micula murus* and *Cribrocorona gallica*, and lacks *Nephrolithus frequens*, suggesting much warmer conditions than those at site 216. The evidence for shallow water deposition is tenuous, being in the form of rare specimens of *Calculites obscurus*. Typical *Lithraphidites quadratus* is absent, but *L. carniolensis*, *L. praequadratus* and *L.* sp. aff. *L. quadratus* are present. *Petrarhabdus copulatus*, *Ceratolithoides aculeus* and *Dodekapodorhabdus reinhardtii* are present. Besides *Micula murus*, the assemblage of core 217-20, core catcher includes the other forms of *Micula* encountered at site 216 (core 216-24, core catcher). Most other species identified in core 216-24, core catcher are present, but *Kamptnerius magnificus* and *Braarudosphaera bigelowii* were not found.

SANTONIAN-CAMPANIAN COCCOLITH BIOGEOGRAPHY

The character of coccolith biogeographic provinces during the Santonian and early Campanian in the Perth and Carnarvon Basins (Sedimentation Cycle A: Gingin Chalk and Toolonga Calcilutite, Tables 10 & 17) is not as strong as during later Cretaceous times (Cycles B & C: Korojon Calcarenite and Miria Marl in the Carnarvon Basin and their equivalents the Lancelin Beds and Breton Marl in the Perth Basin, Tables 17 & 10).

Coccolith assemblages from the Santonian and lower Campanian Gingin Chalk and Toolonga Calcilutite are strikingly similar suggesting similar watermasses. The distribution of *Biscutum coronum* in the lower Campanian part of these units suggests cooler water conditions in the Perth Basin, and occasional cold spells in the southern sector of the Carnarvon Basin. Conditions on the Naturaliste Plateau, south of the Perth Basin, were colder than on the Australian western margin in general.

The Santonian coccolith floras are uniform for the Perth and Carnarvon Basins indicating that the climate was uniform over this interval. The Santonian crinoid *Marsupites*, which occurs in the lower part of the type Gingin Chalk and the lower part of the type Toolonga Calcilutite, has a wide geographic range, extending into North America and Europe. It marks a global event, which is termed in West Germany the "*Marsupites* transgression" (Ernst & Schmid, 1979), and confirms the uniformity of the Santonian climate. Subtropical biotas spread extensively during the Coniacian-Santonian interval in the Western Interior Basin of North America as a response to a global warming and equable climate during this interval (see Kauffman, 1984a, b).

During the early Campanian, differences in geographic distribution of temperature indicators (e.g. *Biscutum coronum*) began to emerge within the coccolith assemblages of the Perth and Carnarvon Basins. However, it is during the deposition of the Lancelin Beds and the Korojon Calcarenite (i.e. during Cycle B in Tables 10 & 17) that these differences became pronounced (Table 27). From the distribution (and relative abundance) of *Biscutum magnum*, *Cribrosphaerella daniae*, *Monomarginatus quaternarius*, *M. pectinatus*, *Ceratolithoides aculeus*, *Quadrum gothicum* and *Q. trifidum*, among others, in sections in the Perth and Carnarvon Basins, it is concluded that the latitudinal differences, expressed as temperature gradients, between locations in the two basins became much sharper than during the deposition of the Gingin Chalk and Toolonga Calcilutite (Cycle A in Tables 10 & 17), with surface-water

Table 27. Main elements of late Campanian - early Maastrichtian coccolith assemblages from Falkland Plateau (SW Atalantic), Perth and Carnarvon Basins (Western Australia).

Falkland Plateau (Wise & Wind, 1977;@)	**Breton Bay #1 corehole** (Perth Basin)	**Cape Cuvier #1 well** (Carnarvon Basin)	**C-Y Creek, Giralia Anticline** (Carnarvon Basin)
Cribrosphaerella daniae was not recognised by Wise & Wind (1977).	*Cribrosphaerella daniae* is common.	Rare *Cribrosphaerella daniae* is present.	*Cribrosphaerella daniae* is extremely rare, but mostly absent.
Persistent *Reinhardtites anthophorus/ R. levis* group. Frequent *Monomarginatus quaternarius, Nephrolithus corystus* and *Zygodiscus bicrescenticus*. Common to abundant *Biscutum magnum, Misceomarginatus pleniporus,* and *Monomarginatus pectinatus*. Very rare *Ceratolithoides aculeus, Quadrum gothicum* and *Q. trifidum* and only at one horizon each.	Persistent *Reinhardtites anthophorus/R. levis* group, *Broinsonia parca* and *Zygodiscus bicrescenticus. Biscutum magnum, Monomarginatus quaternarius, M. pectinatus, Misceomarginatus pleniporus* and *Quadrum gothicum* are present. very rare *Ceratolithoides aculeus* and at one horizon only. No *Quadrum trifidum.*	*Reinhardtites anthophorus/R. levis* group, *Broisonia parca* and *Zygodiscus bicrescenticus are common. Rare Monomarginatus quaternarius* and *Quadrum gothicum* are present.	*Ceratolithoides aculeus, Quadrum gothicum,* the *Reinhardtites anthophorus/levis* group and *Broinsonia parca* are persistent. *Petrorhabdus copulatus* and *Q. trifidum* are present. Among the species *Biscutum magnum, Monomarginatus quaternarius, M. pectinatus* and *Misceomarginatus pleniporus,* only *M. pleniporus* is present and only at one horizon.

@ also Wind & Wise, 1983

temperatures in the Perth Basin being much lower than in the Carnarvon Basin. The same coccolith evidence from the Perth Basin assemblages (in the upper Campanian section of Breton Bay corehole, Table 27) suggests that they were less "austral" than coeval assemblages from the Falkland Plateau (DSDP Hole 327A; Wise & Wind, 1977).

Published palaeotemperature curves, based on oxygen isotopes of belemnites, foraminiferids and/or calcareous nannofossils from Cretaceous sediments (in New Zealand: Stevens, 1971, Stevens & Clayton, 1971; in Europe: Lowenstam & Epstein, 1954, Spaeth & others, 1971; in Central Pacific: Coplen & Schlanger 1973; in NW Pacific: Douglas & Savin, 1975; Savin, 1977) do not necessarily agree in detail, because of several factors, including the palaeolatitude of the material examined. Even so, a general trend emerges: after a temperature peak during the mid Cretaceous, a marked cooling trend, with short-term reversals, seems to have prevailed during the later Cretaceous, particularly during the late Campanian and Maastrichtian.

Data from Europe, the Central Pacific and New Zealand suggest a thermal maximum during the Coniacian-Santonian, consistent with the coccolith evidence of marked similarities between Santonian assemblages in both the Perth and Carnarvon Basins. Thus, Lowenstam & Epstein's (1954) curve records warm temperatures in the European Santonian, following a temperature minimum in the Cenomanian. Data presented by Stevens (1971) and Stevens & Clayton (1971) indicate a temperature peak during the Coniacian-Santonian in New Zealand. Coplen & Schlanger (1973) showed, in sediments from the Central Pacific, a Coniacian-Santonian thermal maximum which they considered to be a worldwide event. In his discussion of various palaeotemperature and palaeobiogeographic data, Frakes (1979) concluded that oceanic surface-waters in the Australian-New Zealand sector were inordinately warm during the Coniacian-Santonian. A global thermal maximum during the Coniacian-Santonian interval has also been suggested by Kauffman (1984a, b).

Based on the geographic distribution of temperature-indicator coccoliths and within the constraints of sampling coverage attainable, several short-term climatic oscillations during the late Campanian to early Maastrichtian interval in the Perth and Carnarvon Basins have been detected. The occurrence of the lower-latitude *Ceratolithoides aculeus* at two horizons within the "austral" Lancelin Beds (Perth Basin) may indicate two short warming episodes, and conversely, the presence of *Misceomarginatus pleniporus* at one horizon in the more "extratropical" Korojon Calcarenite (Carnarvon Basin) may suggest a cold spell. *Ceratolithoides aculeus* was not found in the Falkland Plateau sequence, except for a single questionable occurrence (see chart *in* Wise & Wind, 1977).

The presence of *Quadrum gothicum* in sediments of Cycle B (Tables 10 & 17) in the Perth and Carnarvon Basins may suggest either that the species developed more tolerance to low water temperatures over time (subsequent to its initiation during the mid Campanian as basically a warm-water taxon), or that several reversals have occurred in the cooling trend prevailing during the later part of the Campanian and early Maastrichtian. The rare occurrence of the same species (at three horizons) in the Falkland Plateau sequence (Wise & Wind, 1977) supports these conclusions.

MAASTRICHTIAN COCCOLITH BIOGEOGRAPHY AND BIOSTRATIGRAPHIC IMPLICATIONS

Because Upper Cretaceous coccoliths do not appear to show the well developed provinces found in many marine Cretaceous macrofossils (e.g. Bivalvia, Kauffman, 1973), hierarchical classifications of biogeographic units (e.g. realms, regions, provinces, etc., e.g. Kauffman, 1973) do not seem applicable to these microfossils. The existence among Upper Cretaceous coccoliths of bipolar species (e.g. *Nephrolithus frequens*) and of 'nearshore' species (e.g. *Acuturris scotus*) in transoceanic deposits, suggests that barriers to the spreading of the nannoflora have been ineffective in an oceanic/open-sea situation compared with, for example, bivalves. This study uses the term 'province' in the sense of a 'latitudinal zone'; geographic distribution of coccoliths seems to be largely controlled by temperature.

Various combinations of the key coccolith species, *Biscutum magnum*, *Broinsonia parca*, *Ceratolithoides kamptneri*, the *C. aculeus* group, *Cribrosphaerella daniae*, *Cribrocorona gallica*, *Micula murus*, *Monomarginatus quaternarius*, *Nephrolithus corystus*, *N. frequens*, *Quadrum trifidum*, *Q. gothicum* and others, characterise three main biogeographic provinces: Austral, Extratropical and Tropical. More data is needed to describe a possible fourth province, the 'Periaustral', where conditions were intermediate between those prevailing in the Austral and Extratropical Provinces.

Below is a brief description of coccolith palaeobiogeographic provinces, based on Maastrichtian assemblages from Australia and surrounding areas including the Kerguelen, Naturaliste and Ontong Java Plateaux, Ninetyeast Ridge, Papua New Guinea and New Zealand. In addition, some biostratigraphic problems are discussed in the context of limitations on distribution of species in the provinces, in particular, the Extratropical Province; the biostratigraphy of this province is usually difficult to interpret mainly because of an inherent rarity of key biostratigraphic species.

EARLY MAASTRICHTIAN (TABLE 28)

Austral Province

Austral Province assemblages are characterised by abundant *Cribrosphaerella daniae*, frequent *Nephrolithus corystus*, *Biscutum magnum* and *Broinsonia parca*, and sporadic *Monomarginatus quaternarius* and *Misceomarginatus pleniporus*. *Quadrum trifidum* is absent and *Ceratolithoides aculeus* is extremely rare or absent. Similar assemblages, including strong evidence for deposition in hemipelagic palaeoenvironment, have been identified in the Maastrichtian part of the Lancelin Beds at Breton Bay, Perth Basin. The Austral Province occupied high southern latitudes.

The Perth Basin (Breton Bay) early Maastrichtian assemblages are correlated with an assemblage identified in a sample (MFN-3594) recovered from the Kerguelen Plateau. The Kerguelen Plateau assemblage belongs to the Austral Province, representing colder (or more southerly) conditions than those prevailing in Breton Bay during the early Maastrichtian. The dominant coccolith species in the Kerguelen Plateau sample include *Acuturris scotus*, *Biscutum magnum*, *Kamptnerius magnificus*, *Nephrolithus corystus*, *Cribrosphaerella daniae*. Also present are *Biscutum dissimilis*, *Calculites obscurus*, *Lucianorhabdus cayeuxii*, *L. arcuatus*, *Lapideacassis* spp. (*L. cornuta* and related forms), *Misceomarginatus pleniporus*, *Reinhardtites levis*, *Prediscosphaera stoveri* and *Zygodiscus bicrescenticus*. Other Late Cretaceous species present but extremely rare are *Arkhangelskiella* spp., *Broinsonia* sp., *Markalius astroporus* and *Micula staurophora*. *Watznaueria barnesae*, absent from the Kerguelen Plateau sample, is usually common in most Late Cretaceous assemblages except those from high palaeolatitudes (discussed below).

It has already been suggested that the Campanian/Maastrichtian boundary in this province be taken at the lowest occurrence level of *Cribrosphaerella daniae*.

Extratropical Province

Extratropical Province assemblages are characterised by rare, often sporadic *Quadrum trifidum*, very rare and sporadic *Cribrosphaerella daniae* and *Nephrolithus corystus*, occasional *Quadrum quadratum*, but with common to frequent and reasonably persistent *Broinsonia parca* and *Ceratolithoides aculeus*. *Monomarginatus quaternarius*, *Misceomarginatus pleniporus* and *Biscutum magnum* may be absent, but *Quadrum gothicum* is usually present. These assemblages were identified from the Korojon Calcarenite in the Giralia Anticline and Rough Range areas in the Carnarvon Basin; the foraminiferal assemblages of the Maastrichtian part of the Korojon Calcarenite were described as extratropical by McGowran (1977). Apparently, the Extratropical Province occupied a mid-latitude position, meaning that this province could be identified in both the Southern and Northern Hemisphere.

No coccolith evidence is available to delineate the Campanian/Maastrichtian boundary in the Extratropical Province, and the evidence from other fossils indicates a position within the vertical range of the coccolith *Quadrum trifidum*.

Tropical Province

Tropical Province assemblages are characterised by abundant *Quadrum trifidum* and *Ceratolithoides aculeus*, without either *Broinsonia parca* or *Cribrosphaerella daniae*; *Nephrolithus corystus*, *Monomarginatus quaternarius*, *Misceomarginatus pleniporus* and *Biscutum magnum* are also absent. These assemblages occur in the lower Maastrichtian of the Wabag area in the Western Highlands of Papua New Guinea.

The Campanian/Maastrichtian boundary in this province is approximated by the highest occurrence of *Broinsonia parca*.

Remarks. Worsley (1974) chose the highest occurrence of *Arkhangelskiella parca* (=*Broinsonia parca*) to delineate the lower/upper Maastrichtian boundary, and pointed out that this datum was not subject to major environmental control. Evidence from this study suggests that the highest occurrence of *Broinsonia parca* is diachronous across the boundaries of the biogeographic provinces: *B. parca* seems to have persisted into the upper Maastrichtian Breton Marl in the Austral Province, long after its disappearance near or at the Korojon Calcarenite/Miria Marl disconformity (middle Maastrichtian being missing) in the Extratropical Province. Evidence in Sissingh (1977) suggests that *B. parca* becomes extinct slightly above the Campanian/Maastrichtian in the Kef section of Tunisia which is here included in the Extratropical Province (see below).

Table 28. Coccolith assemblages of the early Maastrichtian biogeographic provinces.

Biogeographic provinces	Distribution and abundance of key species
TROPICAL (Papua New Guinea)	Abundant both *Quadrum trifidum* and *Ceratolithoides aculeus* without the association of *Broinsonia parca* and *Cribrosphaerella daniae*. Campanian/ Maastrichtian boundary at the extinction of *Broinsonia parca*.
EXTRATROPICAL (Carnarvon Basin)	Rare but reasonably persistent *Quadrum trifidum*. More common *Ceratolithoides aculeus* and *Broinsonia parca*. *Cribrosphaerella daniae* is extremely rare or absent, but *Monomarginatus quaternarius* and alike are entirely absent. No coccolith evidence for the Campanian/Maastrichtian boundary.
AUSTRAL (Perth Basin)	Abundant *Cribrosphaerella daniae* and common *Broinsonia parca*. *Monomarginatus quaternarius* and alike are present. *Quadrum trifidum* is absent. Campanian/Maastrichtian boundary at incoming of *Cribrosphaerella daniae*.

LATE MAASTRICHTIAN (TABLE 29)

Austral Province

Austral Province assemblages are characterised by abundant *Nephrolithus frequens*, *Cribrosphaerella daniae* and *Lithraphidites quadratus*, very rare or no *Ceratolithoides aculeus*, and no *Micula murus* during the late Maastrichtian. They occur in the Breton Marl in the Perth Basin, and elsewhere in the southern hemisphere, associated with a cold-water regime in a hemipelagic environment. Similar assemblages may characterise the Boreal Province in the northern Hemisphere.

The Breton Marl late Maastrichtian assemblages are correlated with an assemblage identified in a sample from the New Zealand Pukehou area (Fig. 1; for precise location see Edwards, 1971, p. 382). The Pukehou sample belongs to the Austral Province, representing colder (or more southerly) conditions than in the Perth Basin, because it is less diversified. It is overwhelmingly dominated by *Nephrolithus frequens* and *Kamptnerius magnificus*, and to a lesser degree by *Cribrosphaerella daniae* (apparently replacing *C. ehrenbergii*). Other species are *Arkhangelskiella cymbiformis*, *Ahmuellerella octoradiata*, *Eiffellithus turriseiffeli*, *Gartnergo obliquum*, *Lapideacassis* sp., *Prediscosphaera cretacea*, *P. spinosa* and *Thoracosphaera* sp.. The species *Lithraphidites quadratus*, *Micula staurophora* and *Watznaueria barnesae*, absent from the Pukehou assemblage, are present in coeval assemblages from the Perth Basin.

The absence of *Watznaueria barnesae* from the Pukehou assemblage is consistent with Bukry's (1973a) results from Upper Cretaceous deposits at high latitude locations such as Siberia, New Zealand and DSDP hole 207A in the Tasman Sea. Shafik (1978b) noted that *W. barnesae* is highly resistant to dissolution and its absence is a response to the low temperatures of high latitudes.

Remarks. In this study biostratigraphic resolution of the Maastrichtian in the Austral Province is finer than that in the other biogeographic provinces. This is notwithstanding Worsley's (1974) suggestion, that upper Maastrichtian extinction datums within the Boreal/Austral Province are unreliable because of strong climatic control. Cainozoic coccolith biostratigraphic schemes include evidence for a general loss in biostratigraphic resolution away from the Equator during cold periods (compare resolution of low-latitude Oligocene *in* Bukry, 1973b-c with that of the New Zealand Oligocene *in* Edwards, 1971), and a reverse in this pattern of differing degrees of resolution with palaeolatitudes during warmer periods (e.g. late Eocene: also compare reolutions *in* Bukry, 1973b-c and Edwards, 1971). There is a tempting analogy between the degree of resolution attainable for upper Maastrichtian and upper Eocene sections at different palaeolatitudes. Achieved biostratigraphic resolution in sections at high latitudes (upper Maastrichtian of Perth Basin: this study; upper Eocene of Otway Basin: Shafik, 1983, this study) is finer than at lower latitudes (upper Maastrichtian of Carnarvon Basin: this study; upper Eocene at several DSDP sites in the central Pacific, see Bukry, 1973d) (see also under Remarks below).

The assemblage with abundant *Nephrolithus frequens* and common to frequent *Ceratolithoides aculeus*, and rare or no *Cribrosphaerella daniae* - recorded from the upper Maastrichtian of the Ninetyeast Ridge at DSDP site 216 (present study) - is thought to characterise conditions intermediate between those prevailing in the Austral Province (e.g. Breton Bay in the Perth Basin, and the Pukehou area in New Zealand) and the Extratropical Province (e.g. the Giralia Anticline of the Carnarvon Basin and some areas on the Northwest shelf of Australia). It is envisaged that these conditions may characterise a possible fourth late Maastrichtian province, the 'Periaustral Province'.

Extratropical Province

Extratropical Province assemblages are characterised by rare co-occurring *Nephrolithus frequens* and *Micula murus*, occasional *Cribrocorona gallica*, *Ceratolithoides kamptneri*, *Quadrum quadratum* and *Petrarhabdus copulatus*, and frequent but persistent *Ceratolithoides aculeus* and *Lithraphidites quadratus* during the late Maastrichtian. They occur in the Miria Marl (Giralia Anticline) and its equivalent (Exmouth Gulf) in the Carnarvon Basin, as well as in the Miria equivalent in Delambre #1 on the Australian Northwest Shelf. Late Maastrichtian foraminiferal assemblages from the Miria Marl in the Giralia Anticline were described as extratropical by McGowran (1977).

There is evidence to suggest that during the late Maastrichtian, the Extratropical Province in the Southern Hemisphere extended into the South Atlantic, and that its northern counterpart was broad. The Extratropical Province in the Northern Hemisphere covered areas in Tunisia, Egypt, Israel, France, Switzerland, USSR, Austria, North Atlantic and U.S.A.. This evidence is discussed below, together with an explanation of the apparent inconsistencies

Table 29. Coccolith assemblages of the late Maastrichtian biogeographic province.

Biogeographic province	Distribution and abundance of key species
TROPICAL (Papua New Guinea and DSDP sites 288, 289, 217)	Abundant *Micula murus* (and *M. prinsii* at younger levels), *Cribrocorona gallica, Ceratolithoides aculeus* and *Micula* spp.- with *Lithraphidites quadratus* (hemipelagic and some oceanic) or without *L. quadratus* (oceanic: mostly Pacific).
EXTRATROPICAL (Carnarvon Basin and NW shelf)	*Micula murus* and *Nephrolithus frequens* occur together but both are rare. Frequent and persistent *Ceratolithoides aculeus* and *Lithaphidites quadratus*. Occasional *Cribrocorona gallica* and *Quadrum copulatum*.
AUSTRAL (Perth Basin and NZ)	Abundant *Nephrolithus frequens* and frequent *Cribrasphaerella daniae* and *Lithraphidites quadratus*, with very rare or no *Ceratolithoides aculeus*.

regarding the order of stratigraphic appearances of *Nephrolithus frequens* and *Micula murus* in the literature (referred to on p. 62).

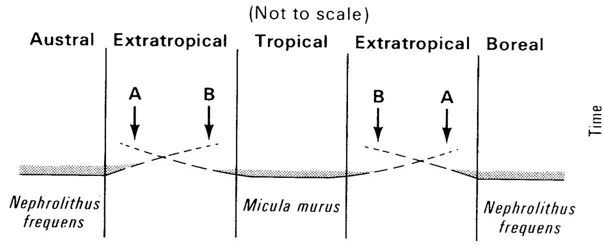
Remarks. According to Verbeek (1977) the coccolith species in the upper Maastrichtian of the Kef section in Tunisia include rare *Ceratolithoides aculeus*, *C. kamptneri*, *Cribrocorona gallica*, *Kamptnerius magnificus*, *Lithraphidites quadratus*, *Micula concava*, *M. murus*, *M. staurophora* and *Tranolithus orionatus*. *Nephrolithus frequens* was not recorded. Sissingh (1977), on the other hand, recorded *Nephrolithus frequens* with *Micula murus* in an equivalent part of the Kef section. The assemblages recorded from the upper Maastrichtian part of the Kef section (Verbeek, 1977; Sissingh, 1977) are similar to the Miria Marl assemblages, suggesting that these Tunisian and Australian late Maastrichtian assemblages might have come from similar biogeographic settings--the northern and southern Extratropical Provinces. That *N. frequens* has been recorded once only in the Kef section suggests that the species is rare and sporadic. Conversely, *Micula murus* is more numerous as it was found by both investigators. In a more recent study, Perch-Nielsen (1979d) could not find *N. frequens* in the upper Maastrichtian of the Kef section but found rare and constant *M. murus*. This confirms the conclusion that *M. murus* is more numerous than *N. frequens* in the extratropical assemblages of the Kef section. The same study (Perch-Nielsen, 1979d) showed that rare *M. murus* and rare *N. frequens* co-occur in one sample from the Hedil section in Tunisia, and only *M. murus* (i.e. without the association of *N. frequens*) occurs in all other samples studied from the same section. (In a routine examination of a Miria Marl sample, the probability of finding *N. frequens* is much greater than finding *M. murus*.) Thus, no matter which of the two species is more persistent in the sequence, the Kef section upper Maastrichtian, the Miria Marl and the Hedil section upper Maastrichtian are extratropical, because they contain rare *N. frequens* and rare *M. murus*.

Based on the co-occurrence of rare *Nephrolithus frequens* and rare *Micula murus* in Upper Cretaceous sediments at DSDP sites 356 and 357 (data *in* Perch-Nielsen, 1977), the southern Extratropical Province could be identified in the South Atlantic. Furthermore, the occurrence of rare *Micula murus*, without *Nephrolithus frequens* in the upper Maastrichtian of Zululand (Siesser, 1982) may suggest that the same province extended to South Africa during the late Maastrichtian. The northern Extratropical Province evidently covered locations in Egypt (see Perch-Nielsen, 1973 for species distribution), in the North Atlantic (DSDP site 384 - see Okada & Thierstein, 1979 for species distribution), near Biarritz in France (data *in* Perch-Nielsen, 1979c), in Switzerland (data *in* Stuijvenberg & others, 1979), in central Negev in Israel (data *in* Romein, 1979a and Moshkovitz, 1984; see also Reiss & others, 1985) possibily in Kyzylsaj (Mangyshlak) in the USSR (data *in* Perch-Nielsen, 1985a) and in east-central Texas, U.S.A. (data *in* Jiang & Gartner, 1986).

Evidence from Bramlette & Martini (1964), Verbeek (1977, 1986) and van Heck (1979) seems to suggest that the type Maastrichtian in southern Holland and northern Belgium was part of the Extratropical Province, or that at times during the late Maastrichtian, conditions there were largely similar to those prevailing in this province.

To account for the usual scarce and sporadic distribution of both *Nephrolithus frequens* and *Micula murus* in the extratropical assemblages, it must be pointed out that the Extratropical Province extended over an area which included the geographic outer limits of both species (Fig. 11). The biostratigraphic implications of this is significant, in regard to the order of stratigraphic appearance of these late Maastrichtian key species. In sections at the extreme limits of the geographic domain of *Nephrolithus frequens*, i.e., adjacent to the Tropical Province (B in Fig. 11: these sections would have been relatively more within the geographic domain of *Micula murus* than within the domain of *N. frequens*), *M. murus* first appears **below** the lowest occurrence of *N. frequens* (as the record by Perch-Nielsen, 1979e), whereas in sections nearer to the extreme limits of the domain of *M. murus* (A in Fig. 11: these would have been relatively more inside the geographic domain of *N. frequens*), *Micula murus* first appears **above** the lowest occurrence of *N. frequens* (as the record by Manivit, 1971, in the Aquitaine Basin in France; the record by Perch-Nielsen, 1977, at DSDP sites 356 & 357 on Sao Paulo Plateau and Rio Grande Rise respectively in the South Atlantic).

Figure 11. Schematic representation of possible latitudinal distribution of the late Maastrichtian markers, Nephrolithus frequens and Micula murus (modified after Worsley, 1974).



Nephrolithus frequens has a bipolar distribution, whereas *Micula murus* is restricted to the Tropical and Extratropical provinces.
Relative lowest occurrence levels and relative abundances of *Nephrolithus frequens* and *Micula murus* could be reversed in areas A and B of the Extratropical province.

Micula murus would be relatively more frequent than *Nephrolithus frequens* in sections at the extreme limits of the geographic domains of the latter, and *viceversa.* (Compare the relative abundance of these species in both the Miria Marl and the Kef sections, discussed above.)

Okada & Thierstein (1979) recorded late Maastrichtian assemblages from four DSDP sites in the North Atlantic: site 384 with persistent and frequent to common *Micula murus* occuring together with somewhat sporadic and rare to frequent *Nephrolithus frequens*; sites 385 and 386 with persistent and common to abundant *M. murus* but no *N. frequens*; and site 387 with frequent to common *M. murus* together with very sporadic and rare *N. frequens*. In this study, the late Maastrichtian assemblages of site 384 are thought to belong to the Extratropical Province; and because *M. murus* is more frequent than *N. frequens*, this site is placed at the extreme limits of the *N. frequens* geographic range and well within the domain of *M. murus*. Also in this study, the late Maastrichtian assemblages of sites 385, 386 and 387 are referred to the Tropical Province; the occurrence of rare cold-water forms (*N. frequens* and *Kamptnerius magnificus*) in the site 387 assemblages is probably attributed to an influence of an intermittent cold current. Presently site 384 (slightly north of Lat. 40°) is 3 to 4 degrees north of the other sites.

It is worth noting the distinction between: a) a locality ascribed to the Extratropical Province because of the occurrence of several assemblages with both rare *Nephrolithus frequens* and rare *Micula murus* (e.g. the Giralia Anticline in the Carnarvon Basin); and b) another locality which assemblages contain common and persistent *N. frequens* and *Cribrosphaerella daniae*, and rare and sporadic *M. murus*, which would be ascribed to the Austral (or Boreal) Province with the presence of *M. murus* being ascribed to an excursion during a warm interval(s) (e.g. the case in Breton Bay, Perth Basin). The record of *M. murus* in the uppermost Maastrichtian in Denmark at one locality (Dania: Perch-Nielsen, 1979e, pl. 1, fig. 12) out of five localities (Perch-Nielsen, 1979a) could be interpreted as excursion by *M. murus* into the Boreal Province in response to a short-lived warm event. Based on the occurrence of large benthic foraminiferal species such as *Lepidorbitoides minor*, *Orbitoides apiculata*, *Omphalocyclus macroporus* and *Helenocyclina* spp. in the Maastricht Formation (Denmark), Cepek & Moorkens (1979) concluded that during the late Maastrichtian the climate became considerably warmer, allowing "Tethyan" forms to migrate to the north.

It is possible that the *Micula murus* excursions into the Austral Province (Perth Basin, Australia) and into the Boreal Province (Denmark) were due to the same thermal event. There is other evidence for such late Maastrichtian warm event in other areas of the Boreal Province: the occurrence of "Tethyan" elements (e.g. *Planoglobulina acervulinoides*) in the foraminiferal fauna of the upper Maastrichtian of central Poland (see Pozaryska & Witwicka, 1983), and the migration of several "southern" bryozoan species to the north (e.g. southern Holland) during the late Maastrichtian as indicated by Voigt (1983). Naidin (1983) concluded that on the Russian Platform the late Maastrichtian was warmer than earlier Maastrichtian.

The postulated resemblance between the upper Maastrichtian and upper Eocene does not seem to be limited to achievable degree of resolution with palaeolatitude (discussed on p. 76). The excursion of the low-latitude foraminiferal species, *Hantkenina alabamensis*, into the higher latitudes south of Australia (e.g. Otway Basin) during the late Eocene (McGowran, 1978; Shafik, 1981) seems to recall the *Micula murus* excursion into the higher latitudes of the Perth Basin of Western Australia and elsewhere during the late Maastrichtian (this study).

Tropical Province

Assemblages of the late Maastrichtian Tropical Province are characterised by abundant *Micula* spp. (including *M. murus*), *Cribrocorona gallica*, *Ceratolithoides aculeus* and *C. kamptneri*: A) with *Lithraphidites quadratus* as those occurring in the Papuan Basin, Papua New Guinea; or B) without *L. quadratus* like those occurring in the upper Maastrichtian section of the Ontong Java Plateau (DSDP sites 288 and 289) and in the upper part of the upper Maastrichtian at DSDP site 217 on the Ninetyeast Ridge.

Remarks. Forms of *Micula* which proved to be difficult to differentiate can be crudely grouped into: i) intermediates between the *staurophora/concava* group and *murus/prinsii* group; and ii) those recalling *M. praemurus* with some actually being very-short-armed *M. murus*. These two broad groups of forms of *Micula* which occur in most of the late Maastrichtian assemblages examined, but are absent from the Pukehou sample from New Zealand, are very insignificant in the Breton Marl of the Perth Basin. Both groups are frequent in the Miria Marl from the Giralia Anticline in the Carnarvon Basin, common in the Miria Marl equivalent on the Australian Northwest shelf, and abundant in the oceanic tropical material from the Ontong Java Plateau. They also occur in material studied from the Ninetyeast Ridge, the 'periaustral' assemblage of DSDP site 216, and the tropical assemblage of DSDP site 217.

AUSTRALIAN UPPER CRETACEOUS CARBONATES: SEDIMENTATION HISTORY

During the Late Cretaceous, a major environmental change occurred, causing the accumulation of coccolith-rich carbonates with little or no terrigenous components after the deposition of a clastic section with few or no calcareous nannofossils in the Perth and Carnarvon Basins. Connections with the open-sea were intermitent during the deposition of the clastic section. This contrasts with the open-marine conditions prevalent during the deposition of the overlying richly fossiliferous carbonates.

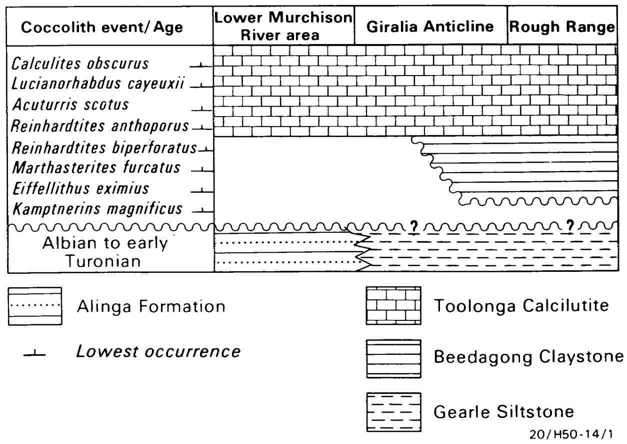
The Late Cretaceous sedimentation regimes, in both the Perth and Carnarvon Basins, are directly related to the early stages of the formation of the western margin of Australia. Veevers & others (*in* Veevers, 1984) summarised the history of the formation of the Australian western and north-western margin: after several phases of breakup from its neighbours from the Late Jurassic to the Early Cretaceous, the Australian western margin slowly subsided during the Cenomanian, about hinges along the coast; India cleared Australia during the later Cretaceous, and ensuing oceanic circulation led to the accumulation of carbonate sediments. During the Late Cretaceous carbonate deposition, there was little terrigenous input from the hinterland, as indicated by the lithological evidence. High relief in the onshore western margin of Australia, caused by tectonism during the Jurassic, was almost entirely eroded during most of the early Cretaceous, resulting in near-peneplained surface by the early Senonian.

DEPOSITIONAL ENVIRONMENT AND DEPTH

Coccolith distribution in the Upper Cretaceous carbonates of the Perth and Carnarvon Basins suggests open-sea conditions in shallow-water (nearshore or shelf) palaeoenvironments: the usually high species diversity suggests good accessibility to the open sea, and the frequent occurrence of several hemipelagic species, such as *Acuturris scotus*, *Calculites obscurus*, *C. ovalis*, *Lapideacassis* spp. and *Lucianorhabdus cayeuxii*, suggests deposition in shallow waters. The limited terrigenous component in these carbonates suggests that deposition of the uppermost part of the Beedagong Claystone and the younger Upper Cretaceous units occurred without significant influx of terrigenous detritus, because of the probable low relief of the hinterland.

Accumulation of Upper Cretaceous carbonates in the Carnarvon Basin commenced during the late Turonian with the deposition of the Beedagong Claystone. This early phase was probably confined to the northern portion of the basin (Fig. 12), and possibly also to offshore areas to the north and west. The calcium carbonate content of this formation is by no means comparable with that of the overlying Toolonga Calcilutite, but it is certainly much more than that of the underlying Gearle Siltstone. Deposition of the overlying Toolonga Calcilutite began during the late Coniacian/early Santonian in both the northern and southern parts of the Carnarvon Basin, reaching its maximum geographic extent during the mid/late Santonian (DI:**Lucianorhabdus cayeuxii*/**Calculites obscurus*). The evidence from the Giralia Anticline suggests continuous sedimentation from the Beedagong Claystone to the Toolonga Calcilutite. Deposition of the Toolonga Calcilutite continued through the Santonian and into the Campanian (even where the rates of sedimentation seem to have been slow, e.g. Giralia Anticline), terminating during the early Campanian. Carbonate deposition in the Carnarvon Basin recommenced during the later part of the Campanian, with the formation of the Korojon Calcarenite which evidently continued into the early Maastrichtian; rates of deposition for the lower part of the Korojon Calcarenite (with several phosphatic nodule beds, see Fig. 9) were slower than for its upper part. The deposition of the Miria Marl occurred during the later part of the Maastrichtian, subsequent to a middle Maastrichtian episode of non-deposition.

Figure 12. Schematic cross section of the basal Upper Cretaceous carbonates in the Carnarvon Basin and their relationship to coccolith biostratigraphic events.



In the Perth Basin a similar history of Upper Cretaceous carbonate deposition was developing. The deposition of the carbonates of the Gingin Chalk probably began prior to the early Santonian DI:**Reinhardtites anthophorus*/**Lucianorhabdus cayeuxii*, presumably about the same time as its deposition in areas to the north (Agaton #19), during the late Coniacian/early Santonian (DI:**Lithastrinus grillii*/**Reinhardtites anthophorus*). The configuration of the top of the Molecap Hill Greensand prior to the deposition of the Gingin Chalk must have been greatly uneven and/or the nodule bed formation (at the base of the chalk) was discontinuous or uneven, for the base of the chalk itself to range in age from early to late Santonian in nearby sections in the type area; the base of the transgression is thought to be isochronous at least locally, nevertheless. Thus during the late Coniacian/early Santonian in the type area of the Gingin Chalk, phosphatic nodules were formed at the Molecap Hill site while calcium carbonates were being deposited in the nearby Ginginup #1 corehole site. At the Molecap site carbonate deposition did not commence until the late Santonian, supporting the notion that the Gingin Chalk reached its maximum geographic extent during the mid/late Santonian (DI:**Lucianorhabdus cayeuxii*/**Calcaulites obscurus*), subsequent to an acceleration in sedimentation rates.

Carbonate deposition in the Perth Basin was interrupted during the early Campanian, probably at about the same time as the intra-Campanian cessation of carbonate deposition in the Carnarvon Basin; the deposition of the Gingin Chalk and Toolonga Calcilutite are likely to have ended at about the same time. Upper Cretaceous carbonate (Lancelin Beds) deposition in the Perth Basin recommenced during the later part of the Campanian at about the same time as deposition of the Korojon Calcarenite started in the Carnarvon Basin. The deposition of the Lancelin Beds continued into the early Maastrichtian. Like the Miria Marl of the Carnarvon Basin, the Breton Marl in the Perth Basin was deposited after a middle Maastrichtian episode of non-deposition.

UPPER CRETACEOUS CARBONATE SEDIMENTATION CYCLES

Three Upper Cretaceous carbonate sedimentation cycles have been recognised in the Perth and Carnarvon Basins (see Tables 10 & 17). The oldest, Cycle A, ended during the early Campanian. The coccolith evidence indicates that this cycle began during the late Turonian (base of Beedagong Claystone) in the northern portion of the Carnarvon Basin. This is earlier than in the southern portion of this basin where it began during the late Coniacian/early Santonian (base of Toolonga Calcilutite). In the Perth Basin, Cycle A began also during the late Coniacian/early Santonian (base of Gingin Chalk). It is possible that older carbonates may have been deposited in areas to the north of the Carnarvon and in offshore areas to the west. The sequence which resulted from Cycle A in both basins is here referred to as the Toolonga/Gingin Sequence.

Unlike Cycle A, whose lower limit may vary in age in different places (being transgressive, Fig. 12), Cycle B is thought to have started at about the same time in both the Perth and Carnarvon Basins. Also, Cycle B ended about the same time in both basins, resulting in the accumulation of probably virtually coeval units (Lancelin Beds and

Korojon Calcarenite). There is no evidence from offshore areas, particularly in the west, to indicate whether the identity of Cycle B (Korojon/Lancelin Sequence) is discernible there. [The term "sequence" is used here and not the term "synthem" of the International Subcomission on Stratigraphic Classification (Amos Sulvador, Chairman) 1987, which was proposed for unconformities-bounded units. The Korojon Calcarenite and Lancelin Beds are bounded by unconformities, but these units are correlatives and from two separate basins.]

Cycle C, the youngest of the Australian Upper Cretaceous carbonate cycles, began during the late Maastrichtian, resulting in the formation of the Miria Marl in the Carnarvon Basin and its equivalent the Breton Marl in the Perth Basin (Miria/Breton Sequence). The evidence of reworked Miria Marl (with coccoliths indicative of latest Maastrichtian) at the base of the Paleocene Boongerooda Greensand (Giralia Anticline) suggests that this cycle continued into the latest Maastrichtian, probably ending at the close of the Maastrichtian. Deposition during the latest Maastrichtian was probably insignificant compared with earlier sediments. This, coupled with active erosion during the earliest Paleocene, may explain the almost non-existent record of uppermost Maastrichtian carbonates in both the Perth and Carnarvon Basins. On the Australian Northwest shelf, much of the section deposited during the late Maastrichtian transgression was removed during extensive early Tertiary erosion (Frakes & others, 1987).

Based on its coccoliths, the thin phosphatic nodule bed between the Korojon Calcarenite and Miria Marl (Giralia Anticline) was formed at the onset of the Miria Marl sedimentation, having included reworked material from the top of the Korojon Calcarenite. Thus Cycle C began with formation of a phosphatic nodule bed (at least in the Carnarvon Basin at sites in the Giralia Anticline), recalling a similar depositional history for the other (older) Australian Upper Cretaceous cycles (see below).

Evidence for erosion at the levels of the two main hiatuses recognised (intra-Campanian: between the Toolonga/Gingin and Korojon/Lancelin Sequences; intra-Maastrichtian: between the Korojon/Lancelin and Miria/Breton Sequences) is tenuous, being a few displaced coccoliths in the nodule bed at the base of Miria Marl in an outcrop at Toothawarra Creek (Giralia Anticline, see Checklist 7); coccoliths are very prone to reworking because of their minute size compared with other microfossils. Thus periods of non-deposition/sea-level fall were not periods of erosion, the consequence being that the limits of the sediment packages (sequences) should neatly coincide with the limits of the sedimentation cycles. Quilty (1980) reached a similar conclusion based on a different line of evidence. He postulated the absence of a well-developed drainage system on the hinterland, because of a low terrigenous content of the shelf carbonates. The absence of an efficient drainage system, meant to Quilty (1980) that during periods of sea-level fall, no erosion nor sedimentation of terrigenous sediments occurred.

Quilty (1980) recognised two Cretaceous depositionary cycles in Western Australia: a late Santonian-early Campanian cycle, based on the outcropping Gingin Chalk and the type Lancelin Beds in the Perth Basin, and on the Toolonga Calcilutite and Korojon Calcarenite in the Carnarvon Basin; and a Maastrichtian cycle based mainly on the Miria Marl. The late Santonian-early Campanian cycle was to be enlarged to include the Coniacian based on unpublished report by the present writer (see Quilty, 1980, p. 364). As such this cycle correlates roughly with the combined Cycles A and B of the present study. Apparently, the similarity of planktic foraminiferal faunas of the Santonian-Campanian sections in Western Australia hindered finer resolution (Quilty, 1980, p. 364), and is probably the reason for Quilty's inability to differentiate his late Santonian-early Campanian cycle (=Toolonga/Gingin & Korojon/Lancelin Sequences of this study) into two cycles. That Quilty (1980) did not extend his cycle into the early Maastrichtian is surprising, however, because the Korojon Calcarenite has long been known to contain early Maastrichtian foraminiferids in its upper parts (e.g. McGowran, 1968).

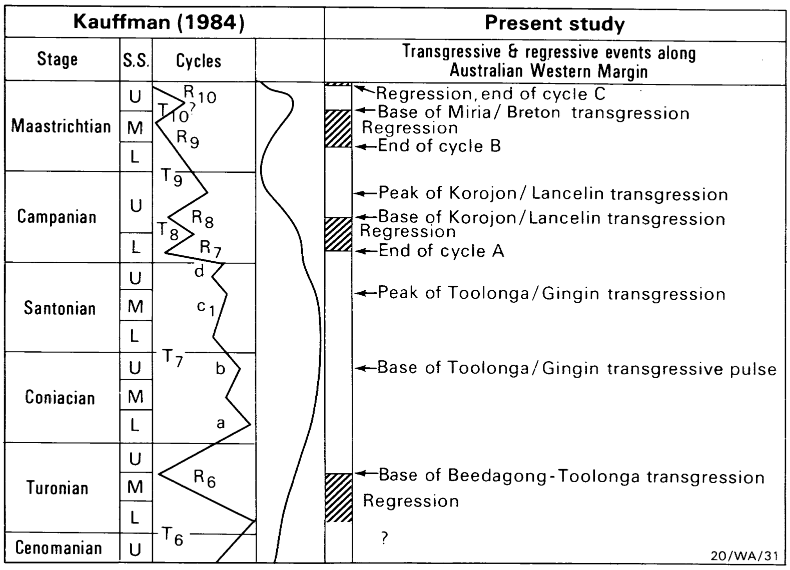
Quilty's (1980) Maastrichtian cycle is based mainly on the Miria Marl in the Carnarvon Basin and on an offshore Maastrichtian occurrence in the Perth Basin. As such, it is similar to Cycle C of the present study, in spite of a difference in their timing. Quilty's cycle involves both middle and late Maastrichtian times, whereas Cycle C began during the late Maastrichtian, following a major middle Maastrichtian regression.

It is interesting to note that Cycle A (Toolonga/Gingin Sequence) began in the southern Carnarvon and Perth Basins with the formation of a thin phosphatic nodule bed probably at the top of an older phosphatic nodule zone and immediately prior to the calcium carbonate accumulation. The same is true for Cycle B (Korojon/Lancelin Sequence) at least in the Carnarvon Basin; the subsurface nature of the contact between the Gingin Chalk and Lancelin Beds in the Perth Basin may prove a hindrance to recognition of a thin nodule bed at the base of the Lancelin Beds. A thin phosphatic nodule bed occurs at the base of the Korojon Calcarenite. Cycle C (Miria/Breton Sequence) commenced with the formation of a thin phosphatic nodule bed immediately before the calcium carbonate deposition of the Miria at outcrop sites in the Carnarvon Basin; also the corresponding carbonate base in the Perth Basin is confined to the subsurface, with the attendant improbability of finding a thin nodule bed at its base.

Although the sedimentation cycles discussed above could have been caused by processes, other than those which produce global sea-level changes (e.g. local tectonism resulting in subsidence and emergence), the evidence points to a mainly eustatic cause. Slow subsidence about hinges along the coast (Veevers & others *in* Veevers, 1984) is not inconsistent with a mainly eustatic cause for the sedimentation cycles. This would produce virtually the same lithostratigraphic sequence in close and widely-separated sections/wells, as is the case in both the Carnarvon and Perth Basins (see Quilty, 1980, fig. 2B). These cycles can be roughly correlated with three of Kauffman's (1977a, 1984b) third-order (transgressive-regressive) epicontinental eustatic cycles. Also, the West Australian Upper Cretaceous cycles can be traced in the Upper Cretaceous sequence stratigraphy and sea-level curve chart of Haq & others (1987).

Kauffman (1977a, 1984b) recognised the Upper Cretaceous of the Western Interior Basin of North America as being formed during three major and two relatively minor third-order cycles. Of these, the two major Cycles T7-R7 and T9-R9 seem to parallel the West Australian Cycles A and B respectively, and the minor Cycle T10-R10 seems to fit the Australian Cycle C (see Fig. 13). According to Kauffman (1984b) the regressive phase R6 gave rise to the transgressive phase T7 during the late Turonian. This is about the time when the Beedagong Claystone (base of Australian Cycle A) began to accumulate in the northern Carnarvon Basin . Cycle T7-R7, being coincident with a time of sea-level highstand and global warming, lasted through the Coniacian and Santonian and ended during the early Campanian (Kauffman, 1984b). The age of the very top of the Toolonga/Gingin Sequence (deposited during the last phase of the Australian Cycle A) is early Campanian. Thus Kauffman's (1984b) Cycle T7-R7 of the Western Interior Basin of North America is, at least broadly, coeval with Cycle A occurring along the Australian western margin. This indicates that the two cycles have a common origin, confirming that the Australian Cycle A is mainly eustatically caused. Several transgressive pulses (separated by short regressive phases) occurred during the long Cycle T7-R7, among which a middle Santonian transgression was significantly more extensive than most of the others (Kauffman, 1984b). The timing of this middle Santonian transgression seems to coincide with the maximum expansion of the Toolonga/Gingin sea along the Australian western margin.

Figure 13. The Western Australian sedimentation cycles, and the eustatic cycles and palaeotemperature curve of the Western Interior of North America.



The Australian western margin lacks marine deposits coeval with Kauffman's (1984b) Cycle T8-R8 . This is the time of the biostratigraphic discontinuity along this margin, between the Toolonga/Gingin and the Korojon/Lancelin Sequences. According to Kauffman (1984b), the last major transgression (T9) in the history of the Western Interior Basin began and peaked in the middle late Campanian, followed by a major regression (R9) which reached its maximum in the middle Maastrichtian. The timing of the start and end of Kauffman's Cycle T9-R9 seems to coincide with the onset and demise of the Australian Cycle B. The base of the Korojon/Lancelin Sequence is late Campanian in age, and a mainly middle Maastrichtian hiatus is indicated between this sequence and the overlying carbonates of Cycle C. The late Campanian-middle Maastrichtian interval is marked in Europe by the maximum extent of Cretaceous shelf seas (see Hancock, 1984; Tyson & Funnell, 1987).

The late Maastrichtian Cycle C of this study correponds with the peak of Kauffman's (1984d) Cycle T10-R10 (see Fig. 13).

Important features of the Upper Cretaceous chart presented by Haq & others (1987) are given in Figure 14. The evolution of the Upper Cretaceous carbonate sequences in the Carnarvon and Perth Basins, as deduced in this study, is placed against these authors' Upper Cretaceous sequence stratigraphy and sea-level curve in the same figure, in order to test the 'presumed global' eustatic changes. Except for the foraminiferal and coccolith zones, other biostratigraphic data *in* Haq & others' (1987) chart are excluded from Figure 14. Moreover, only coccolith zones compiled by Roth (1978) are retained in Figure 14, and other coccolith zones are replaced by events of lowest and highest occurrence of coccolith zonal markers, in keeping with the biostratigraphic approach of this study, and because these zones do not represent a single zonal scheme but rather they seem to be a mixed bag; coccolith biostratigraphic events are almost certainly much more understandable than the excluded zones. Although the writer disagrees with the numerical ages given by Haq & others (1987) to some of the zonal boundaries (e.g. lowest occurrence of *Calculites obscurus* as being 83 Ma within the early Campanian), to facilitate comparison with Haq & others' chart, no attempt was made to change these age assignments in Figure 14; numerical age assessments of biostratigraphic events and also stage boundaries (see Tables 18 & 19) are generally in state of flux.

Cycle A roughly corresponds to the later part of Supercycle UZA-2 and the entire Supercycle UZA-3 of Haq & others (1987). The base of the Beedagong Claystone (base of the Toolonga/Gingin Sequence) evidently coincides with the surface of maximum flooding (downlap surface) occurring within the Upper Cretaceous (Upper Zuni) Cycle 2.2 of Haq & others (1987). This surface is bracketed by the coccolith DI:**Quadrum gartnerii*/* *Eiffellithus eximius*, during which time the sea level reached its highest stand for the late Mesozoic and Cainozoic, according to the data in the charts given by Haq & others (1987). The lower limit of the Beedagong Claystone is assignable to the same datum interval. Because the coccolith datum interval in question is reasonably short, it is suggests that the two boundaries (downlap surface of Cycle 2.2 of Haq & others (1987), and lower limit of the Beedagong Claystone) are coeval. The sequence boundary, between Supercycles UZA-3 and UZA-4 coincides with a drop in sea level which was probably initiated within the range of *Broinsonia parca*, and prior to the appearance (lowest occurrence) of *Ceratolithoides aculeus* (for biostratigraphic evaluation see Table 2). This was probably at the same time as the cessation of the deposition of the Toolonga Calcilutite (Carnarvon Basin) and Gingin Chalk (Perth Basin) - during the early Campanian (Fig. 14).

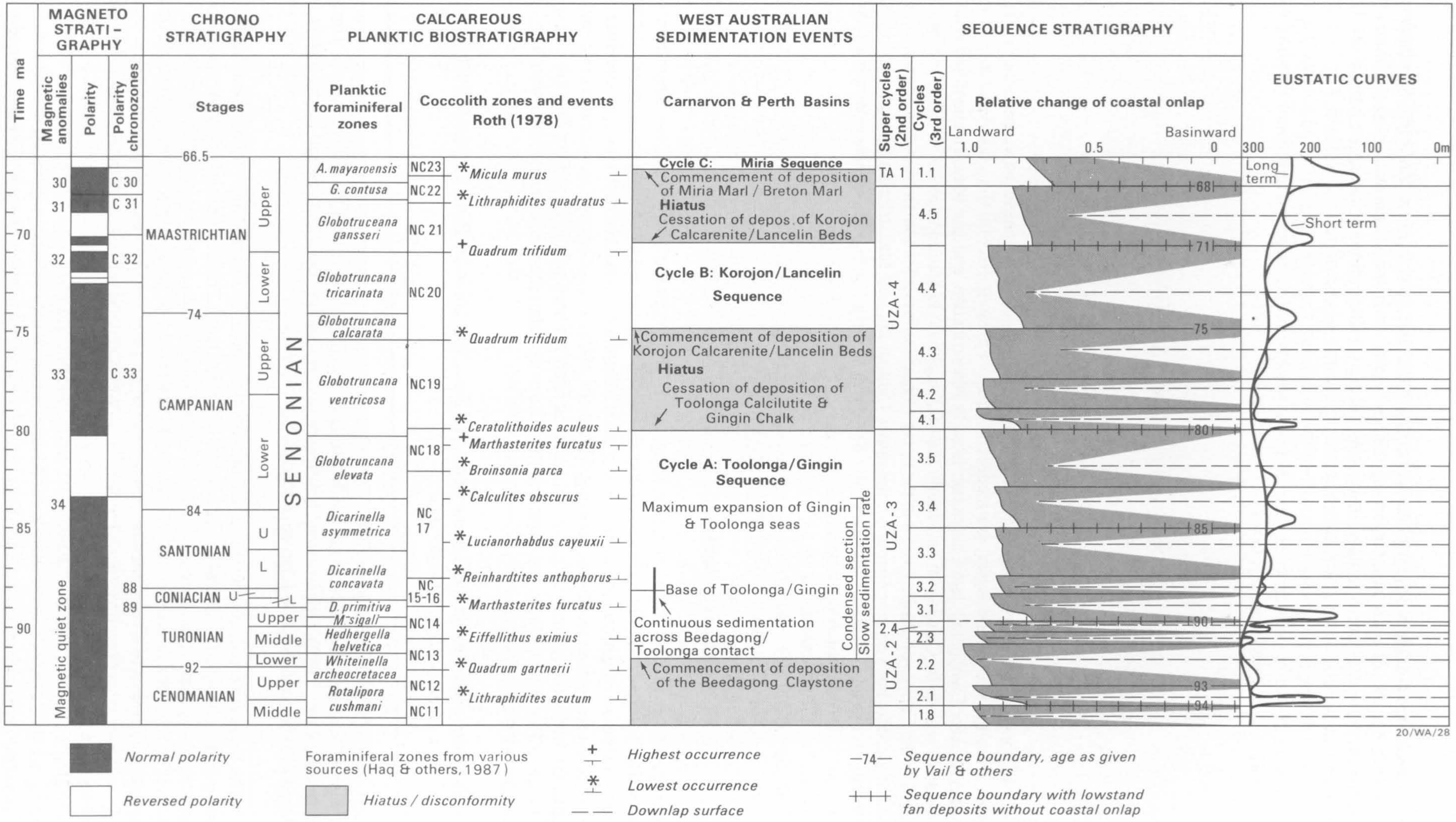
The Beedagong Claystone/Toolonga Calcilutite contact and the base of Gingin Chalk seem to coincide with the surface of maximum flooding (downlap surface) which occurred during the Upper Cretaceous (Upper Zuni) Cycle 3.2 of Haq & others (1987). This surface is within the coccolith DI:**Marthasterites furcatus*/**Reinhardtites anthophorus* (data *in* Haq & others 1987). The same short coccolith datum interval brackets the bases of the Toolonga Calcilutite and Gingin Chalk, suggesting that these bases and the downlap surface of the Upper Cretaceous Cycle 3.2 of Haq & others are probably coeval. During the early part of Cycle A, rates of sedimentation were slow, resulting in a condensed section at least in the Giralia Anticline (Beedagong Claystone and Toolonga Calcilutite). Sometime during the coccolith DI:**Lucianorhabdus cayeuxii*/**Calculites obscurus*, an acceleration in the rate of sedimentation (accompanied by a maximum inundation) in both basins occurred, probably coincident with the surface of maximum flooding of the Upper Cretaceous (Upper Zuni) Cycle 3.4 of Haq & others (1987).

The sharp drop in sea level which appears in Haq & others' curve (1987) at the base of Supercycle UZA-3 could not be detected within the sequence of Cycle A. Sedimentation of the Toolonga Calcilutite or Gingin Chalk began long *after* this drop in sea level.

Cycles B and C (of the present study) can also be traced in the chart given by Haq & others (1987). Cycle B has a counterpart which is the Upper Cretaceous (Upper Zuni) Cycle 4.4, and Cycle C corresponds to a part of Cycle 1.1 within the new Supercycle set Tejas A (see Fig. 14).

Upper Cretaceous Cycle (Upper Zuni) 4.4 corresponds to the coccolith DI:**Quadrum trifidum*/+*Q. trifidum* (Fig. 14). The base of the type Korojon Calcarenite is assigned to the same biostratigraphic interval, based on very rare *Q. trifidum* within the basal nodule bed (immediately above the Toolonga Calcilutite). The top of the type

Figure 14. Correlation between the Western Australian Upper Cretaceous carbonate cycles with global sequence stratigraphy and eustatic curves as given by Haq & others (1987).



Korojon Calcarenite is assignable to the broader coccolith DI:**Quadrum trifidum*/**Lithraphidites quadratus* (see Fig. 14 & Table 2) because of uncertainty regarding the position of the highest occurrence of *Q. trifidum* relative to this top. Sedimentation rates seem to have been slow during the formation of the lower part of the type Korojon Calcarenite (which includes several nodule beds - see columnar section of the type Korojon, Fig. 9), but much faster rates prevailed during the deposition of most of the remaining Korojon. The writer postulates that this possible acceleration in the sedimentation rates may have coincided with the surface of maximum flooding within Haq & others' (1987) Upper Cretaceous Cycle 4.4.

CONCLUSIONS

BIOSTRATIGRAPHIC EVENTS

Two contemporaneous sets of Late Cretaceous coccolith biostratigraphic events, one from the Perth Basin and the other from the Carnarvon Basin, are recorded. These represent discrete time intervals: late Coniacian/early Santonian to early Campanian, late Campanian to early Maastrichtian, and late Maastrichtian; two regional hiatuses are indicated, within the Campanian and within the Maastrichtian. In addition, events as old as the late Turonian are identified in the Carnarvon Basin. Events in the upper Coniacian/lower Santonian - lower Campanian section in both basins are similar, but younger events (in the upper Campanian and Maastrictian sections) are mostly different between the two basins. The late Coniacian/early Santonian to early Campanian sequence comprises the events,

+*Marthasterites furcatus*
**Broinsonia parca*
**Calculites obscurus*
**Lucianorhabdus cayeuxii*
**Acuturris scotus*
**Reinhardtites anthophorus*
**Lithasterinus grillii*,

being recognisable in both basins, in descending order. This sequence of events is not dissimilar to a sequence recognised in Tunisia by Sissingh (1977). Understandably, the events are of unequal value in correlation, because of limitations on the geographic distribution of their species. Thus the event marked by the lowest occurrence of *Broinsonia parca* has been recognised worldwide (see, e.g. Thierstein, 1976) and is currently more useful in correlation than, for example, the lowest occurrence of *Acuturris scotus* which has not been widely identified; *Broinsonia parca*, known in oceanic as well as hemipelagic sediments, is more cosmopolitan than *Acuturris scotus* which is susceptible to dissolution in the oceanic realm.

The older events recognisable in the Carnarvon Basin (but not in the Perth Basin) are (in descending order):

**Reinhardtites biperforatus*
**Marthasterites furcatus*
**Eiffellithus eximius*
**Kamptnerius magnificus*.

Events in this sequence can be correlated with similar events recorded in sections elsewhere (e.g. Tunisia: Sissingh, 1977; Britain: Crux, 1982). Of particular significance in correlation is the event marked by the lowest occurrence of *Marthasterites furcatus* because it has been recognised worldwide.

The biostratigraphic resolution for the late Campanian-early Maastrichtian interval for both basins is much coarser than for the earlier interval (Santonian-early Campanian). The events marked by the lowest occurrence of *Ceratolithoides aculeus, Quadrum gothicum* and *Q. trifidum* are recognisable in the Carnarvon Basin, but are at the same level because of a disconformity. The lowest occurrence of *Q. trifidum* is known elsewhere to be younger than the lowest occurrences of *Ceratolithoides aculeus* and of *Q. gothicum.* The latter two species occur more frequently than *Q. trifidum* in sections investigated in the Carnarvon Basin. Nevertheless, because of the age significance, the lowest occurrence of *Q. trifidum* is considered as more relevant. The event of lowest occurrence of *Reinhardtites levis s.l.* is of limited use in correlation because of taxonomic uncertainties regarding the typical form. Other events occurring within the upper Campanian-lower Maastrichtian of the Carnarvon Basin are the highest occurrences of *Broinsonia parca, Quadrum trifidum* and *Zygodiscus bicrescenticus*, the latter event being the youngest. The event of the highest occurrence of *Q. trifidum* is considered unreliable because the species occurs rarely and sporadically over

Table 30. A combined sequence of coccolith biostratigraphic events for the Upper Cretaceous of the Carnarvon and Perth Basins.

AGE	BIOSTRATIGRAPHIC EVENT
Late Maastrichtian	**Nephrolithus frequens/Micula murus*
Biostratigraphic discontinuity	
Early Maastrichtian	*+Z. bicrescenticus/B. parca* *+Monomarginatus quaternarius* **Nephrolithus corystus* *+Broinsonia parca*
	**Cribrosphaerella daniae*
Late Campanian	**Monomarginatus quaternarius/Q. trifidum*
Biostratigraphic discontinuity	
Early Campanian	*+Marthasterites furcatus*
	**Broinsonia parca*
Late Santonian	**Calculites obscurus*
	**Lucianorhabdus cayeuxii*
Middle Santonian	**Acuturris scotus*
Early Santonian	**Reinhardtites anthophorus*
	**Lithasterinus grillii*
Coniacian	**Reinhardtites biperforatus* **Marthasterites furcatus*
Late Turonian	**Eiffellithus eximius* **Kamptnerius magnificus*

***Lowest occurrence** **+Highest occurrence**

Z.=Zygodiscus, B.= Broinsonia, Q.=Quadrum

the interval near its last appearance (highest occurrence) level in the Carnarvon Basin. The Campanian/Maastrichtian boundary in the Carnarvon Basin sequence could not be delineated using coccoliths.

In the Perth Basin, the events which are recognisable in the upper Campanian include the lowest occurrences of *Monomarginatus quaternarius* and *Reinhadtites levis s.l.*, at the base of the section. Those, recognisable in the Maastrichtian, are (in descending order):

+*Zygodiscus bicrescenticus*
+*Monomarginatus quaternarius*
**Nephrolithus corystus*
+*Broinsonia parca*
**Cribrosphaerella daniae*.

The event of lowest occurrence of *Cribrosphaerella daniae* appears to be a good approximation for the Campanian/Maastrichtian boundary. The two events of the highest occurrences of *Broinsonia parca* and *Zygodiscus bicrescenticus*, discernible in both the Carnarvon and Perth Basins, are useful in local correlation of lower Maastrichtian sediments. (The event of the highest occurrence of *Broinsonia parca* is used to approximately mark the Campanian/Maastrichtian boundary in low-latitude sections, but is thought to be diachronous, becoming younger away from the Equator.)

The key species *Nephrolithus frequens* occurs in the upper Maastrichtian of both basins, but is more useful as biostratigraphic criterion in the Perth Basin, because it occurs less sporadically there than in the Carnarvon Basin. The other key species for the late Maastrichtian, *Micula murus*, is more likely to be encountered in material from the Carnarvon Basin than from the Perth Basin. *Lithraphidites quadratus*, indicative of mid and late Maastrichtian, abounds in the upper Maastrichtian sediments of both basins.

The biostratigraphic successions recognised in the Carnarvon and Perth Basins are pieced together in one sequence of events in Table 30. There are some limitations to the use of this sequence of events: for example, events such as the lowest occurrences of *Nephrolithus frequens* and *Micula murus* may not always be recognisable in the same section, and may not be coeval (see Fig. 11); and the lowest occurrences of *Nephrolithus corystus* and *Cribrosphaerella daniae* are reliable for sections in the Perth Basin but not for those in the Carnarvon Basin.

BIOSTRATIGRAPHIC CHARACTERISTICS OF FORMATIONS

The coccolith evidence indicates that the Upper Cretaceous carbonate units of the Carnarvon and Perth Basins are bounded by biostratigraphic discontinuities/disconformities, with the consequence that each of these units can be very readily characterised by an association of coccoliths distinct from the other associations in the bracketing units. The same evidence also suggests that the disconformities are at similar levels in both basins, i.e. representing the same time intervals. At the Toolonga Calcilutite/Korojon Calcarenite boundary (Carnarvon Basin), a biostratigraphic discontinuity exists, indicated by the sudden appearance of *Ceratolithoides aculeus, Quadrum gothicum* and *Q. trifidum* at the base of Korojon Calcarenite. These species are not known from the Toolonga Calcilutite. However, as *Quadrum gothicum* and *Q. trifidum*, in particular, are rare and sporadic (in the Korojon Calcarenite), the Korojon assemblages can be differentiated from the Campanian Toolonga Calcilutite assemblages by:

1. The size of *Broinsonia parca*: This species is usually larger with a smaller central area in the Korojon assemblages.
2. Abundance of *Eiffellithus eximius*: This species, which tends to be very rare or absent from the Korojon assemblages, is usually common in the Toolonga Calcilutite assemblages.
3. The *Reinhardtites anthophorus*/*R. levis* group: This group is well developed in the Korojon assemblages, with typical *R. levis* being present. In the Toolonga assemblages, typical *R. anthophorus* abounds, but typical *R. levis* or forms similar to it are absent. *Reinhardtites biperforatus* occurs in the Toolonga Calcilutite but is usually absent or very rare in the Korojon Calcarenite.
4. *Kamptnerius magnificus*: This species is usually more prominent in the Toolonga Calcilutite than in the Korojon Calcarenite.

The evidence outlined above negates the opinions expressed earlier by several investigators (e.g. Bate, 1972) that the Toolonga Calcilutite and Korojon Calcarenite are in part or wholly correlatives. The disconformity at the Toolonga Calcilutite/Korojon Calcarenite contact in the Carnarvon Basin is probably equivalent to the hiatus between the Gingin Chalk and Lancelin Beds in the Perth Basin. The appearance of forms referable to *Reinhardtites levis s.l.*, and to the index species *Monomarginatus quaternarius* at the base of the Lancelin Beds is the main evidence for the hiatus, and identification of the Lancelin Beds can be made on the presence of these forms as well as *Misceomarginatus pleniporus, Monomarginatus pectinatus* and occasionally *Quadrum gothicum*. These species are not known from the Gingin Chalk.

The Korojon Calcarenite/Miria Marl contact in the Giralia Anticline (Carnarvon Basin) is marked by the disappearance of the *Reinhardtites anthophorus*/*R. levis* group and *Zygodiscus bicrescenticus*, and by the up-section appearance of *Lithraphidites quadratus* and other late Maastrichtian coccolith species. This is similar to the contact between the Lancelin Beds and the Breton Marl at the top of the Upper Cretaceous carbonates of Breton Bay #1 corehole (Perth Basin). Identification of both the Miria Marl (in the subsurface) and the Breton Marl, is achievable by their coccolith assemblages. The presence of *Lithraphidites quadratus* is characteristic; together with this species, the presence of the late Maastrichtian index species *Nephrolithus frequens* and/or *Micula murus* are conclusive evidence for the presence of the Miria Marl. *Nephrolithus frequens* and *N. corystus* are usually common in the Breton Marl.

The contacts between the Upper Cretaceous units of the Carnarvon and Perth Basins are usually marked by the presence of a phosphatic nodule bed/zone. Previously, this nodule bed was included at the top of the underlying formation in each sequence (see, e.g., original definition of the Alinga Formation and Toolonga Calcilutite *in* Johnstone & others, 1958). The coccolith evidence has consistently shown that the nodule bed (at least that representing the topmost of the nodule zone) is separated from the underlying unit by a major hiatus. Age assignment based on the coccoliths in the nodule bed between the Alinga Formation and the Toolonga Calcilutite in the Lower Murchison River area indicates a disconformity between the Alinga Formation and the nodule bed, the consequence being that the nodule bed is included at the base of the Toolonga Calcilutite rather than the top of the Alinga Formation. Similarly, the coccoliths recorded from the nodule bed between the Toolonga Calcilutite and the Korojon Calcarenite in the C-Y Creek section (Giralia Anticline) suggests a late Campanian age which is the maximum age of the Korojon Calcarenite; the minimum age of the Toolonga Calcilutite is early Campanian. The nodule bed between the Korojon Calcarenite and the Miria Marl at Toothawara Creek (Giralia Anticline) contains coccolith elements from both formations, indicating that it was formed at the advent of the Miria accumulation, subsequent to minor erosion. The contact between the Molecap Hill Greensand and Gingin Chalk is usually sharply defined at the lowest occurrence of coccoliths in sections where no nodule zone between the two formations can be recognised. But in the case of an outcrop at Molecop Hill (Gingin area), the uppermost nodule bed, which is immediately beneath the chalk, contains coccoliths, indicating that it was formed during the early phases of the Gingin transgression.

BIOGEOGRAPHIC PROVINCES

The striking similarities between the Santonian coccoliths successions in the Perth and Carnarvon Basins indicate similar watermasses and uniform climate over much of the Australian western margin. During the early Campanian cooler water conditions prevailed more in the Perth Basin, compared with the Carnarvon Basin where only the southern sector has evidence of cold spells. During the late Campanian and Maastrichtian, coccolith biogeographic provinces became progressively more established following the period, during the Santonian and early Campanian, when the nannofloras were generally uniformly distributed. Thus, provincial differentiation seems to have started during the late Campanian, although slim evidence (based on occurrences of *Biscutum coronum*) may indicate an earlier initiation, during the early Campanian. Published palaeotemperature curves (e.g. Spaeth & others, 1971) support these conclusions by showing a general trend of temperature decline during the later part of the Cretaceous, subsequent to a peak during the Coniacian-Santonian interval. A cooling trend means an increased latitudinal thermal gradient with the attendant appearance of species tolerant to *narrow* temperature ranges, due to increased pressure by thermal barriers.

Data from this study and elsewhere suggest that the species *Biscutum coronum, B. magnum, Ceratolithoides aculeus, Cribrosphaerella daniae, Micula murus, Misceomarginatus pectinatus, Monomarginatus quaternarius, Nephrolithus corystus, N. frequens, Seribiscutum primitivum, Quadrum gothicum, Q. trifidum* and *Petrarhabdus copulatus* are reliable temperature indicators, and that the absence of the highly-resistant *Watznaueria barnesae* and the relative abundance of members of the *Micula staurophora/concava/murus/prinsii* are useful climatic pointers.

In Australian upper Campanian and Maastrichtian sediments, coccolith evidence shows the development of an Austral Province including the Perth Basin, and an Extratropical Province encompassing the Carnarvon Basin to the North. A third biogeographic province, the Tropical Province, could also be identified further to the north, including Papua New Guinea and other low-latitude areas (such as the Ontong Java Plateau).

The Austral Province included other locations in the Southern Hemisphere (e.g. Kerguelen Plateau and New Zealand). The evidence from several locations in the Northern Hemisphere suggests a wide (northern) Extratropical Province during the late Maastrichtian, including areas in North Africa, Europe and the Atlantic Ocean. The three biogeographic provinces (Austral, Extratropical and Tropical) were apparently more distinct during the late Maastrichtian.

During the Maastrichtian, high-latitude species (such as *Cribrosphaerella daniae, Biscutum magnum, Misceomarginatus pleniporus, Monomarginatus pectinatus, M. quaternarius Nephrolithus corystus* and *N. frequens*) characterise the Austral Province, and low-latitdue species (such as *Ceratolithoides aculeus, Quadrum gothicum, Q. trifidum, Cribrocorona gallica* and *Micula murus*) characterise the Tropical Province. The Extratropical Province, occupying mid latitudes, is characterised by mixtures of high- and low-latitude species, particularly during the late Maastrichtian; for example, the overlap of the low-latitude *Micula murus* and the higher-latitude *Nephrolithus frequens* characterises the Extratropical Province during this time.

BIOSTRATIGRAPHIC LIMITATIONS IN THE EXTRATROPICAL PROVINCE

Bearing in mind some limitations, biostratigraphic subdivision of sections in the Extratropical Province is possible in spite of an inherent rarity of the key biostratigraphic species in this province. *Quadrum trifidum, Q. gothicum* and *Ceratolithoides aculeus*, are uncommon and sporadic in the type Korojon Calcarenite in the Giralia Anticline (Extratropical Province), but nevertheless, are important biostratigraphic markers in the province; their rarity is expected because evidence from elsewhere suggests that these species have preferred tropical conditions. The absence of any of these species, in the presence of the others, in extratropical assemblages (e.g. Korojon assemblages) does not necessarily mean the same, in biostratigraphic terms, as its absence from tropical assemblages.

The Maastrichtian *Cribrosphaerella daniae*, absent from the Tropical Province and usually common in the Perth Basin (Austral Province), is extremely rare in the Korojon Calcarenite and is virtually absent from the extratropical assemblages of the Miria Marl in the Carnarvon Basin.

Slight shifts in the environmental preferences of some of the key species, probably combined with some favourable changes in environments, may have occurred over time. For example, *Ceratolithoides aculeus* in extratropical assemblages, being usually more persistent in the younger Miria Marl than in the Korojon Calcarenite, may have become more eurythermal, developing tolerance to lower temperatures, with time, and/or conditions during the formation of the Miria Marl became more favourable for this species.

The late Maastrichtian coccolith markers, *Nephrolithus frequens* and *Micula murus*, may not always be found in samples from the Miria Marl, though it has been demonstrated that this formation was laid down within the temporal range of both species; the 'coeval' late Maastrichtian foraminiferal index *Abathomphalus mayaroensis* has been recorded from the Miria Marl by several investigators (e.g. McGowran, 1968).

The stratigraphic order of appearance of the (bipolar) austral/boreal *Nephrolithus frequens* and the tropical *Micula murus* is often reversed in sections within the Extratropical Province. This can be attributed to the possible fact that this province extended over the limits of the geographic domains of the two species. Thus areas such as the Giralia Anticline which envisaged as near the extreme geographic limits of *N. frequens* would be well within the geographic limits of *M. murus*, the implications being the earlier appearance (in an up-section direction) of *M. murus* than *N. frequens* which is also likely to be less frequent. The reverse is also true for areas (such as the central Negev in Israel, and the Kef section in Tunisia) at the extreme geographic limits of *M. murus*.

LATE CAMPANIAN-LATE MAASTRICHTIAN CLIMATIC OSCILLATIONS

The evidence of this study supports the global decline in temperatures of the oceans during the Campanian-Maastrichtian, but suggests that this decline was interrupted by several warm intervals. The few occurrences of *Ceratolithoides aculeus* and *Micula murus* in the Perth Basin (Austral Province) indicates short warm episodes (Table 31): two during the late Campanian, and one during the late Maastrichtian. The latter had probably caused *Micula murus* (and other warm-water species) to extend its geographic range briefly into the Boreal Province as well. A cold episode during the late Campanian-early Maastrichtian occurred in the Extratropical Province, based on occurrence of *Misceomarginatus pleniporus* in the Carnarvon Basin.

PALAEOENVIRONMENTS AND SEDIMENTATION CYCLES

The presence of several hemipelagic species, including holococcoliths and pentaliths, in most of the Upper Cretaceous carbonates examined from the Carnarvon and Perth Basins, suggests that deposition during the Late Cretaceous along the Australian western margin took place on the shelf or in nearshore palaeoenvironments. Three Late Cretaceous carbonate sedimentation cycles, eustatically caused, have been recognised along the Australian western margin. The earliest, Cycle A, began in the northern Carnarvon Basin during the late Turonian, commencing later in the southern Carnarvon and Perth Basins during the late Coniacian/early Santonian. Cycle A ended in both basins, at about the same time during the early Campanian. This cycle resulted in the formation of the Beedagong Claystone and Toolonga Calcilutite in the Carnarvon Basin, and the Gingin Chalk in the Perth Basin (the Toolonga/Gingin Sequence). Cycle B, which seems to have the same timing in both basins, resulted in the accumulation of the Korojon Calcarenite in the Carnarvon Basin and the Lancelin Beds in the Perth Basin. This cycle began late in the Campanian and ended during the early Maastrichtian; the resultant package of sediments is referred to as the Korojon/Lancelin Sequence. Cycle C, which occured during the late Maastrichtian resulted in the formation of the Miria Marl in the Carnarvon Basin and the Breton Marl in the Perth Basin (the Miria/Breton Sequence); this cycle continued into the latest Maastrichtian at least in parts of the Carnarvon Basin as evidenced by the occurrence of

Table 31. Summary of events(1) recognised in the present study, arranged in a chronologic order, and their possible correlative elsewhere.

Paleocene:

Erosion of top of Miria Marl during the early Paleocene, and subsequent redeposition of latest Maastrichtian Miria (with *Micula prinsii*) at the base of the middle Paleocene Boongerooda Greensand.

Maastrichtian:

Excursion of *Micula murus* into the Austral Province, and together with many other warm-water species into the Boreal Province during the late Maastrichtian.

Commencement of carbonate deposition of the Miria/Breton Sequence (Cycle C) during the late Maastrichtian, subsequent to the appearance of *Micula murus* in the world ocean.

Minor erosion of top of Korojon Calcarenite, and formation of the nodule bed at the base of the Miria Marl, subsequent to the appearance of *Nephrolithus frequens* in the world ocean. This seems to correspond with the base of the transgressive phase of Kauffman's (1984b) Cycle T10-R10 in the Western Interior Basin of North America.

Major regression reaching its maximum during the middle Maastrichtian: along the Australian western margin (present study), Russian Platform (Naidin, 1983), and Western Interior of North America (Kauffman, 1984b).

Cessation of deposition of the Korojon/Lancelin Sequence (end of Cycle B), probably related to the sea-level fall prior to the appearance of *Lithraphidites quadratus* as given by Haq & others (1987). This was during the regressive phase of Kauffman's (1984b) Cycle T9-R9.

Campanian:

Acceleration in sedimentation rates of Korojon Calcarenites during the late Campanian, probably coincident with the surface of maximum flooding within Upper Zuni Cycle 4.4 of Haq & others (1987).

Two excursions by *Ceratolithoides aculeus* into the Breton Bay part of the Austral Province sometime during the late Campanian.(2)

Commencement of carbonate deposition of the Korojon/Lancelin Sequence (Cycle B) late in the Campanian. This event appears to correlate with the peak of the last major Late Cretaceous transgression (T9) in the Western Interior Basin of North America (in Kauffman, 1984b).

Campanian:

Formation of the nodule bed at the base of the Korojon Calcarenite during the late Campanian, subsequent to the appearance of *Quadrum trifidum* in the world ocean. This event probably corresponds with the sequence boundary separating the Upper Zuni Cycles 4.3 and 4.4 of Haq & others (1987).

Regression in the Carnarvon and Perth Basins during the middle Campanian.

Cessation of deposition of the Toolonga /Gingin Sequence (end of Cycle A) during the early Campanian, at about the time when the regressive phase R7 of Kauffman (1984b) reached its maximum in the Western Interior Basin of North America. The event seems to correspond also with the sequence boundary separating the Supercycles UZA-3 and UZA-4 of Haq & others (1987).

Santonian:

Maximum flooding in the Carnarvon and Perth Basins (peak of Toolonga and Gingin transgressions) during the mid/late Santonian DI: **Lucianorhabdus cayeuxii*/**Calculites obscurus*. This seems to correlate with an extensive middle Santonian transgressive pulse in the Western Interior Basin of North America (in Kauffman, 1984b). It also seems to equate with the surface of maximum flooding within the Upper Zuni Cycle 3.4 of Haq & others (1987).

Coniacian/Santonian transition:

Commencement of carbonate deposition of Toolonga Calcilutite and Gingin Chalk, subsequent to the formation of phosphatic nodule beds. These events represent the base of Cycle A in the southern Carnarvon and Perth Basins. They occurred around the time of the surface of maximum flooding during the Upper Zuni Cycle 3.2 of Haq & other (1987).

Turonian:

Commencement of deposition of Beedagong Claystone in the northern Carnarvon Basin, subsequent to the appearance of *Kamptnerius magnificus* during the late Turonian (base of Cycle A). This is about the time when the regressive phase R6 gave rise to the transgressive phase T7 in the Western Interior Basin of North America (Kauffman, 1984b). It also seems to coincide with the timing of the surface of maximum flooding within the Upper Zuni Cycle 2.2 of Haq & others (1987).

*Lowest occurrence;

(1) Events are not necessarly biostratigraphic; (2) Placement relative to above event uncertain.

reworked Miria Marl, bearing *Micula prinsii*, within the base of the Paleocene Boongeroooda Greensand (Table 31).

Outcropping Upper Cretaceous carbonate units in both the Carnarvon and Perth Basins are bounded by thin phosphatic nodule beds/zones; Beedagong Claystone may be an exception, but this unit is known mainly from subsurface sections where such a thin nodule bed is usually difficult to detect. The nodule bed at the base of the Gingin Chalk in Molecap Hill (Perth Basin) was probably formed initially as blanket near the end of the regressive phase which deposited the Molecap Greensand, to be reworked with the initiation of the sedimentation of the overlying Gingin Chalk. A similar mechanism is considered likely for the formation of the nodule bed at the base of the Toolonga Calcilutite in the southern Carnarvon Basin.

The phosphatic nodule bed at the base of either the Korojon Calcarenite or the Miria Marl was probably formed in a similar manner to that forming the phosphatic nodule bed at the base of either the Gingin Chalk or the Toolonga Calcilutite. A coccolith evidence of minor reworking is recorded from the nodule bed at the base of the Miria Marl in the Giralia Anticline supports this conclusion.

The coccolith evidence from the lower part of the Toolonga Calcilutite, in the Lower Murchison River area (southern Carnarvon Basin), suggests that the sedimentation rates were slow during the early stages of the Toolonga transgression (late Coniacian/early Santonian to mid Santonian), and were accelerated during the mid/late Santonian DI:**Lucianorhabdus cayeuxii*/**Calculites obscurus*, when the transgression reached its peak. This mirrors a contemporaneous pattern of deposition in the Perth Basin, which resulted in the formation of the Gingin Chalk.

POSSIBLE ORIGIN AND CORRELATION OF WESTERN AUSTRALIAN CYCLES

A eustatic origin for the Upper Cretaceous carbonate cycles along the Australian western margin is indicated by good correlation with other eustatic cycles elsewhere. Periods of sea-level falls between the cycles (represented by the two regional intra-Campanian and intra-Maastrichtian hiatuses) are thought to be periods with little or no erosion, meaning that the limits of the sediment sequences are virtually time planes, neatly fitting the limits of the cycles.

The West Australian Cycles A, B and C seem to parallel the two major Cycles T7-R7 and T9-R9 and the minor Cycle T10-R10 which were recognised by Kauffman (1984b) in the Western Interior Basin of North America. The timing of a middle Santonian pulse in Kauffman (1984b) appears to correspond with the time of maximum expansion of the Toolonga Calcilutite and Gingin Chalk.

Cycle A corresponds with the later part of the Supercycle UZA-2 and the entire Supercycle UZA-3 of Haq & others (1987). The base of Cycle A correlates with the surface of maximum flooding within the Upper Zuni Cycle 2.2, and the bases of the Toolonga Calcilutite and Gingin Chalk occurred around the time of the surface of maximum flooding within Cycle 3.2 of Haq & others (1987). The mid/late Santonian maximum expansion of the transgressions in the Carnarvon and Perth Basins seems to equate with the surface of maximum flooding within Cycle 3.4 of Haq & others (1987).

Cycle B correlates with the Upper Zuni Cycle 4.4 of Haq & others (1987). A possible acceleration in the sedimentation rates during the deposition of the Korojon Calcarenite is thought to correlate with the surface of maximum flooding within Cycle 4.4 of Haq & others (1987).

A major middle Maastrichtian regression occurred along the Australian western margin and also on the Russian Platform and the Western Interior of North America.

List of nannofossil species referred to in the study

Actinozygus regularis (Gorka) Gartner, 1968.
Acuturris scotus (Risatti) Wind & Wise *in* Wise & Wind, 1977.
Ahmuellerella octoradiata (Gorka) Reinhardt, 1967.
Amphizygus brooksii brooksii Bukry, 1969.
Amphizygus tesselatus (Noel) Shafik n. comb. (basionym: *Bipodorhabdus tesselatus* Noel, 1970, p. 20, text-fig. 10; pl. 13, figs. 7a-b; pl. 14, figs. 1a-4; pl. 15, fig. 1.)
Angulofenestrellithus snyderi Bukry, 1969.
Arkhangelskiella cymbiformis Vekshina, 1959.
Arkhangelskiella orthocancellata (Bukry) Shafik, n.comb. (basionym: Bukry, 1969 partim, p. 23, pl. 2, fig. 12; pl. 3, fig. 1; non pl. 3, fig. 2.)
Arkhangelskiella specillata Vekshina, 1959.
Axopodorhabdus dietzmanni (Reinhardt) Wind & Wise *in* Wise & Wind, 1977.
Bidiscus cruciatus cruciatus Bukry, 1969.
Bidiscus cruciatus multicruciatus Bukry, 1969.
Bidiscus monocavus Bukry, 1969.
Bidiscus rotatorius Bukry, 1969.
Biscutum sp. cf. *B. blackii* Gartner, 1968.
Biscutum bukryi bukryi (Reinhardt) Shafik, n. comb. (Basionym: *Watznaueria bukryi* Reinhardt, 1971, p.34, text-fig.37.)
Biscutum bukryi nanum Shafik, n. ssp.
Biscutum coronum Wind & Wise *in* Wise & Wind, 1977.
Biscutum magnum Wind & Wise *in* Wise & Wind, 1977.
Biscutum melaniae (Gorka) Reinhardt, 1969.
Biscutum notaculum Wind & Wise *in* Wise & Wind, 1977.
Boletuvulum candens Wind & Wise *in* Wise & Wind, 1977.
Boletuvulum flabellatum Shafik, n. sp.
Boletuvulum wisei Shafik, n. sp.
Braarudosphaera sp. cf. *B. africana* Stradner, 1961.
Braarudosphaera amputans Jiang & Gartner, 1986.
Braarudosphaera bigelowii (Gran & Braarud) Deflandre, 1947.
Braarudosphaera discula Bramlette & Riedel, 1954.
Broinsonia bukryi Shafik, n. sp.
Broinsonia dentata Bukry, 1969.
Broinsonia expansa Wise & Watkins, 1983 *in* Wise, 1983.
Broinsonia handfieldii Bukry, 1969.
Broinsonia parca (Stradner) Bukry, 1969 (partim).
Broinsonia pseudoparca Shafik, n. sp.
Broinsonia? staytonae Bukry, 1969.
Calculites biperforatus Shafik, n. sp.
Calculites obscurus (Deflandre) Prins & Sissingh *in* Sissingh, 1977
Calculites ovalis (Stradner) Prins & Sissingh *in* Sissingh, 1977.
Ceratolithoides aculeus (Stradner) Prins & Sissingh *in* Sissingh, 1977.
Ceratolithoides kamptneri Bramlette & Martini, 1964.
Chiastozygus amphipons (Bramlette & Martini) Gartner, 1968.
Chiastozygus fessus (Stover) Shafik, 1979.
Chiastozygus garrisonii Bukry, 1969.
Chiastozygus litterarius (Gorka) Manivit, 1971.
Clinozygus gartnerii Shafik, n. gen., n. sp.
Clinozygus synquadriperforatus (Bukry) Shafik, n. comb. (basionym: *Chiastozygus synquadriperforatus* Bukry, 1969, p.51, pl.28, figs.6-9.)
Corollithion exiguum Stradner, 1961.
Corollithion geometricum (Gorka) Manivit, 1971.
Corollithion rhombicum rhombicum (Stradner & Adamiker) Bukry, 1969.
Corollithion rhombicum symetricum Shafik, n. ssp.
Corollithion signum Strdaner, 1963
Cretarhabdus conicus Bramlette & Martini, 1964.
Cretarhabdus lorieri Gartner, 1968.
Cretarhabdus surirellus (Deflandre & Fert) Reinhardt, 1970b.
Cribrocorona gallica (Stradner) Perch-Nielsen, 1973.
Cribrosphaerella circula (Risatti) Verbeek, 1977.
Cribrosphaerella daniae Perch-Nielsen, 1973.
Cribrosphaerella ehrenbergii (Arkhangelsky) Deflandre *in* Piveteau, 1952.
Cyclagelosphaera bergeri Roth, 1978.
Cyclagelosphaera columnata Shafik, n. sp.
Cyclagelosphaera margereli Noel, 1965.
Cyclagelosphaera perforata (Perch-Nielsen) Verbeek, 1977.
Cyclagelosphaera rotaclypeata Bukry, 1969.
Cyclindralithus biarcus Bukry, 1969.
Cyclindralithus nudus Bukry, 1969.
Cyclindralithus serratus Bramlette & Martini, 1964.
Dodekapodorhabdus noelii Perch-Nielsen, 1968.
Eiffellithus dissimils Shafik, n. sp.
Eiffellithus eximius (Stover) Perch-Nielsen, 1968.
Eiffellithus sp. cf. *E. planus* (Bukry) Shafik, n. comb. (basionym: *Chiastozygus planus* Bukry, 1969, p. 50, pl. 27, fig. 12; pl. 28, figs. 1-2.
Eiffellithus trabeculatus (Gorka) Reinhardt & Gorka, 1967.
Eiffellithus turriseiffeli (Deflandre) Reinhardt, 1965.
Eiffellithus? transversus Shafik, n. sp.
Eprolithus floralis (Stradner) Stover, 1966.
Gartnerago obliquum (Stradner) Reinhardt, 1970b.
Gartnerago striatum (Stradner) Forchheimer, 1972.
Gephyrorhabdus coronadventis (Reinhardt) Hill, 1976.
Grantarhabdus camaratus (Bukry) Wise, 1983.
Grantarhabdus punctatus Black, 1972.
Haqius circumradiatus (Stover) Roth, 1978.
Helicolithus anceps (Gorka) Noel, 1970.
Heterorhabdus sinuosus Noel, 1970.
Kamptnerius magnificus Deflandre, 1959.
Lapideacassis cornuta (Forchheimer & Stradner) Wind & Wise *in* Wise & Wind, 1977.
Lapideacassis fasciata Shafik, n. sp.
Lapideacassis mariae Black, 1971b emend. Wind & Wise *in* Wise & Wind, 1977.
Lapideacassis simplex Shafik, n. sp.
Lapideacassis uncinata Shafik, n. sp.
Lithastrinus grillii Stradner, 1962.
Lithraphidites carniolensis Deflandre, 1963.
Lithraphidites grossopectinatus Bukry, 1969.
Lithraphidites kennethii Perch-Nielsen, 1986.
Lithraphidites praequadratus Roth, 1978.
Lithraphidites quadratus Bramlette & Martini, 1964.
Loxolithus armilla (Black) Noel, 1965.
Lucianorhabdus arcuatus Forchheimer, 1972.
Lucianorhabdus cayeuxii Deflandre, 1959.

Lucianorhabdus sp. cf. *L. inflatus* Perch-Nielsen & Feinberg *in* Perch-Nielsen, 1986.

Lucianorhabdus maleformis Reinhardt, 1966a.

Manivitella gronosa (Stover) Black, 1973.

Manivitella pemmatoidea (Deflandre *in* Manivit) Thierstein, 1971b

Manivitella redimiculatus (Stover) Shafik, n. comb. (Basionymy: *Cyclolithus redimiculatus* Stover, 1966, p. 141, pl. 1, figs. 4-5; pl. 8, fig. 2.)

Markalius astroporus (Stradner) Hay & Mohler, 1967.

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Marthasterites inconspicuus Deflandre, 1959.

Microrhabdulus belgicus Hay & Towe, 1963.

Microrhabdulus decoratus Deflandre, 1959.

Microrhabdulus helicoideus Deflandre, 1959.

Micula concava (Stradner) Bukry, 1969.

Micula murus (Martini) Bukry, 1973c.

Micula praemurus (Bukry) Stradner & Steinmetz, 1984.

Micula prinsii Perch-Nielsen, 1979d.

Micula staurophora (Gardet) Stradner, 1963 (partim).

Misceomarginatus pleniporus Wind & Wise *in* Wise & Wind, 1977.

Misceorepagulum tarboulensis (Shafik & Strader) Shafik, n. comb. (basionym: *Zygodiscus tarboulensis* Shafik & Stradner, 1971, p. 91.)

Monomarginatus pectinatus Wind & Wise *in* Wise & Wind, 1977.

Monomarginatus quaternarius Wind & Wise *in* Wise & Wind, 1977.

Multicyclolithus magnificus Shafik, n. gen., n. sp.

Munarinus keadyi Risatti, 1973.

Neochiastozygus acutus Shafik, n. sp.

Neochiastozygus antiquus Perch-Neilsen, 1973.

Neocrepidolithus ginginensis Shafik, n. sp.

Neocrepidolithus neocrassus (Perch-Nielsen) Romein, 1979b.

Nephrolithus corystus Wind, 1983.

Nephrolithus frequens Gorka, 1957.

Octocyclus reinhardtii (Bukry) Wind & Wise *in* Wise & Wind, 1977.

Ottavianus giannus Risatti, 1973.

Parhabdolithus embergeri (Noel) Stradner, 1963.

Perchnielsenella stradneri (Perch-Nielsen) Watkins *in* Watkins & Bowdler, 1984.

Percivalia porosa Bukry, 1969.

Pervilithus glaessnerius Shafik, n. sp.

Petrorhabdus copulatus (Deflandre) Wind & Wise *in* Wise, 1983.

Placozygolithus roeglii (Thierstein) Shafik, n. comb.

Placozygus fibuliformis (Reinhardt) Hoffmann, 1970b.

Placozygus sigmoides (Bramlette & Sullivan) Romein, 1979b.

Pontosphaera multicarinata (Gartner) Shafik & Stradner, 1971.

Prediscosphaera bukryi Perch-Nielsen, 1973.

Prediscosphaera cretacea (Arhangelsky) Gartner, 1968.

Prediscosphaera grandis Perch-Nielsen, 1979.

Prediscosphaera honjoi Bukry, 1969 (partim).

Prediscosphaera majungae Perch-Nielsen, 1973.

Prediscosphaera spinosa (Bramlette & Martini) Gartner, 1968.

Prediscosphaera stoveri (Perch-Nielsen) Shafik & Stradner, 1971.

Quadrum descriptum (Martini) Shafik, n. comb. (basionym: *Tetralithus descriptus* Martini, 1961, p. 5, pl. 1, fig. 7; pl. 4, fig. 43.)

Quadrum gartneri Prins & Perch-Nielsen *in* Manivit & others, 1977

Quadrum gothicum (Deflandre) Prins & Perch-Nielsen *in* Manivit & others, 1977.

Quadrum trifidum (Stradner) Prins & Perch-Nielsen *in* Manivit & others, 1977.

Reinhardtites anthophorus (Deflandre) Perch-Nielsen, 1968.

Reinhardtites biperforatus (Gartner) Shafik, 1979.

Reinhardtites levis Prins & Sissingh *in* Sissingh, 1977.

Reinhardtites mirabilis Perch-Nielsen, 1968.

Repagulum parvidentatum (Deflandre & Fert) Forchheimer, 1972.

Retacapsa schizobrachiata (Gartner) Grun *in* Grun & Allemann, 1975.

Rhabdophidite moeslensis Manivit, 1971.

Rhagodiscus angustus (Stradner) Reinhardt, 1971.

Rhagodiscus asper (Stradner) Reinhardt, 1967.

Rhagodiscus fischeri (Bukry) Shafik, n. comb. (basionym: *Parhabdolithus fischeri* Bukry, 1969, p. 53, pl. 29, fig. 12; pl. 30, figs. 1-3.)

Rhagodiscus reniformis Perch-Nielsen, 1973.

Rhagodiscus splendens (Deflandre) Verbeek, 1977.

Russellia laswelli Risatti, 1973.

Scapholithus fossilis Deflandre *in* Deflandre & Fert, 1954.

Seribiscutum primitivatum (Thierstein) Filewicz, Wind & Wise *in* Wind & Wise, 1983.

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Stephanolithion laffittei Noel, 1956.

Teichorhabdus ethmos Wind & Wise *in* Wise & Wind, 1977.

Tetrapodorhabdus decorus (Deflandre) Wind & Wise, 1983.

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Tranolithus exiguus Stover, 1966.

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Tranolithus orionatus (Reinhardt) Reinhardt, 1966a.

Tubodiscus brevis Shafik, n. sp.

Vekshinella aachena (Bukry) Shafik & Stradner, 1971.

Vekshinella ara Gartner, 1968.

Vekshinella cristata Shafik, n. sp.

Vekshinella dentata dentata (Bukry) Hattner & Wise, 1980.

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Vekshinella? delicatus Shafik, n. sp.

Vekshinella dibrachiatus Gartner, 1968.

Vekshinella dorfi (Bukry) Shafik, n. comb. (basionym: *Vagalapilla dorfi* Bukry, 1969, p. 57, pl. 32, figs. 7-8.)

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Vekshinella imbricata Gartner, 1968.

Vekshinella solida (Forchheimer) Shafik, n. comb. (basionym: *Vagalapilla solida* Forchheimer, 1972, p. 66, pl. 23, figs.1-2.)

Watznaueria barnesae (Black) Perch-Nielsen, 1968.

Watznaueria biporta Bukry, 1969.

Watznaueria cruciata Shafik, n. sp.

Zeugrhabdotus acanthus Reinhardt, 1965.

Zygodiscus abbottii Hattner & Wise, 1980.

Zygodiscus bicrescenticus (Stover) Wind & Wise *in* Wise & Wind, 1977.

Zygodiscus deflandrei Bukry, 1969.

Zygodiscus lacunatus Gartner, 1968.

Zygodiscus ponticulus (Deflandre) Reinhardt, 1966a.

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APPENDIX A: DETAILS OF SAMPLES.

The prefix MFN- indicates sample's preparation and registration number in the Registry (Microfossil--Nanno) of the Bureau of Mineral Resources, Canberra.

I. MATERIAL FROM PERTH BASIN

A. Gingin Chalk outcrops

1. McIntyre Gully outcrops (Gingin Chalk type section).
(Lat. 31° 19' S - Long. 115° 54' E)
MK82- samples in Shafik's Field Note 1982.

Sample MFN-2162 Molecap Greensand, topmost part (MK82-01)
Sample MFN-2163 - 2166 basal Gingin Chalk, highly glauconitic; exposure 1:
MFN-2163 (MK82-02) base of Gingin Chalk
MFN-2164 (MK82-03) 40 cm above MFN-2163
MFN-2165 (MK82-04) 40 cm above MFN-2164
MFN-2166 (MK82-05) 40 cm above MFN-2165
Samples MFN-2167 - MFN-2169 Gingin Chalk, less glauconitic than below; exposure 2:
MFN-2167 (MK82-06) about 40 cm above MFN-2166
MFN-2168 (MK82-07) 40 cm above MFN-2167
MFN-2169 (MK82-08) 40 cm above MFN-2168
Samples MFN-2170 - MFN-2175 Gingin Chalk with *Inoceramus*; exposure 3:
MFN-2170 (MK82-09) about 40 cm above MFN-2169
MFN-2171 (MK82-10) 40 cm above MFN-2170
MFN-2172 (MK82-11) 40 cm above MFN-2171
MFN-2173 (MK82-12) 40 cm above MFN-2172
MFN-2174 (MK82-13) 40 cm above MFN-2173
MFN-2175 (MK82-14) 40 cm above MFN-2174
Samples MFN-2176 - MFN-2180 Gingin Chalk; exposure 4:
MFN-2176 (MK82-15) about 40 cm above MFN-2175
MFN-2177 (MK82-16) 40 cm above MFN-2176
MFN-2178 (MK82-17) 40 cm above MFN-2177
MFN-2179 (MK82-18) 40 cm above MFN-2178
MFN-2180 (MK82-19) 40 cm above MFN-2179
Samples MFN-2181 - MFN-2201 Gingin Chalk; exposure 5:
MFN-2181 (MK82-20) about 40 cm above MFN-2180
MFN-2182 (MK82-21) 40 cm above MFN-2181
MFN-2183 (MK82-22) 40 cm above MFN-2182
MFN-2184 (MK82-23) 40 cm above MFN-2183
MFN-2185 (MK82-24) 40 cm above MFN-2184
MFN-2186 (MK82-25) 40 cm above MFN-2185
MFN-2187 (MK82-26) 40 cm above MFN-2186
MFN-2188 (MK82-27) 40 cm above MFN-2187
MFN-2189 (MK82-28) 40 cm above MFN-2188
MFN-2190 (MK82-29) 40 cm above MFN-2189
MFN-2191 (MK82-30) 40 cm above MFN-2190
MFN-2192 (MK82-31) 40 cm above MFN-2191
MFN-2193 (MK82-32) 40 cm above MFN-2192
MFN-2194 (MK82-33) 40 cm above MFN-2193
MFN-2195 (MK82-34) 40 cm above MFN-2194
MFN-2196 (MK82-35) 40 cm above MFN-2195
MFN-2197 (MK82-36) 40 cm above MFN-2196
MFN-2198 (MK82-37) 40 cm above MFN-2197
MFN-2199 (MK82-38) 40 cm above MFN-2198
MFN-2200 (MK82-39) 40 cm above MFN-2199
MFN-2201 (MK82-40) 40 cm above MFN-2200
Samples MFN-2202 - MFN-2203 Gingin Chalk; exposure 6:
MFN-2202 (MK82-41) 100 cm above MFN-2201
MFN-2203 (MK82-42) 40 cm above MFN-2202
Sample MFN-2204 (MK82-43) 100 cm above MFN-2203 (exposure 7)
Sample MFN-2205 (MK82-44) 100 cm above MFN-2204 (exposure 8)
Sample MFN-2206 (MK82-45) 100 cm above MFN-2205 (exposure 9)
Sample MFN-2207 (MK82-46) 100cm above MFN-2206 (exposure 10)
Samples MFN-2208 - MFN-2209 from the top metre of the Gingin Chalk (exposure 11)
Sample MFN-2210 Poison Hill Greensand, base.

2. Top part of the type Gingin Chalk on the opposite bank (McIntyre Gully; MKT82- samples in Shafik's Field Note 1982:

Sample MFN-2215 (MKT82-1) topmost Gingin Chalk, immediately below Poison Hill Greensand
Sample MFN-2214 (MKT82-2) 50 cm below top of the chalk
Sample MFN-2213 (MKT82-3) 100 cm below top of the chalk
Sample MFN-2212 (MKT82-4) 145 cm below top of the chalk
Sample MFN-2211 (MKT82-5) 185 cm below top of the chalk.

3. Molecap Hill outcrop, Gingin, near town water supply tanks (Lat. 31 22 S - Long. 115 54 E) GG82- samples in Shafik's Field Note 1982.

Samples MFN-2218 - MFN-2219, MFN-2230, MFN-2231 are from phosphatic nodule beds within the top 200 cm of the Molecap Greensand.
MFN-2218 (GG82-1) about 200 cm below base of chalk
MFN-2219 (GG82-2) 80 cm above MFN-2218
MFN-2230 (GG82-3A) 110 cm above MFN-2219
MFN-2231 (GG82-3B) same as MFN-2230, upper part
MFN-2232 (GG82-4) marl about 50 cm above base of the Gingin Chalk
MFN-2234 (GG82-5) 70 cm above base of chalk
MFN-2235 (GG82-6) marl with *Inoceramus* 120 cm above base of chalk
MFN-2236 (GG82-7) glauconitic marl with *Inoceramus*, 170 cm above base of chalk
MFN-2237 (GG82-8) marl with *Inoceramus*, 205 cm above base of chalk
MFN-2238 (GG82-9) marl, 235 cm above base of chalk
MFN-2239 (GG82-10) friable marl with *Inoceramus*, 275 cm above base of chalk
MFN-2240 (GG82-11) 315 cm above base of chalk, 80 cm below base of soil overburden

4. Molecap Quarry (main quarry at Gingin), samples 7164-0006 -- 7164/0011 in Belford's Field Note 1971. Gingin Chalk-Molecap Greensand contact dug clean.

Sample MFN-230 (7164-0006) phosphatic nodule bed at the top of the Molecap Greensand

MFN-231 base of Gingin chalk, 10 cm above MFN-230 (7164-0007)
MFN-232 60 cm above base of chalk (7164- 0008)
MFN-233 120 cm above base of chalk (7164-0009)
MFN-234 195 cm above base of chalk (7164-0010)
MFN-235 275 cm above base of chalk (7164-0011)

5. Quarry on One-Tree Hill, Gingin - about 90 metres SSW of radio masts.
Samples 7164-0001 -- 7164-0005 in Belford's Field Note 1971.
Sample MFN-225 base of chalk (7164-0001)
MFN-226 35 cm above base of chalk (7164-0002)
MFN-227 70 cm above base of chalk (7164-0003)
MFN-228 120 cm above base of chalk (7164-0004)
MFN-229 160 cm above base of chalk (7164-0005)

B. Subsurface Gingin Chalk

1. Agaton #19 borehole cores
(Lat. 30° 19' 00" S - Long. 115° 52' 14" E)
Seven samples from two cores are examined: Core 1 cut between 33.52 and 39.62 metres (110'-130'), and Core 2 between 60.95 and 67.05 metres (200'-220'). Samples were supplied by the Western Australian Department of Mines.
Sample MFN-2482 Core 1 - Bag 1, top of the core between 39.6 and 33.5 metres (110-130')
MFN-2483 Core 1 - Bag 3
MFN-2484 Core 1 - Bag 5
MFN-2485 Core 1 - bag 7
MFN-2486 Core 2 - Bag 1, top of the core between 60.9 and 67 metres (200-220')
MFN-2487 Core 2 - Bag 2
MFN-2488 Core 2 - Bag 4

2. Gingin Brook #4 borehole
(Lat. 31° 19' 15" S - Long. 115° 32' 47" E)
The Gingin Chalk is between 39.6 and 64.6 metres. Four samples taken from core 1 (61 - 64 metres), were supplied by the Western Australian Department of Mines.
Sample MFN-2668 from 61.56 metres (202') level
MFN-2669 from 61.87 metres (203') level
MFN-2670 from 62. 17 metres (204') level

3. Ginginup #1 corehole
(Lat. 31° 19' 00" S - Long. 115° 54' 15" E)
The Gingin Chalk is between 53.57- & 74.75-metre levels in this corehole.
Samples supplied by the Western Australian Department of Mines.
MFN-2489 bottom section of core above 55.5 metre core.
MFN-1256 at 55.5-metre level
MFN-4424 at 56 metre level
MFN-1257 at 57-metre level
MFN-1258 at 58-metre level
MFN-1259 at 59-metre level
MFN-4425 at 60-metre level
MFN-1260 at 62-metre level
MFN-1271 at 63-metre level
MFN-1272 at 64-metre level
MFN-1261 at 65-metre level
MFN-4426 at 66-metre level
MFN-4427 at 67-metre level
MFN-1262 at 68-metre level
MFN-4428 at 69-metre level
MFN-1263 at 70-metre level
MFN-1264 at 72-metre level
MFN-1265 at 73-metre level
MFN-1266 at 74-metre level
MFN-1267 at 74.75-metre level

C. Material from Lancelin Beds

1. Joondalup #25p, one core sample was provided by the Western Australian Department of Mines.
MFN-2159 at 45-metre level in Joondalup #25p

2. Lancelin #2B borehole (Lancelin Beds type section)
(Lat. 31° 04' 00" S - Long. 115° 19' 20" E)
Three samples were provided by the Western Australian Department of Mines.
MFN-1268 from (115'-120')
MFN-1269 from (125'-130')
MFN-1270 from (145'-150')

D. Breton Bay coreholes

(Lat. 31° 10' 36" S - Long. 115° 24' 06" E)
1. Breton Bay #1 corehole
Samples were supplied by the Department of Geology, University of Western Australia; numbers between brackets are those of the university. Samples MFN-2665 and MFN-2984 were identified as Gingin Chalk. Samples MFN-2985 (at 95-metre level) to MFN-3018 (at 34-metre level) were identified as Lancelin Beds. Samples MFN-3019 (at 32-metre level) to MFN-3023 (at 27.56-metre level) were identified as the type Breton Marl.
MFN-2665 at 100-metre level
MFN-2984 at 99-metre level (UWA 97793)
MFN-2985 at 95-metre level (UWA 97797)
MFN-2986 at 90-metre level (UWA 97802)
MFN-2987 at 87-metre level (UWA 97807)
MFN-2988 at 86-metre level (UWA 97808)
MFN-2664 at 85-metre level
MFN-2989 at 84-metre level (UWA 97809)
MFN-2990 at 82-metre level (UWA 97810)
MFN-2991 at 80-metre level (UWA 97812)
MFN-2992 at 78-metre level (UWA 97814)
MFN-2993 at 76-metre level (UWA 97816)
MFN-2994 at 72-metre level (UWA 97818)
MFN-2663 at 71-metre level
MFN-2995 at 68-metre level (UWA 97821)
MFN-2996 at 66-metre level (UWA 97823)
MFN-2997 at 64-metre level (UWA 97825)
MFN-2998 at 62 metre level (UWA 97827)
MFN-2662 at 61-metre level
MFN-2999 at 59-metre level (UWA 97830)
MFN-3000 at 57-metre level (UWA 97832)
MFN-3001 at 55-metre level (UWA 97834)
MFN-3002 at 53-metre level (UWA 97836)
MFN-2661 at 51-metre level
MFN-3003 at 50-metre level (UWA 97839)

MFN-3004 at 49-metre level (UWA 97840)
MFN-3005 at 48-metre level (UWA 97841)
MFN-3006 at 47-metre level (UWA 97842)
MFN-3007 at 46-metre level (UWA 97843)
MFN-3008 at 45-metre level (UWA 97844)
MFN-3009 at 44-metre level (UWA 97845)
MFN-3010 at 43-metre level (UWA 97846)
MFN-3011 at 42-metre level (UWA 97847)
MFN-3012 at 41-metre level (UWA 97848)
MFN-3013 at 40-metre level (UWA 97849)
MFN-2660 at 39-metre level
MFN-3014 at 38-metre level (UWA 97850)
MFN-3015 at 37-metre level (UWA 97851)
MFN-3016 at 36-metre level (UWA 97852)
MFN-3017 at 35.09-metre level (UWA 97853)
MFN-3018 at 34-metre level (UWA 97854)
MFN-3019 at 32-metre level (UWA 97855)
MFN-3020 at 30-metre level (UWA 97856)
MFN-3021 at 29.5-metre level (UWA 97857)
MFN-3022 at 28.56-metre level (UWA 97858)
MFN-3023 at 27.56-metre level (UWA 97859)

2. Breton Bay #5 corehole
Samples were supplied by the Department of Geology, University of Western Australia; numbers between brackets are those of the University of Western Australia.
Samples listed below were identified as Breton Marl.
MFN-3024 at 37-metre level (UWA 97860)
MFN-3025 at 36-metre level (UWA 97861)
MFN-2667 at 33-metre level
MFN-2666 at 32.7-metre level

II. OUTCROPS OF CARNARVON BASIN

A. Lower Murchison River and Shark Bay areas

1. Toolonga Point section; samples 7164-0067 -- 7164-0074 in Belford's Field Note, 1971.
Sample MFN-1902 Alinga Formation (7164-0067), 100 cm above contact with the underlying Thirindine Formation.
MFN-1903 Alinga Formation (7164-0068), 225 cm above base of formation
MFN-1904 Alinga Formation (7164-0069), 475 cm above base of formation
MFN-1905 uppermost Alinga Formation (7164-0070), 12.45 metres above base of formation.
MFN-1906 basal Toolonga Calcilutite (7164-0071), 170 cm above MFN-190.
MFN-1907 Toolonga Calcilutite (7164-0072), 160 cm above MFN-1906.

2. Alinga Point section; AP82- samples in Shafik's Field Note, 1982.
Sample MFN-2439 Alinga Formation (AP82-01), middle of the unit
MFN-2440 Alinga Formation (AP82-02), 240 cm above MFN-2439
MFN-2441 Alinga Formation (AP82-03), 430 cm above MFN-2439
MFN-2442 Alinga Formation (AP82-04), 495 cm above MFN-2439
MFN-2443 Alinga Formation (AP82-05), 565 cm above MFN-2439
MFN-2444 (AP82-06) nodule bed between the Alinga Formation and Toolonga Calcilutite, 570 cm above MFN-2439
MFN-2445 Toolonga Calcilutite (AP82-07), base of chalk unit
MFN-2446 Toolonga Calcilutite(AP82-08), 10 cm above base of the chalk unit (MFN-2445).
MFN-2447 Toolonga Calcilutite (AP82-09), 25 cm above base of the chalk unit (MFN-2445).
MFN-2448 Toolonga Calcilutite (AP82-10), 70 cm above base of the chalk unit (MFN-2445).
MFN-2449 Toolonga Calcilutite (AP82-11), 110 cm above base of the chalk unit (MFN-2445).
MFN-2450 Toolonga Calcilutite (AP82-112), 140 cm above base of the chalk unit (MFN-2445).
MFN-2451 Toolonga Calcilutite (AP82-13), 180 cm above base of the chalk unit (MFN-2445).
MFN-2452 Toolonga Calcilutite (AP82-14), 230 cm above base of the chalk unit (MFN-2445).
MFN-2453 Toolonga Calcilutite (AP82-15), 285 cm above base of the chalk unit (MFN-2445).
MFN-2454 Toolonga Calcilutite (AP82-16) 330 cm above base of the chalk unit (MFN-2445).
MFN-2455 Toolonga Calcilutite (AP82-17), 380 cm above base of the chalk unit (MFN-2445).
MFN-2456 Toolonga Calcilutite (AP82-18), 415 cm above base of the chalk unit (MFN-2445).
MFN-2457 Toolonga Calcilutite (AP82-19), 490 cm above base of the chalk unit (MFN-2445).
MFN-2458 Toolonga Calcilutite (AP82-20), 530 cm above base of the chalk unit (MFN-2445).
MFN-2459 Toolonga Calcilutite (AP82-21), 595 cm above base of the chalk unit (MFN-2445).
MFN-2460 Toolonga Calcilutite (AP82-22), 625 cm above base of the chalk unit (MFN-2445).
MFN-2461 Toolonga Calcilutite (AP82-23), 690 cm above base of the chalk unit (MFN-2445).
MFN-2462 Toolonga Calcilutite (AP82-24), 730 cm above base of the chalk unit (MFN-2445).
MFN-2463 Toolonga Calcilutite (AP82-25), 770 cm above base of the chalk unit (MFN-2445).
MFN-2464 Toolonga Calcilutite (AP82-26), 835 cm above base of the chalk unit (MFN-2445).
MFN-2465 Toolonga Calcilutite (AP82-27), 920 cm above base of the chalk unit (MFN-2445).
MFN-2466 Toolonga Calcilutite (AP82-28), 10.05 metres above base of the chalk unit (MFN-2445).
MFN-2467 Toolonga Calcilutite (AP82-29), 10.65 metres above base of the chalk unit (MFN-2445).
MFN-2468 Toolonga Calcilutite (AP82-30), 11.65 metres above base of the chalk unit (MFN-2445).
MFN-2469 Toolonga Calcilutite (AP82-31), 12.45 metres above base of the chalk unit (MFN-2445).
MFN-2470 Toolonga Calcilutite (AP82-32), 13.00 metres above base of the chalk unit (MFN-2445).
MFN-2471 Toolonga Calcilutite (AP82-33A), about 0.5 metres above the travertinised carbonates.

MFN-2472 Toolonga Calcilutite (AP82-33B), 13.40 metres above base of the chalk unit (MFN-2445).

MFN-2473 Travertine Tertiary carbonate (AP82-34), 290 cm above MFN-2472.

3. Toolonga Hills section; TP82- samples in Shafik's Field Note 1982.

Sample MFN-2548 Toolonga Calcilutite (TP82-01), base of outcrop

MFN-2549 Toolonga Calcilutite (TP82-02), base of chalk unit

MFN-2550 Toolonga Calcilutite (TP82-03), 20 cm above base of the chalk unit (MFN-2549).

MFN-2551 Toolonga Calcilutite (TP82-04), 30 cm above base of the chalk unit (MFN-2549).

MFN-2552 Toolonga Calcilutite (TP82-05), 40 cm above base of the chalk unit (MFN-2549).

MFN-2553 Toolonga Calcilutite (TP82-06), 70 cm above base of the chalk unit (MFN-2549).

MFN-2554 Toolonga Calcilutite (TP82-07), 110 cm above base of the chalk unit (MFN-2549).

MFN-2555 Toolonga Calcilutite (TP82-08), 150 cm above base of the chalk unit (MFN-2549).

MFN-2556 Toolonga Calcilutite (TP82-09), 190 cm above base of the chalk unit (MFN-2549).

MFN-2557 Toolonga Calcilutite (TP82-10), 235 cm above base of the chalk unit (MFN-2549).

MFN-2558 Toolonga Calcilutite (TP82-11), 275 cm above base of the chalk unit (MFN-2549), top of the chalk unit.

MFN-2559 Toolonga Calcilutite (TP82-12), 315 cm above base of the chalk unit (MFN-2549).

MFN-2560 Toolonga Calcilutite (TP82-13), 345 cm above base of the chalk unit (MFN-2549).

MFN-2561 Toolonga Calcilutite (TP82-14), 365 cm above base of the chalk unit (MFN-2549).

MFN-2562 Toolonga Calcilutite (TP82-15), 395 cm above base of the chalk unit (MFN-2549).

MFN-2563 Toolonga Calcilutite (TP82-16), 425 cm above base of the chalk unit (MFN-2549).

MFN-2564 Toolonga Calcilutite (TP82-17), 455 cm above base of the chalk unit (MFN-2549).

MFN-2565 Toolonga Calcilutite (TP82-18), 465 cm above base of the chalk unit (MFN-2549).

MFN-2566 Toolonga Calcilutite (TP82-19), 475 cm above base of the chalk unit (MFN-2549).

4. North face of Pillarawa Hill (Ajana Run 8/5076, DJB 7164 pt.1);

Samples 7164-0034 -- 7164-0049 in Belford's Field Note 1971.

Sample MFN-252 Alinga Formation (7164-0034), base of outcrop, barren of nannofossils.

MFN-253 Alinga Formation (7164-0035), 70 cm above MFN-252, and 50 cm below base of Toolonga Calcilutite.

MFN-254 Toolonga Calcilutite (7164-0036), 50 cm above its base.

MFN-255 Toolonga Calcilutite (7164-0037), 150 cm above base of the formation.

MFN-256 Toolonga Calcilutite (7164-0038), 250 cm above base of the formation.

MFN-257 Toolonga Calcilutite (7164-0039), 350 cm above base of the formation.

MFN-258 Toolonga Calcilutite (7164-0040), 450 cm above base of the formation.

MFN-259 Toolonga Calcilutite (7164-0041), 550 cm above base of the formation.

MFN-260 Toolonga Calcilutite (7164-0042), 650 cm above base of the formation.

MFN-261 Toolonga Calcilutite (7164-0043), 750 cm above base of the formation.

MFN-262 Toolonga Calcilutite (7164-0044), 850 cm above base of the formation.

MFN-263 Toolonga Calcilutite (7164-0045), 950 cm above base of the formation.

MFN-264 Toolonga Calcilutite (7164-0046), 10.45 m above base of the formation.

MFN-265 Toolonga Calcilutite (7164-0047), 11.75 m above base of the formation.

MFN-266 Toolonga Calcilutite (7164-0048), 12.75 m above base of the formation.

MFN-267 Toolonga Calcilutite (7164-0049), 14.55 m above base of the formation.

5. Yaringa North Station outcrop (Wooramel Run 15/50173, DJB pt.2;

Yaringa Run 1/5031, DJB pt.629); samples 7164-0075 -- 7164-0081 in Belford's Field Note 1971.

Sample MFN-268 Toolonga Calcilutite (7164-0075), base of outcrop

MFN-269 Toolonga Calcilutite (7164-0076), 130 cm above base of the outcrop (MFN-268).

MFN-270 Toolonga Calcilutite (7164-0077), 215 cm above base of the outcrop (MFN-268).

MFN-271 Toolonga Calcilutite (7164-0078), 275 cm above base of the outcrop (MFN-268).

MFN-272 Toolonga Calcilutite (7164-0079), 355 cm above base of the outcrop (MFN-268).

MFN-273 Toolonga Calcilutite (7164-0080), 445 cm above base of the outcrop (MFN-268).

MFN-274 Toolonga Calcilutite (7164-0081), 545 cm above base of the outcrop (MFN-268).

6. Northwestern Coastal Highway (western side) near Wooramel (Wooramel Run 15/5017, DJB pt. 1); samples 7164-0404 -- 7164-0411 in Belford's Field Note 1971.

Sample MFN-390 Toolonga Calcilutite (7164-0404), base of outcrop

MFN-391 Toolonga Calcilutite (7164-0405), base of outcrop

MFN-392 Toolonga Calcilutite (7164-0406), 80 cm above base of the outcrop (MFN-391).

MFN-393 Toolonga Calcilutite (7164-0407), 180 cm above base of the outcrop (MFN-391).

MFN-394 Toolonga Calcilutite (7164-0408), 280 cm above base of the outcrop (MFN-391).

MFN-395 Toolonga Calcilutite (7164-0409), 390 cm above base of the outcrop (MFN-391).

MFN-396 Toolonga Calcilutite (7164-0410), 510 cm above base of the outcrop (MFN-391).

MFN-397 Toolonga Calcilutite (7164-0411), 675 cm above base of the outcrop (MFN-391).

7. Hamelin Pool outcrop (Yanrey Run 6, DJB 5036, pt. 626);

samples 7164-00412 -- 7164-00418 in Belford's Filed Note 1971.

Sample MFN-398 Toolonga Calcilutite (7164-0412), base of outcrop

MFN-399 Toolonga Calcilutite (7164-0413), 40 cm above base of the outcrop (MFN-398).

MFN-400 Toolonga Calcilutite (7164-0414), 100 cm above base of the outcrop (MFN-398).

MFN-401 Toolonga Calcilutite (7164-0415), 200 cm above base of the outcrop (MFN-398).

MFN-402 Toolonga Calcilutite (7164-0416), 300 cm above base of the outcrop (MFN-398).

MFN-403 Toolonga Calcilutite (7164-0417), 400 cm above base of the outcrop (MFN-398).

MFN-404 Toolonga Calcilutite (7164-0418), 520 cm above base of the outcrop (MFN-398).

Above MFN-404: 100 cm of siliceous calcilutite below variable thicknesses of travertine Tertiary carbonates.

B. Giralia Anticline

1. C-Y Creek exposures (Yanrey Run 14, DJB 5086); samples 7164-0103 -- 7164-0155 in Belford's Field Note, 1971.

Sample MFN-292 Gearle Siltstone (7164-0103), Pt. 1, soft dark grey siltstone.

MFN-293 Gearle Siltstone (7164-0104), Pt.1, 70 cm above MFN-292.

MFN-294 Gearle Siltstone (7164-0105), Pt. 2, soft dark grey siltstone.

MFN-295 Gearle Siltstone (7164-0106), Pt. 3, soft dark grey siltstone.

MFN-296 Gearle Siltstone (7164-0107), Pt. 4, soft light grey silstone.

MFN-297 Gearle Siltstone (7164-0108), Pt. 5, soft weathered light grey siltstone.

MFN-298 Gearle Siltstone (7164-0109) Pt. 6, small outcrop weathered light grey siltstone.

MFN-299 Gearle Siltstone (7164-0110), Pt. 7, soft dark grey siltstone.

MFN-300 Gearle Siltstone (7164-0111), Pt. 8, soft dark grey siltstone.

MFN-301 Beedagong Claystone (7164-01120), Pt.8, 100 cm above MFN-300.

MFN-302 (7164-0113), Pt. 9, transitional between Beedagong Claystone and Toolonga Calcilutite: soft light brown calcilutite with some *Inoceramus* fragments and gypsum.

MFN-303 Toolonga Calcilutite (7164-0114), Pt. 9, 100 cm above MFN-302.

MFN-304 Toolonga Calcilutite (7164-0115), Pt. 10, soft green calcareous silt, 320 cm below base of Korojon Calcarenite.

MFN-305 Toolonga Calcilutite (7164-0116), Pt. 10, 60 cm above MFN-304.

MFN-306 Toolonga Calcilutite (7164-0117), Pt. 10, 160 cm above MFN-304.

MFN-307 Toolonga Calcilutite (7164-0118), Pt. 10, 260 cm above MFN-304.

MFN-308 (7164-0119) immediately below or base of nodule bed which is at at base Korojon Calcarenite, 150 metres NNE of locality of MFN-307.

MFN-309 (7164-0120) upper part of nodule bed at base of Korojon Calcarenite, same locality as MFN-308.

MFN-310 Korojon Calcarenite (7164-0121), Pt. 11, soft grey calcarenite, 250 cm above base of the formation.

MFN-311 Korojon Calcarenite (7164-0122), Pt. 11, hard light grey calcarenite, 70 cm above MFN-310.

MFN-312 Korojon Calcarenite (7164-0123), Pt. 11, hard light grey calcarenite, 130 cm above MFN-310.

MFN-313 Korojon Calcarenite (7164-0124), Pt. 11, hard light grey calcarenite, 175 cm above MFN-310.

MFN-319 Korojon Calcarenite (7164-0125), Pt. 11, hard grey to brown calcarenite, 260 cm above MFN-310.

MFN-320 Korojon Calcarenite (7164-0126), Pt. 11, friable cream calcarenite, 315 cm above MFN-310.

MFN-321 Korojon Calcarenite (7164-0127), Pt. 11, hard brittle calcarenite, 370 cm above MFN-310.

MFN-322 Korojon Calcarenite (7164-0128), Pt. 12, hard dark grey calcarenite with abundant *Inoceramus*.

MFN-323 Korojon Calcarenite (7164-0129), Pt. 12, 95 cm above MFN-317.

MFN-324 Korojon Calcarenite (7164-0130), Pt. 12, 185 cm above MFN-317.

MFN-325 Korojon Calcarenite (7164-0131), Pt. 12, 245 cm above MFN-317.

MFN-326 Korojon Calcarenite (7164-0132), Pt. 12, first nodule bed of Bull. 25, 335 cm above MFN-317.

MFN-327 Korojon Calcarenite (7164-0133), 150 metres N of MFN-326, 150 cm above first nodule bed, immediately below second nodule bed.

MFN-328 Korojon Calcarenite (7164-0134), same exposure as MFN-327, hard, brown calcarenite, 50 cm above MFN-327, immediately below third nodule bed.

MFN-329 Korojon Calcarenite (7164-0135), same exposure as MFN-327, brittle cream calcarenite with abundant *Inoceramus*, 125 cm above MFN-327, from base of 6' calcarenite interval above third nodule bed of BMR Bull. 25.

MFN-330 Korojon Calcarenite (7164-0136), same exposure as MFN-327, 275 cm above MFN-327.

MFN-331 Korojon Calcarenite (7164-0137), Pt. 14, hard band above *Inoceramus* coquinite.

MFN-332 Korojon Calcarenite (7164-0138), Pt. 14, 420 cm above MFN-331.

MFN-333 Korojon Calcarenite (7164-0139), Pt. 14, 480 cm above MFN-331.

MFN-334 Korojon Calcarenite (7164-0140), Pt. 14, 580 cm above MFN-331.

MFN-345 Korojon Calcarenite (7164-0141), Pt. 14, from a 45-cm-thick dark band with abundant *Inoceramus*, 630 cm above MFN-331.

MFN-346 Korojon Calcarenite (7164-0142), Pt. 14, 730 cm above MFN-331.

MFN-347 Korojon Calcarenite (7164-0143), Pt. 14, 830 cm above MFN-331.

MFN-348 Korojon Calcarenite (7164-0144), Pt. 14, 890 cm above MFN-331, immediately below hard band.

MFN-349 Korojon Calcarenite (7164-0145), Pt. 15, hard dark grey calcarenite with nodules, from base of exposure at Pt. 15.

MFN-350 Korojon Calcarenite (7164-0146), Pt. 15, grey calcarenite, 100 cm above MFN-339.

MFN-351 Korojon Calcarenite (7164-0147), hard light grey calcarenite with abundant *Inoceramus*, 200 cm above MFN-339.

MFN-352 Korojon calcarenite (7164-0148), Pt. 15, hard dark grey calcarenite, immediately below band with abundant *Inoceramus*, 290 cm above MFN-339.

MFN-353 Korojon Calcarenite (7164-149), Pt. 15, light grey brittle calcarenite, 390 cm above MFN-339.

MFN-354 Korojon Calcarenite (7164-0150), Pt. 15, hard brittle pale grey calcarenite with abundant *Inoceramus*, 475 cm above MFN-339.

MFN-355 Korojon Calcarenite (7164-0151), Pt. 16, 200 cm below top of formation.

MFN-356 Korojon Calcarenite (7164-0152), 100 above MFN-340.

MFN-357 Miria Marl (7164-0153), immediately above nodule bed.

MFN-358 Miria Marl (7164-0154), 30 cm above MFN-357.

MFN-359 Miria Marl (7164-0155), 50 cm above MFN-357, immediately below Boongerooda Greensand.

2. Excavation east of No. 10 Bore

Several samples were collected from the wall surrounding a dam, about 9 kilometres east of No. 10 Bore. The samples were dug from the outside of the wall (MFN-2688 - MFN-2689) as well as from the inside of the wall. Only three samples are considered *in situ*.

MFN-2688 Gearle Siltstone (DW83-1), dark grey siltstone, dug from the base of the wall.

MFN-2689 Beedagong Claystone (DW83-2), light greyish green claystone, a few centimetres above MFN-2688.

MFN-2690 Beedagong Claystone/Toolonga Calcilutite (DW83-2), from the inside of the wall, slightly above MFN-2689.

3. Maastrichtian material (uppermost Korojon and Miria)

i. Toothawarra Creek TWB section; samples TWB-1 -- TWB-13 in Shafik's Field Note, 1982.

Samples MFN-2313 & MFN-2314 (TWB-1 & TWB-2) are from the topmost Korojon at 30 & 20 cm levels below base of nodule bed which separates the Korojon and Miria.

Sample MFN-2315 (TWB-3) is from the nodule bed. The thickness of the nodule bed is estimated to be 18 cm in this section.

Samples MFN-2316 to MFN-2323 are from the type Miria Marl:

MFN-2316 (TWB-4) Immediately above the nodule bed
MFN-2317 (TWB-5) 10 cm above nodule bed
MFN-2318 (TWB-6) 20 cm above nodule bed
MFN-2319 (TWB-7) 30 cm above nodule bed
MFN-2320 (TWB-8) 40 cm above nodule bed
MFN-2321 (TWB-9) 50 cm above nodule bed
MFN-2322 (TWB-10) 65 cm above nodule bed
MFN-2323 (TWB-11) 77 cm above nodule bed
MFN-2324 (TWB-12) 87 cm above nodule bed
MFN-2325 (TWB-13) from the topmost Miria, 92 cm above nodule bed.
MFN-2326 (TWB-14) from the base of the Boongerooda Greensand, with Paleocene calcareous nannofossils.

ii. Toothawarra Creek TOB-83 section; samples TOB83-1 -- TOBC-83-4 in Shafik's Field Note 1983.

This section is very close to the TWB section. Erosion greatly reduced the Paleocene Boongerooda Greensand in this section. The TWB section is the type section of both the Miria Marl and the Boongerooda Greensand.

Samples MFN-2638 to MFN-2643 are from the top part of the Korojon Calcarenite:

MFN-2638 (TOB83-1) 145 cm below base of nodule bed separating the Korojon Calcarenite from Miria marl.
MFN-2639 (TOB83-2) 65 cm below base of nodule bed
MFN-2640 (TOB83-3) 25 cm below base of nodule bed
MFN-2641 (TOB83-4) 15 cm below base of nodule bed
MFN-2642 (TOB83-5) 7 cm below base of nodule bed
MFN-2643 (TOB83-6) immediately below nodule bed.

Samples MFN-2644 & MFN-2645 are from the nodule bed: MFN-2644 (TOB83-7) near base of bed and MFN-2645 (TOB83-8) is 16 cm higher. Sample MFN-2646 (TOB83-9) is from top part of the nodule bed and the basal part of the overlying marl. The nodule bed is estimated to be 30 cm thick in this section.

Samples MFN-2647 to MFN-2652 from the Miria Marl:

MFN-2647 (TOB83-10) 5 cm above top of nodule bed
MFN-2648 (TOB83-11) 15 cm above top of nodule bed
MFN-2649 (TOB83-12) 25 cm above top of nodule bed
MFN-2650 (TOB83-13) 45 cm above top of nodule bed
MFN-2651 (TOB83-14) 75 cm above top of nodule bed
MFN-2652 (TOB83-15) from very top of the Miria Marl, immediately above MFN-2651.

The contact Miria Marl/Boongerooda Greensand was carefully sampled at this section. Also the reworked Miria Marl at the base of the greensand was successfully sampled; samples TOBC83-1 -- TOBC83-4.

MFN-2653 (TOBC83-1) from topmost Miria Marl
MFN-2654 (TOBC83-2) immediately above MFN-2653, also Miria Marl
MFN-2655 (TOBC83-3) reworked Miria Marl, from within the base of the Boongerooda Greensand.
MFN-2656 (TOBC83-4) from the base of the Boongerooda Greensand, with Paleocene nannofossils: *Chiasmolithus bidens, Cruciplacolithus tenuis, Toweius eminens*..etc.

iii. C-Y Creek section (CY-83-MGS section), the type section of the Korojon Calcarenite; samples CY83MGS-1 -- CY83MGS-15 in Shafik's Field Note, 1983.

Samples MFN-2671 to MFN-2676 are from the top part of the type Korojon Calcarenite:

MFN-2671 (CY83MGS-1) 300 cm below the base of the nodule bed separating the Korojon from the Miria.
MFN-2672 (CY83MGS-2) 250 cm below base of the nodule bed
MFN-2673 (CY83MGS-3) 200 cm below base of nodule bed
MFN-2674 (CY83MGS-4) 140 cm below base of nodule bed
MFN-2675 (CY83MGS-5) 80 cm below base of nodule bed
MFN-2676 (CY83MGS-6) 30 cm below base of nodule bed

Sample MFN-2677 (CY83MGS-7) is from either the very top of the Korojon Calcarenite or the base of the nodule bed.

Sample MFN-2678 (CY83MGS-8) is from either the top of the nodule bed orthe very base of the Miria Marl.

Samples MFN-2679 to MFN-2683 are from the Miria Marl:

MFN-2679 (CY83MGS-9) 10 cm above nodule bed

MFN-2680 (CY83MGS-10) 20 cm above nodule bed

MFN-2681 (CY83MGS-11) immediately below a band of byrite crystals, 30 cm above nodule bed

MFN-2682 (CY83MGS-12) 40 cm above nodule bed

MFN-2683 (CY83MGS-13) separated from MFN-2682 (CY83MGS-14) by a 10-cm thick band of byrite crystals.

MFN-2684 (CY83MGS-14) Miria Marl from the very base of the Boongerooda Greensand, 5 cm above MFN-2683

MFN-2685 (CY83MGS-15) Miria Marl at the base of the Boongerooda Greensand, immediately above MFN-2684.

iv. Toothawarra Creek TOA-83 section; samples TOA83-1 -- TOA83-11 in Shafik's Field Note 1983. This section is immediately to the west of TWB section, being very close.

Sample MFN-2605 is from the the top part of the Korojon Calcarenite, 10 cm below the nodule bed at the base of the Miria Marl.

Sample 2606 (TOA83-2) is from the top part of the nodule bed at the base of the Miria Marl, with *Inoceramus* being partly replaced by iron oxides.

MFN-2607 (TOA83-3) Miria Marl 20 cm above MFN-2606, with heavily stained *Inoceramus*.

MFN-2608 (TOA83-4) Miria Marl, 20 cm above MFN-2607.

MFN-2609 (TOA83-5) Miria Marl, 20 cm above MFN-2608.

MFN-2610 (TOA83-6) Miria Marl, 20 cm above MFN-2609, with abundant pelecypods.

MFN-2611 (TOA83-7) Miria Marl, 20 cm above MFN-2610.

MFN-2612 (TOA83-8) Miria Marl, 20 cm above MFN-2611.

MFN-2613 (TOA83-9) Miria Marl, immediately above MFN-2612, and slightly below a thin conglomerate bed at the base of the Boongerooda Greensand.

MFN-2614 (TOB83-11)) from the conglomerate bed at the base of the Boongerooda Greensand; the conglomerate bed is 10 cm in thickness.

MFN-2615 (TOA83-11) Boongerooda Greensand, from the base, with Paleocene calcareous nannofossils.

v. Miria Marl type section (7164-0160 - 7164-0164) in Belford's Field Note 1971 (Toothawarra Creek).

Sample MFN-4441 (7164-0160) from the topmost part of the Korojon Calcarenite or the base of the Miria Marl, with nodules and *Inoceramus*.

MFN-4442 (7164-0161) basal Miria Marl, with nodules and fragments of *Inoceramus*.

MFN-4443 (7164-0162) Miria Marl, 30 cm above MFN-4442.

MFN-4444 (7164-0163) Miria Marl, 40 cm above MFN-4443, immediately below the Boongerooda Greensand.

MFN-4445 (7164-0164) probably Miria Marl, immediately above a nodule bed.

MFN-4446 (7164-0165) basal Boogerooda Greensand.

III. SUBSURFACE OF CARNARVON BASIN

1. WAPET Rough Range South #1

(Lat. 22° 37, 19. 5" S - Long. 113° 57' 37.6" E)

Cores 50, 63 and 55 are from the Korojon Calcarenite. Cores 65, 58 and 59 are from the Toolonga Calcilutite. Cores 61 to 69 inclusive are from the type Beedagong Claystone. Cores 70 and 71 are from the Gearle Silstone.

MFN-1986 core 50 between 682.7 and 684.2 metres (2240-2245')

MFN-1987 core 53 between 710.1 and 711.7 metres (2330-2335')

MFN-278 core 55 between 719.9 and 722.9 metres (2362-2372')

MFN-279 core 56 between 728.4 and 729.3 metres (2390-2393')

MFN-1988 core 58 between 740.3 and 742.2 metres (2429-2435')

MFN-1989 core 59 between 742.2 and 745.8 metres (2435-2447')

MFN-1990 core 61 between 762.0 and 763.5 metres (2500-2505')

MFN-1979 core 62 between 763.5 and 765.3 metres (2505-2511')

MFN-4429 core 63 between 765.3 and 765.6 metres (2511-2514')

MFN-1236 core 64 between 792.4 and 794.3 metres (2600-2606')

MFN-4430 core 65 between 802.2 and 804.1 metres (2632-2638')

MFN-1980 core 66 between 810.7 and 812.2 metres (2660-2665')

MFN-1981 core 67 between 819.3 and 821.7 metres (2688-2696')

MFN-1982 core 68 between 828.1 and 830.5 metres (2717-2725')

MFN-1983 core 69 between 837.5 and 840.6 metres (2748-2758')

MFN-1984 core 70 between 838.2 and 841.8 metres (2750-2762')

MFN-1985 core 71 between 871.7 and 873.8 metres (2860-2867')

2 .WAPET Dirk Hartog wells

(Lat. 25° 51' 58" S - Long. 113° 04' 40.5" E)

i. Dirk Hartog #17B

MFN-415 core 1 between 533.4 and 539.5 metres (1750-1770')

MFN-416 core 2 between 563.9 and 569.3 metres (1850-1868')

MFN-417 core 3 between 600.4 and 605.9 metres (1970-1988')

MFN-418 core 4 between 640.0 and 643.1 metres (2100-2110')

MFN-419 core 5 between 651.0 and 657.1 metres (2136-2156')

MFN-420 core 6 between 664.4 and 669.9 metres (2180-2198')

ii. Dirk Hartog #4

MFN-411 core 1 between 304.8 and 306.9 metres (1000-1007')

MFN-412 core 2 between 342.3 and 345.3 metres (1123-1133')

MFN-413 core 3 between 424.6 and 427.0 metres (1393-1401')

MFN-414 cores 4 & 5 between 454.1 and 457.2 metres (1490-1500')

iii. Dirk Hartog #1

MFN-405 core 13 between 167.9 and 168.8 metres (551-554')

MFN-406 core 14 between 213.3 and 216.4 metres (700-710')

MFN-407 core 15 between 243.8 and 246.9 metres (800-810')

MFN-408 core 16 between 274.3 and 277.3 metres (900-910')

MFN-409 core 17 between 304.8 and 307.8 metres (1000-1010')

MFN-4010 core 18 between 335.3 and 338.3 metres (1100-1110')

3. WAPET Cape Cuvier #1 well

MFN-1211 core 2 between 92.3 and 94.2 metres (303-309') barren of coccoliths.

MFN-1212 core 4 between 120.4 and 121.9 metres (395-400') barren of coccoliths.

MFN-1213 core 5 between 121.9 anf 125 metres (400-410')

MFN-1214 core 6 between 155.4 and 158.5 metres (510-520')

MFN-1215 core 7 between 195.1 and 198.1 metres (640-650')

MFN-1216 core 8 between 256.0 and 259.1 metres (840-850')

MFN-1217 core 9 between 335.3 and 338.3 metres (1100-1110')

4. Giralia (BMR) #5

Samples MFN-512 to MFN-515 are Korojon Calcarenite, samples MFN-516 to MFN-518 are Toolonga Calcilutite, samples MFN-519 to MFN-521 are Beegagong Claystone, and MFN-522 to MFN-526 are Gearle Siltsone and probably older unit.

MFN-512 core 1 between 30.5 and 30.7 metres (100'-100' 1")

MFN-513 core 1 between 31.2 and 31.5 metres (102' 6"-103' 4")

MFN-514 core 1 between 32.0 and 32.2 metres (105'-105' 10")

MFN-515 core 1 between 32.8 and 33.0 metres (107' 6"-108' 4")

MFN-516 core 2 between 58.8 and 58.9 metres (193'-193' 10")

MFN-517 core 2 between 60.2 and 60.3 metres (197' 2"-198')

MFN-518 core 2 between 61.6 and 61.9 metres (202' 2"-203')

MFN-519 core 3 between 89.9 and 90.1 metres (295'-295' 10")

MFN-520 core 3 between 90.0 and 91.1 metres (295' 4"-299' 2")

MFN-521 core 3 between 92.2 and 92.4 metres (302' 6"-303' 4")

MFN-522 core 4 between 121.0 and 121.4 metres (397'-398' 4")

MFN-523 core 4 between 123.0 and 123.4 metres (403' 8"-405')

MFN-524 core 4 between 153.3 and 153.6 metres (503'-504')

MFN-525 core 5 between 154.1 and 154.3 metres (505' 6"-506' 3")

MFN-526 core 5 between 152.4 and 152.7 metres (500'-501')

5. Other WAPET Rough Range wells

MFN-4431: Rough Range #8 core 1 between 466.3 and 471.8 metres (1530-1548')

MFN-275: Rough Range #4 core 1 at 420.6 metres (1380')

MFN-276: Rough Range #4 core 1 between 420.6 and 423 metres (1380-1388')

6. WAPET Hope Island #1 well

(Lat. 27° 09' 34" S - Long. 114° 28' 35" E)

MFN-151 sidewall core 1 at 289.5 metres (950')

MFN-152 sidewall core 2 at 304.8 metres (1000')

MFN-153 sidewall core 3 at 320 metres (1050')

MFN-154 sidewall core 4 at 335.2 metres (1100')

MFN-155 sidewall core 5 at 350.5 metres (1150')

MFN-156 sidewall core 6 at 365.7 metres (1200')

MFN-157 sidewall core 7 at 381 metres (1250')

MFN-158 sidewall core 8 at 396.2 metres (1300')

MFN-159 sidewall core 9 at 411.5 metres (1350')

MFN-160 sidewall core 10 at 426.7 metres (1400')

MFN-161 sidewall core 11 at 442 metres (1450')

MFN-162 sidewall core 13 at 472.4 metres (1550')

7. WAPET Paterson #1 well

MFN-142 sidewall core at 591.3 metres (1940')

MFN-143 sidewall core at 597.4 metres (1960')

MFN-144 sidewall core at 600.4 metres (1970')

MFN-145 sidewall core at 1234.4 metres (4050')

8. WAPET Tortoise #1 well

(Lat. 21° 35' 08" S - Long. 114° 51' 11" E)

MFN-89 sidewall core 1 at 204.2 metres (670')

MFN-90 sidewall core 2 at 222.5 metres (730')

MFN-91 sidewall core 3 at 233.2 metres (765')

MFN-92 sidewall core 4 at 246.8 metres (810')

MFN-93 sidewall core 5 at 257.5 metres (845')

MFN-94 sidewall core 6 at 281.9 metres (925')

MFN-95 sidewall core 7 at 304.8 metres (1000')

MFN-96 sidewall core 8 at 344.4 metres (1130')

9. Pasco #1 well

MFN-87 sidewall core 11 at 288.9 metres (948')

MFN-88 sidewall core 12 at 303.5 metres (996')

10. WAPET Trimouille #1 well

MFN-126 core 3 between 1130.8 and 1134.2 metres (3710-3721')

IV. OFFSHORE AUSTRALIAN NORTHWEST

1. Woodside Offshore Petroleum Delambre #1

MFN-2241 at 2070 metres

MFN-2242 at 2072 metres

MFN-2243 at 2080 metres

MFN-2244 at 2085 metres

MFN-2245 at 2090 metres

MFN-2246 at 2095.5 metres

MFN-2247 at 2104 metres

MFN-2248 at 2108.5 metres

MFN-2249 at 2113.5 metres

MFN-2250 at 2120 metres

MFN-2251 at 2136 metres

MFN-2252 at 2144 metres

MFN-2253 at 2150 metres

V. AREAS SURROUNDING AUSTRALIA

1. Naturaliste Plateau, DSDP site 264

MFN-4447 core 264-11-1, 147-150 cm

MFN-4448 core 264-11-2, 17-20 cm

See *Initial Reports of the Deep Sea Drilling Project* vol. 28; Hayes, Frakes & others, 1975.

2. Papua New Guinea (Papuan Basin)

i. Lai (Gai) River area

Sample examined from this area are washed residues after their foraminiferids have been picked.

MFN-3061 sample 20NG 1591 *in* Owen (1973, Waia Creek, SW Lingnanas.

MFN-3062 sample 20NG 1592 *in* Owen (1973, Waia Creek, SW Lingnanas.

MFN-3063 sample 20NG 1594 *in* Owen (1973, Waia Creek, SW Lingnanas.

MFN-3064 sample 20NG 1596 *in* Owen (1973, Waia Creek, SW Lingnanas.

MFN-3065 sample 20NG 1600 *in* Owen (1973, Waia Creek, SW Lingnanas.

MFN-3079 sample 20NG 1593 *in* Owen (1973, Waia Creek, SW Lingnanas.

ii. Wabag area

Samples examined from this area are washed residues after their have been picked.

MFN-3070 sample F287 collected by F.E. Dekker (1963), the Lagaip River, Wabag area, Western Highlands; see Owen (1973)

MFN-3071 sample F202 collected by F.E. Dekker (1963), the Lagaip River, Wabag area, Western Highlands; see Owen (1973)

MFN-3072 sample F229 collected by F.E. Dekker (1963), the Lagaip River, Wabag area, Western Highlands; see Owen (1973)

MFN-3073 sample F473 collected by F.E. Dekker (1963), the Lagaip River, Wabag area, Western Highlands; see Owen (1973)

MFN-3074 sample F187 collected by F.E. Dekker (1963), the Lagaip River, Wabag area, Western Highlands; see Owen (1973)

MFN-3075 sample F160 collected by F.E. Dekker (1963), the Lagaip River, Wabag area, Western Highlands; see Owen (1973)

MFN-3076 sample F418 collected by F.E. Dekker (1963), the Lagaip River, Wabag area, Western Highlands; see Owen (1973)

MFN-3077 sample F225 collected by F.E. Dekker (1963), the Lagaip River, Wabag area, Western Highlands; see Owen (1973)

MFN-3078 sample F1019 collected by F.E. Dekker (1963), the Lagaip River, Wabag area, Western Highlands; see Owen (1973)

iii. Mendi area

MFN-3941A sample KRC-2 *in* Campbell & Herrara (1968)
MFN-3941B sample KRC-3 *in* Campbell & Herrara (1968)
MFN-3942 sample KRC-4 *in* Campbell & Herrara (1968)
MFN-3943 sample KRC-6 *in* Campbell & Herrara (1968)
MFN-3944 sample KRC-7 *in* Campbell & Herrara (1968)
MFN-3945 sample KRC-22 *in* Campbell & Herrara (1968)

3. Ontong Java Plateau

See *Initial Reports of the Deep Sea Drilling Project* vol.30; Andrews, Packham & others, 1975.

i. DSDP site 288

MFN-3037A core 288A-9-1, 21-22 cm
MFN-3037B core 288A-9-1, 62-63 cm
MFN-3038 core 288A-9-1, 130-131 cm
MFN-3039A core 288A-9-2, 30-31 cm
MFN-3039B core 288A-9-2, 80-81 cm
MFN-3040 core 288A-9-2, 130-131 cm
MFN-3041A core 288A-9-3, 30-31 cm
MFN-3041 core 288A-9-3, 30-31 cm
MFN-3042 core 288A-9-3, 120-121 cm
MFN-3043A core 288A-9-4, 30-31 cm
MFN-3043B core 288A-9-4, 80-81 cm
MFN-3044 core 288A-9-4, 120-121 cm
MFN-3045A core 288A-9-5, 30-31 cm
MFN-3045B core 288A-9-5, 80-81 cm
MFN-3046 core 288A-9-5, 120-121 cm
MFN-3047 core 288A-9-6, 30-31 cm
MFN-3048A core 288A-9-6, 120-121 cm
MFN-3048B core 288A-9-6, core catcher
MFN-4432 core 288A-10-1, 58-59 cm
MFN-4433 core 288A-10-1, 111-113 cm
MFN-4434 core 288A-10-2, 120-121 cm
MFN-4435 core 288A-10-3, 85-87 cm
MFN-4436 core 288A-10-3, core catcher
MFN-4437A core 288A-11-1, 89-90 cm
MFN-4437B core 288A-11-1, 116-119 cm
MFN-4438 core 288A-11-2, 29-30 cm

ii. DSDP site 289

MFN-3049 core 289-122-1, top
MFN-3050 core 289-122-1, 117-118 cm
MFN-3051 core 289-122-1, 148-150 cm
MFN-3052 core 289-122-1, bottom
MFN-3053 core 289-122-2, 138-140 cm
MFN-3054A core-289 123, top
MFN-3054B core-289 123, bottom
MFN-3056 core 289-124-1, 124-125 cm
MFN-3055 core 289-124-2, 148-149 cm
MFN-3057 core 289-125-1, 96-97 cm
MFN-3058 core 289-126-1, bottom
MFN-3059 core 289-127-1, 131-132 cm
MFN-4439 core 289-128-1, 119-120 cm
MFN-4440 core 289-129-1, 119-120 cm

4. Ninetyeast Ridge, DSDP sites 216 & 217

MFN-4449 core 216-24, core catcher
MFN-4450 core 217-20, core catcher

See *Initial Reports of the Deep sea Drilling Project* vol. 22; von der Boch, Sclater & others, 1974.

5. Kerguelen Plateau

MFN-3594 core sample Kerguelen 86-12c (86701), at Lat. 57 03.76S - Long. 81 12.8E. Water Depth 3850 metres.

6. New Zealand, Pukehou area

Pukehou section in the southern part of North Island; see Edwards (1971) for location.

APPEBNDIX B: CHECKLISTS OF NANNOFOSSIL DISTRIBUTION IN SEQUENCES EXAMINED.

Checklist 1. Nannofossil distribution in the McIntyre Gully outcrops, Perth Basin.

	ACTINOZYGUS REGULARIS	ACUTURRIS SCOTUS	AHMUELLERELLA OCTORADIATA	AMPHIZYGUS BROOKSII BROOKSII	AMPHIZYGUS TESSELATUS	ANGULOFENESTRELLITHUS SNYDERI	ARKHANGELSKIELLA SPECILLATA	AXOPODORHABDUS DIETZMANNI	BIDISCUS CRUCIATUS	BIDISCUS MONOCAVUS	BIDISCUS SPP.	BISCUTUM BUKRYI BUKRYI	BISCUTUM CORONUM	BISCUTUM MELANIAE	BISCUTUM NOTICULUM	BOLETUVELUM CANDENS	BRAARUDOSPHAERA BIGELOWII	BROINSONIA AFF. PARCA	BROINSONIA BUKRYI	BROINSONIA CF. EXPANSA	BROINSONIA DENTATA	BROINSONIA EXPANSA	BROINSONIA HANDFIELDI	BROINSONIA PARCA	BROINSONIA PSEUDOPARCA	CALCULITES OBSCURUS	CALCULITES OVALIS	CHIASTOZYGUS AMPHIPONS	CHIASTOZYGUS FESSUS	CHIASTOZYGUS GARRISONII	CHIASTOZYGUS LITTERARIUS	CLINOZYGUS SYNQUADRIPERFORATUS	COROLLITHION EXIGUUM
MFN-2208	.	X	X	.	.	.	X	.	.	.	X	.	X	.	.	.	.	.	.	.	X	.	.	X	.	X	X	.	.	.	X	.	.
MFN-2207	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.	.	.	X	.	X	.	.
MFN-2206	.	.	X	.	.	.	.	.	.	.	X	X	.	.	.	.	.	X	.	.	.	X	.	.	.	.	X	.	.	.	X	.	X
MFN-2205	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-2204	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	X
MFN-2203	.	X	X	.	.	?	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.
MFJN-2202	.	X	X	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	.	X	X	X	.	.	X	.	.	X	X	.	X	.	.
MFN-2201	.	X	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	X	X	.	.	X	.	.	X	X	.	X	.	.
MFN-2200	.	.	X	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	X	X	.	.	X	.	X	X	X	.	X	.	.
MFN-2199	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	X	.	.	.	X	.	.	.	.
MFN-2198	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	X	.	X	.	X	.	X	.	.
MFN-2197	.	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	X	.	X	.	X	.	X	.	.
MFN-2196	.	X	X	.	.	.	X	.	.	.	.	?	.	X	.	.	.	.	X	.	X	X	.	.	.	.	X	.	X	.	X	.	.
MFN-2195	.	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	X	X	X	.	X	.	.
MFN-2194	.	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	.	.
MFN-2193	.	X	X	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	X	.	.	X	.	X	.	X	.	.	.	X
MFN-2192	.	X	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	X	X	.	.	X	.	X	.	X	.	X	.	.
MFN-2191	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	X	.	X	.	.
MFN-2190	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	X	X	X	.	X	.	X	.	.
MFN-2189	.	X	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	X	.	.	X	.	.	X	X	X	.	.	.	.	.	.
MFN-2188	X	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	X	X	.	X	.	X	.	.
MFN-2187	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	X	X	X	.	X	.	.	.	.
MFN-2186	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	X	.	X
MFN-2185	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.
MFN-2184	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2183	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.
MFN-2182	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.
MFN-2181	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	X	.	.	.	X	.	X
MFN-2180	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	X	X	.	.	.	.	X	.	.
MFN-2179	.	X	X	X	.	.	X	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	X	X	X	.	.	.	X	.	.
MFN-2178	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.
MFN-2177	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2176	.	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	X	.	X	.	X	.	.
MFN-2175	.	X	X	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	X	.	X	.	.
MFN-2174	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	X	.	X	.	X	.	.
MFN-2173	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	X	.	.
MFN-2172	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2171	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	X	X	.	.	.	.	X	.	X	X	X	.	.
MFN-2170	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	X	.	X	.	X	.	X	.	X
MFN-2169	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
MFN-2168	.	X	X	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X	.	X	.	X	.	X	.	X
MFN-2167	.	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	X	.	X	.	.
MFN-2166	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.
MFN-2165	.	X	X	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	X	X	.	X	.	.	.	.	?	.	X	.	.	.	.
MFN-2164	.	X	X	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	X	.	.	.	X	.	X	.	.
MFN-2163	X	X	X	.	X	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	X	?	X	.	X	.	X	X	.

Checklist 1 (continued)

	COROLLITHION RHOMBICUM RHOMBICUM	COROLLITHION SIGNUM	CRETARHABDUS CONICUS	CRETARHABDUS SURRIRELLUS	CRIBROSPHAERELLA CIRCULA	CRIBROSPHAERELLA EHRENBERGII	CYLINDRALITHUS BIARCUS	CYLINDRALITHUS NUDUS	CYLINDRALITHUS SERRATUS	EIFFELLITHUS AFF. EXIMIUS	EIFFELLITHUS CF. PLANUS	EIFFELLITHUS EXIMIUS	EIFFELLITHUS TRABECULATUS	EIFFELLITHUS TURRISEIFFELI	EPROLITHUS FLORALIS	GARTNERAGO OBLIQUUM	GEPHYRORHABDUS CORONADVENTUS	GRANTARHABDUS CAMARUTUS	GRANTARHABDUS PUNCTATUS	HAQIUS CIRCUMRADIATUS	HELICOLITHUS ANCEPS	HETERORHABDUS SINUOSUS	KAMPTNERIUS MAGNIFICUS	LAPIDEACASSIS CF. MARIAE	LAPIDEACASSIS CORNUTA	LAPIDEACASSIS SPP.	LAPIDEACASSIS UNCINATA	LITHASTRINUS GRILLI	LITHRAPHIDITES CARNIOLENSIS	LITHRAPHIDITES PRAEQUADRATUS	LOXOLITHUS ARMILLA	LUCIANORHABDUS CAYEUXII	LUCIANORHABDUS CF. INFLATA
MFN-2208	.	.	X	.	.	X	X	.	.	.	.	X	.	X	.	X	.	X	.	.	.	.	X	.	.	.	.	.	X	X	.	X	.
MFN-2207	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	X	.	X	.	.	X	X	X	.	.	.	.	.	.	X	.	.	.
MFN-2206	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.
MFN-2205	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	X	.
MFN-2204	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	X	.	.	.	X	X	.	.	X	.	.	X	.	.	.	.
MFN-2203	.	.	.	X	.	.	.	.	.	.	.	X	X	.	.	X	.	X	.	.	.	.	X	.	X	X	.	.	.	.	.	X	.
MFN-2202	.	.	X	X	.	.	.	.	.	.	.	X	.	X	.	X	X	.	.	.	.	.	X	.	.	.	.	.	X	.	.	X	.
MFN-2201	.	.	.	.	.	X	X	.	X	.	.	.	.	X	.	X	X	.	.	.	.	X	X	.	.	.	.	.	.	.	.	X	.
MFN-2200	.	X	X	.	.	X	.	.	.	.	.	X	.	X	.	X	.	.	X	.	.	.	X	.	.	.	.	.	X	.	.	X	.
MFN-2199	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.
MFN-2198	X	.	X	.	.	X	.	.	.	.	.	X	.	X	.	X	.	X	.	.	.	X	X	.	.	.	.	X	.	.	.	X	.
MFN-2197	.	.	.	X	.	X	.	.	.	.	.	X	.	X	.	X	X	X	.	.	.	X	X	.	.	.	.	.	.	.	.	X	.
MFN-2196	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	X	X	.	.	.	.	X	X	.	.	X	.
MFN-2195	.	.	.	X	.	X	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.
MFN-2194	.	.	X	.	.	X	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	X	.
MFN-2193	.	.	.	.	.	X	.	X	.	.	.	X	.	X	.	X	.	X	.	.	.	X	X	.	.	.	.	.	X	.	.	X	.
MFN-2192	.	.	.	X	.	X	X	.	X	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.
MFN-2191	.	.	X	.	.	X	.	.	X	.	.	X	.	X	.	X	X	X	.	.	.	X	X	.	.	.	.	.	X	.	X	X	.
MFN-2190	.	.	X	.	.	X	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	X	X	.	.	.	.	.	X	.	.	X	.
MFN-2189	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	.	.	X	.	.	.	X	X	.	.	.	.	.	X	.	.	X	.
MFN-2188	.	.	X	.	.	X	.	X	X	.	.	X	.	X	.	X	.	.	.	.	.	X	X	.	.	.	.	.	.	.	X	X	.
MFN-2187	.	X	.	X	.	X	X	.	.	X	.	X	.	X	.	X	X	X	.	.	.	.	X	.	.	.	.	.	X	.	.	X	.
MFN-2186	.	X	.	X	.	.	.	.	.	.	.	X	.	X	.	X	.	X	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.
MFN-2185	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.
MFN-2184	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.
MFN-2183	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.
MFN-2182	.	.	.	X	.	X	.	.	.	.	.	X	X	X	.	X	.	.	.	.	.	X	X	.	.	.	.	.	X	.	.	X	.
MFN-2181	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	X	X	.	.	.	.	.	X	.	.	.	.
MFN-2180	.	.	X	X	.	X	.	.	.	.	.	X	.	X	.	X	.	X	X	.	.	X	X	.	.	.	.	.	X	.	.	X	.
MFN-2179	.	.	.	.	.	X	X	.	.	.	.	X	X	X	.	X	.	X	.	.	.	.	X	.	X	.	.	.	X	.	.	X	.
MFN-2178	.	.	X	.	.	X	.	.	.	.	.	X	X	X	.	X	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	X	.
MFN-2177	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.
MFN-2176	.	.	.	X	.	X	X	.	.	.	.	X	?	X	.	X	.	X	.	.	.	X	X	.	.	.	.	.	X	X	.	X	.
MFN-2175	.	.	.	X	.	X	X	.	.	.	.	X	X	X	.	X	.	X	.	.	.	X	X	X	.	.	.	.	X	.	.	.	.
MFN-2174	.	.	X	X	.	X	.	.	.	.	.	X	.	X	.	X	.	X	.	.	.	X	X	.	.	.	.	.	X	X	.	X	.
MFN-2173	.	.	.	X	.	X	.	.	.	.	.	X	?	X	.	X	.	X	.	.	.	X	X	.	.	.	.	X	.	.	.	X	.
MFN-2172	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
MFN-2171	.	.	.	X	.	X	X	.	.	.	.	X	.	X	.	X	.	X	.	.	.	X	X	.	.	.	.	.	.	X	.	X	.
MFN-2170	.	X	.	X	.	.	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	X	X	.	.	.	.	.	X	X	.	X	.
MFN-2169	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.
MFN-2168	.	.	.	X	X	X	X	.	.	.	.	X	.	?	.	X	X	X	.	.	.	X	X	.	.	.	.	X	X	.	.	X	.
MFN-2167	.	.	.	X	.	X	.	.	.	.	.	X	.	X	X	X	.	.	.	.	.	X	X	.	.	.	.	X	.	X	.	X	.
MFN-2166	.	.	.	.	X	X	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
MFN-2165	.	.	.	X	X	X	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	X	X	.	.	X	X	X	.	.	.	X	.
MFN-2164	.	.	.	X	.	X	X	.	.	.	.	.	X	X	.	X	X	X	.	X	.	X	.	X	.	.	.	X	X	X	.	X	.
MFN-2163	X	.	.	X	.	X	X	.	.	.	X	X	?	.	.	X	.	X	X	X	.	X	X	.	.	.	.	.	X	X	.	X	X

Checklist 1 (continued)

	LUCIANORHABDUS MALEFORMIS	MANIVITELLA GRONOSA	MANIVITELLA PEMMATOIDEA	MARTHASTERITES FURCATUS	MICRORHABDULUS BELGICUS	MICRORHABDULUS DECORATUS	MICRORHABDULUS HELICOIDEUS	MICULA CONCAVA	MICULA STAUROPHORA	NEOCHIASTOZYGUS ACUTUS	NEOCREPIDOLITHUS NEOCRASSUS	OCTOCYLUS REINHARDTII	PARHABDOLITHUS EMBERGERI	PERCIVALIA POROSA	PLACOZYGOLITHUS ROEGLII	PLACOZYGUS FIBULIFORMUS	PLACOZYGUS SIGMOIDES	PREDISCOSPHAERA BUKRYI-STOVERI	PREDISCOSPHAERA CRETACEA	PREDISCOSPHAERA HONJOI	PREDISCOSPHAERA SPINOSA	REINHARDTITES ANTHOPHORUS	REINHARDTITES BIPERFORATUS	REPAGULUM PARVIDENTATUM	RHAGODISCUS AFF. RENIFORMIS	RHAGODISCUS ANGUSTUS	RHAGODISCUS ASPER	RHAGODISCUS FISCHERI	RHAGODISCUS RENIFORMIS	RHAGODISCUS SPLENDENS	**SCAPHOLITUS FOSSILIS**	SERIBISCUTUM PRIMITIVUM	SOLLASITES LOWEI
MFN-2208	X	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.
MFN-2207	X	X	.	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.
MFN-2206	X	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	.	X	.	X	.	.
MFN-2205	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2204	X	.	.	.	X	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	X	X	X	.	.	X	.	.	.	.	X	.	.
MFN-2203	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	.	.
MFN-2202	X	X	.	X	X	X	X	.	.	.	.	.	.	.	.	X	.	.	X	.	X	X	X	.	.	X	.	.	.	.	.	.	.
MFN-2201	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	.	.
MFN-2200	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	X	X	.	X	X	X	.	.	.	X	.	X	.	.	.	.
MFN-2199	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	X	X	X	.	.	X	.	.	X	.	.	.	.
MFN-2198	X	X	.	X	X	.	X	.	X	.	.	.	.	.	.	.	.	X	X	.	X	X	.	.	.	X	.	.	.	.	.	.	.
MFN-2197	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.	.	.	X	.	X	X	X	.	.	X	.	.	.	.	.	.	.
MFN-2196	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	X	.	X	X	.	.	X	.	.	.	X	.	.	X	.	.	.	.
MFN-2195	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	X	X	X	X	.	.	X	X	.	.	.	.	.	.
MFN-2194	X	.	X	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	X	.	X	X	X	.	X	.	.	.	.	.	.	.	X
MFN-2193	.	.	.	.	.	X	X	X	.	.	.	.	.	.	X	.	?	.	X	.	.	X	X	.	.	X	X	.	.	.	.	.	.
MFN-2192	.	.	.	X	X	.	X	.	X	.	.	.	.	.	.	X	.	.	X	.	X	X	X	.	.	.	X	.	.	X	.	.	.
MFN-2191	X	.	X	.	X	.	X	.	X	.	.	.	.	X	.	.	?	X	X	.	X	X	X	.	.	.	.	.	.	.	.	.	.
MFN-2190	.	.	.	.	.	.	X	.	X	.	X	.	.	.	.	X	?	.	X	.	X	X	.	.	.	.	.	.	.	.	X	.	.
MFN-2189	X	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	X	X	.	.	X	.	.	.	.	.	.	.
MFN-2188	X	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	X	.	X	X	X	.	X	.	X	.	.	.	.	.	.
MFN-2187	.	.	.	X	X	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	X	.	.	.
MFN-2186	.	.	.	.	.	X	X	.	X	.	.	.	.	.	.	.	.	.	X	.	X	X	X	.	.	X	X	.	.	.	X	.	.
MFN-2185	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.
MFN-2184	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	X	.	.	X	X	.	.	.	.	.	.
MFN-2183	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2182	.	.	X	.	X	.	X	.	X	.	.	.	.	.	.	.	.	.	X	.	.	X	X	.	.	.	X	.	.	X	.	.	.
MFN-2181	X	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.
MFN-2180	X	.	X	X	X	.	X	X	.	.	.	.	.	.	.	.	.	.	X	.	X	X	X	.	.	.	X	.	.	.	X	X	.
MFN-2179	X	X	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	X	.	X	X	X	.	.	.	X	.	.	X	X	.	.
MFN-2178	X	.	X	X	.	.	.	.	X	.	.	.	.	.	.	X	.	.	X	.	X	X	X	.	.	X	.	.	.	.	.	.	.
MFN-2177	X	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
MFN-2176	X	X	X	.	.	.	X	X	X	.	.	.	.	.	.	X	.	.	X	.	X	X	X	.	.	X	X	.	.	.	X	.	.
MFN-2175	X	X	.	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	X	.	X	X	X	.	.	X	.	.	.	.	X	.	.
MFN-2174	X	.	X	.	X	X	.	X	X	.	.	.	.	.	.	.	.	.	X	.	X	X	X	.	.	X	.	.	X	.	.	.	.
MFN-2173	X	X	X	X	X	.	.	X	X	.	.	.	.	.	.	X	.	.	.	.	X	X	X	.	.	X	X	.	X	.	.	.	.
MFN-2172	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.
MFN-2171	.	.	.	X	.	.	X	X	X	.	.	.	.	.	.	X	.	.	X	.	X	X	.	.	.	X	X	.	.	.	X	.	.
MFN-2170	X	.	.	X	X	X	X	X	X	.	.	.	.	.	.	X	.	.	X	.	X	X	X	.	.	.	X	.	.	.	X	.	.
MFN-2169	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2168	X	.	.	X	X	.	X	X	X	X	.	.	.	.	.	X	.	.	X	.	.	X	X	X	.	X	.	.	X	X	X	?	.
MFN-2167	X	X	X	X	X	.	X	X	X	.	.	.	.	.	.	X	.	.	X	.	X	X	X	.	.	.	X	.	.	.	.	.	.
MFN-2166	.	.	.	X	.	.	X	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2165	X	.	X	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	X	.	.	.	.	X	.	.
MFN-2164	X	X	.	X	X	X	.	X	X	.	.	X	X	.	.	.	.	.	X	.	X	X	X	.	.	X	.	.	X	.	X	.	.
MFN-2163	.	.	X	X	X	.	X	X	X	X	.	X	.	.	.	.	.	.	X	.	X	X	X	X	.	X	X	X	X	.	X	.	.

Checklist 1 (continued)

	STEPHANOLITHION LAFFITTEI	TETRAPODORHABDUS DECORUS	TRANOLITHUS EXIGUUS	TRANOLITHUS GABALUS	TRANOLITHUS ORIONATUS	VEKSHINELLA AACHENA	VEKSHINELLA CRISTATA	VEKSHINELLA DIBRACHIATUS	VEKSHINELLA DORFI	VEKSHINELLA ELLIPTICA	VEKSHINELLA IMBRICATA	WATZNAUERIA BARNESAE	WATZNAUERIA BIPORTA	WATZNAUERIA CRUCIATA	ZEUGRHABDOLITHUS ACANTHUS	ZYGODISCUS BICRESCENTICUS	ZYGODISCUS DEFLANDREI	ZYGODISCUS LACUNATUS	
MFN-2208	.	.	.	.	.	.	.	.	X	X	.	X	.	.	.	.	.	.	MFN-2208
MFN-2207	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	MFN-2207
MFN-2206	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	MFN-2206
MFN-2205	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	MFN-2205
MFN-2204	.	X	.	.	.	.	.	.	X	X	.	X	.	.	.	.	X	.	MFN-2204
MFN-2203	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	MFN-2203
MFN-2202	.	.	X	.	X	.	.	.	X	.	X	X	.	.	.	X	X	.	MFN-2202
MFN-2201	X	.	X	.	X	.	.	.	X	X	X	X	.	.	.	.	X	.	MFN-2201
MFN-2200	.	.	.	.	X	.	.	.	.	X	X	X	.	.	.	X	.	.	MFN-2200
MFN-2199	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	MFN-2199
MFN-2198	.	X	X	.	X	.	.	.	.	X	X	X	.	.	.	.	.	.	MFN-2198
MFN-2197	.	.	X	.	X	.	X	.	.	X	X	X	.	.	.	.	.	.	MFN-2197
MFN-2196	.	X	X	X	X	X	X	.	.	X	.	X	.	.	.	X	.	.	MFN-2196
MFN-2195	.	.	X	.	X	.	.	.	.	X	X	X	.	.	.	.	X	.	MFN-2195
MFN-2194	.	X	X	.	X	.	X	.	.	X	X	X	.	.	.	X	.	.	MFN-2194
MFN-2193	.	X	.	.	X	.	X	.	.	.	X	X	.	.	.	X	.	.	MFN-2193
MFN-2192	.	X	.	.	.	.	X	.	.	.	.	X	X	.	.	X	X	.	MFN-2192
MFN-2191	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	MFN-2191
MFN-2190	.	.	X	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	MFN-2190
MFN-2189	.	X	X	.	.	.	.	.	.	.	X	X	.	.	.	X	.	.	MFN-2189
MFN-2188	X	X	X	.	.	.	.	.	.	.	X	X	.	.	.	X	.	.	MFN-2188
MFN-2187	.	.	X	.	X	.	.	.	.	.	X	X	.	.	.	.	.	.	MFN-2187
MFN-2186	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	MFN-2186
MFN-2185	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	MFN-2185
MFN-2184	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	MFN-2184
MFN-2183	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	MFN-2183
MFN-2182	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	MFN-2182
MFN-2181	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	MFN-2181
MFN-2180	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	MFN-2180
MFN-2179	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	MFN-2179
MFN-2178	X	.	.	.	.	.	.	.	X	X	.	.	.	.	.	X	X	.	MFN-2178
MFN-2177	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	MFN-2177
MFN-2176	X	.	.	.	.	.	.	.	.	X	.	X	.	.	.	X	X	.	MFN-2176
MFN-2175	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	MFN-2175
MFN-2174	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	MFN-2174
MFN-2173	X	.	.	.	.	.	.	.	X	X	.	X	.	.	.	.	.	.	MFN-2173
MFN-2172	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	MFN-2172
MFN-2171	X	.	.	.	.	.	.	.	X	X	.	.	.	.	X	X	X	.	MFN-2171
MFN-2170	X	.	.	.	.	.	.	.	X	X	.	.	.	.	.	X	X	X	MFN-2170
MFN-2169	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	MFN-2169
MFN-2168	X	.	.	.	.	.	.	.	.	X	.	X	X	.	.	.	.	X	MFN-2168
MFN-2167	X	.	.	.	.	.	.	.	X	.	.	X	.	.	.	X	X	.	MFN-2167
MFN-2166	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	X	.	MFN-2166
MFN-2165	.	.	.	.	.	.	.	X	X	X	.	X	.	.	.	X	X	.	MFN-2165
MFN-2164	X	X	.	.	.	.	.	.	X	X	.	X	.	.	.	X	X	.	MFN-2164
MFN-2163	X	X	.	.	.	.	.	.	X	X	.	X	.	X	.	X	X	.	MFN-2163

Checklist 2. Nannofossil distribution in three outcrops in the Gingin area, and in Gingin Brook #4 and Agaton #19 boreholes, Perth Basin.

	ACTINOZYGUS REGULARIS	ACUTURRIS SCOTUS	AHMUELLERELLA OCTORADIATA	AMPHIZYGUS BROOKSII BROOKSII	ARKHANGELSKIELLA SPECILLATA	BIDISCUS MONOCAVUS	BIDISCUS ROTATORIUS	BIDISCUS SPP.	BISCUTUM BUKRYI BUKRYI	BISCUTUM BUKRYI NANUM	BISCUTUM CORONUM	BISCUTUM MELANIAE	BISCUTUM NOTICULUM	BRAARUDOSPHAERA BIGELOWII	BRAARUDOSPHAERA DISCULA	BROINSONIA AFF. PARCA	BROINSONIA BUKRYI	BROINSONIA DENTATA	BROINSONIA EXPANSA	BROINSONIA PSEUDOPARCA	CALCULITES OBSCURUS	CALCULITES OVALIS	CHIASTOZYGUS AMPHIPONS	CHIASTOZYGUS FESSUS	CHIASTOZYGUS LITTERARIUS	COROLLITHION GEOMETRICUM	CRETARHABDUS CONICUS	CRETARHABDUS SURIRELLUS	CRIBROSPHAERELLA CIRCULA	CRIBROSPHAERELLA EHRENBERGII	CYCLAGELOSPHAERA PERFORATA	CYLINDRALITHUS BIARCUS	CYLINDRALITHUS SERRATUS
MOLECAP HILL																																	
MFN-2240	.	X	X	.	X	X	.	X	.	.	?	.	X	.	.	.	?	.	X	X	X	X	.	X	.	.	.	X	.	X	.	.	.
MFN-2239	.	X	.	.	X	.	X	.	.	.	.	X	.	.	.	.	.	.	X	X	.	X	.	.	X	.	.	X	.	X	.	.	.
MFN-2238	.	.	X	.	X	.	.	.	.	.	.	X	.	X	.	.	.	.	X	X	X	X	.	.	.	.	.	X	.	.	.	X	.
MFN-2237	.	X	X	.	X	.	.	.	.	.	.	X	.	.	.	.	X	X	X	X	X	X	X	X	X	.	.	.	.	X	.	.	X
MFN-2236	.	X	.	.	X	.	.	.	X	.	.	X	.	.	.	.	X	X	X	X	X	X	.	X	X	.	X	.	.	X	.	X	.
MFN-2235	.	.	X	.	X	.	.	.	.	.	?	X	X	.	.	.	X	X	X	X	X	X	.	.	X	.	X	.	.	X	.	X	.
MFN-2234	X	X	.	.	X	.	.	.	.	.	.	X	.	.	X	.	.	.	X	X	X	X	.	X	X	.	.	X	.	X	.	X	.
MFN-2232	X	X	.	.	X	.	.	.	.	.	?	X	.	.	.	.	?	.	X	X	X	X	.	X	X	.	X	.	X	.	.	.	.
MFN-2231	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?	.	.	.	.	.	.
MFN-2230	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2219	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2218	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MOLECAP QUARRY																																	
MFN-235	.	X	.	.	X	.	.	.	X	.	.	X	.	.	.	.	.	X	X	X	X	X	.	X	X	.	X	.	.	X	.	X	X
MFN-234	.	.	X	.	X	.	.	.	X	.	.	X	.	.	.	.	.	X	X	X	.	X	.	.	X	.	X	.	.	X	.	.	.
MFN-233	.	X	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	X	X	X	X	X	.	X	X	.	.	X	.	X	X	X	X
MFN-232	.	.	X	.	X	.	.	.	X	.	.	X	.	X	.	.	.	.	.	X	X	X	.	X	X	.	.	X	.	.	.	.	.
MFN-231	.	X	.	.	X	.	.	.	X	.	.	X	.	.	.	.	.	.	X	X	X	X	.	.	X	.	X	.	.	X	.	.	.
MFN-230	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ONE-TREE HILL																																	
MFN-229	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.
MFN-228	.	.	X	.	X	.	.	.	.	.	.	X	.	X	.	.	.	X	.	X	X	X	.	.	X	.	X	X	.	.	.	X	X
MFN-227	.	.	X	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	X	X	.	X	.	.	.	.	X	X	.	.	.	X	.
MFN-226	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	X	X	X	X	X	X	X	.	.	X	.	X	.	.	.
MFN-225	.	.	X	.	X	.	.	.	.	.	X	.	.	.	X	.	.	X	.	X	X	X	X	X	X	.	.	.	.	X	.	X	.
GINGIN BROOK #4																																	
MFN-2668	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	X	.	X	.	X	.
MFN-2669	.	X	X	.	X	.	.	.	.	.	.	.	.	.	.	X	X	X	X	.	.	X	.	.	X	.	X	X	.	X	.	X	.
MFN-2670	.	X	X	X	.	.	.	.	.	.	X	X	.	.	.	X	X	.	X	X	.	X	.	.	X	.	X	X	.	X	.	X	.
AGATON #19																																	
MFN-2482	.	X	X	.	X	.	.	X	.	.	.	.	.	.	.	.	X	X	X	X	.	X	.	.	.	.	X	X	X	X	.	X	.
MFN-2483	.	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	X	.	X	X	X	X	.	.	.	.	X	.
MFN-2484	.	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	X	.	X	X	.	X	.	.	X	.	.	.
MFN-2485	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	X	.	X	X	.	.	.	.	.	.	.	.
MFN-2486	X	X	X	X	X	.	X	X	X	X	.	.	.	.	.	.	.	X	X	X	.	X	.	X	X	.	X	X	.	X	.	X	.
MFN-2487	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2488	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Checklist 2 (continued)

	DODEKAPODORHABDUS NOELII	EIFFELLITHUS AFF. EXIMIUS	EIFFELLITHUS EXIMIUS	EIFFELLITHUS TRABECULATUS	EIFFELLITHUS TURRISEIFFELI	EPROLITHUS FLORALIS	GARTNERAGO OBLIQUUM	GEPHYRORHABDUS CORONADVENTUS	GRANTARHABDUS CAMARUTUS	HETERORHABDUS SINUOSUS	KAMPTNERIUS MAGNIFICUS	LAPIDEACASSIS SIMPLEX	LITHASTRINUS GRILLI	LITHRAPHIDITES CARNIOLENSIS	LUCIANORHABDUS CAYEUXII	LUCIANORHABDUS MALEFORMIS	MANIVITELLA GRONOSA	MANIVITELLA PEMMATOIDEA	MARTHASTERITES FURCATUS	MARTHASTERITES INCONSPICUUS	MICRORHABDULUS BELGICUS	MICRORHABDULUS DECORATUS	MICRORHABDULUS HELICOIDEUS	MICULA CONCAVA	MICULA STAUROPHORA	NEOCREPIDOLITHUS NEOCRASSUS	PARHABDOLITHUS EMBERGERI	PERCIVALIA CF. POROSA	PLACOZYGOLITHUS ROEGLII	PLACOZYGUS FIBULIFORMUS	PLACOZYGUS SIGMOIDES	PREDISCOSPHAERA CRETACEA	PREDISCOSPHAERA HONJOI
MOLECAP HILL																																	
MFN-2240	.	.	X	.	X	.	X	.	.	.	X	.	.	X	X	X	.	.	.	.	X	.	X	X	.	.	.	.	.	.	?	X	.
MFN-2239	X	.	X	.	X	.	X	.	.	.	X	.	.	X	X	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	?	X	.
MFN-2238	.	.	X	.	X	.	X	.	.	X	X	.	.	X	X	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.
MFN-2237	.	.	X	X	X	.	.	X	X	X	X	X	.	X	.	X	.	.	.	.	.	.	.	.	X	X	.	X	X	.	.	X	X
MFN-2236	.	.	X	X	X	.	X	.	X	.	X	.	.	X	X	.	.	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.
MFN-2235	.	.	X	.	.	.	X	.	.	X	X	.	.	X	X	X	.	.	.	.	.	.	.	.	X	X	.	.	.	X	?	X	.
MFN-2234	.	X	X	.	.	.	.	.	X	X	X	.	.	X	X	X	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	X	.
MFN-2232	.	.	X	.	X	.	X	X	.	.	X	.	.	X	X	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	X	.
MFN-2231	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2230	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2219	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2218	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MOLECAP QUARRY																																	
MFN-235	.	.	X	.	X	.	X	X	X	.	X	.	.	X	X	X	.	.	X	.	X	.	X	.	X	.	.	.	.	.	.	X	.
MFN-234	.	X	X	.	X	.	X	.	X	.	X	.	.	X	X	.	.	.	.	.	X	.	X	.	X	.	X	.	.	.	.	X	.
MFN-233	.	.	X	.	.	.	X	.	X	.	X	.	.	.	X	X	.	.	.	.	X	.	X	.	X	X	.	.	.	X	.	X	.
MFN-232	.	.	X	.	X	.	X	.	.	.	X	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.
MFN-231	.	.	X	.	.	.	X	.	X	.	X	.	.	.	X	X	.	.	X	.	.	.	X	.	.	X	.	.	.	.	?	X	X
MFN-230	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ONE-TREE HILL																																	
MFN-229	.	.	.	.	.	.	.	.	.	.	?	.	.	.	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
MFN-228	.	.	X	.	X	.	X	.	.	.	X	.	.	X	X	X	.	.	.	.	.	.	X	.	X	.	.	.	.	X	.	X	.
MFN-227	.	.	X	.	X	.	X	.	.	.	X	.	.	X	X	X	.	.	X	.	X	X	.	.	X	.	.	.	.	X	.	.	.
MFN-226	.	.	X	.	X	.	X	.	.	.	X	.	.	X	X	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	.	X	.
MFN-225	.	.	X	.	.	X	X	.	.	.	X	.	.	X	X	X	.	.	.	X	X	X	.	.	X	.	.	.	.	.	.	X	.
GINGIN BROOK #4																																	
MFN-2668	.	.	X	.	.	.	X	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	X	.
MFN-2669	.	.	X	.	X	.	.	.	.	.	X	.	.	.	X	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.
MFN-2670	.	.	X	.	X	.	X	.	.	.	X	.	.	X	X	X	.	.	.	.	.	.	X	.	X	.	.	.	.	X	?	X	.
AGATON #19																																	
MFN-2482	.	.	X	.	X	.	X	.	.	X	X	.	.	X	X	X	X	.	X	X	X	.	X	X	X	.	.	.	.	.	.	X	.
MFN-2483	.	.	X	.	X	.	X	X	.	X	X	.	.	X	.	.	.	.	X	.	X	.	X	X	X	.	.	.	.	.	.	X	.
MFN-2484	.	.	X	.	.	.	.	X	.	X	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	?	X	.
MFN-2485	.	.	X	.	X	.	X	.	.	X	X	.	.	.	X	.	.	X	.	.	.	.	.	X	X	.	.	.	.	.	.	X	.
MFN-2486	.	.	X	X	X	.	X	.	X	X	X	.	.	X	.	X	.	X	X	.	X	X	X	X	X	.	X	.	.	.	?	X	.
MFN-2487	.	.	.	.	X	X	X	.	.	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
MFN-2488	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Checklist 2 (continued)

	PREDISCOSPHAERA SPINOSA	QUADRUM GARTNERI	REINHARDTITES ANTHOPHORUS	REINHARDTITES BIPERFORATUS	RHAGODISCUS ANGUSTUS	RHAGODISCUS ASPER	RHAGODISCUS FISCHERI	RHAGODISCUS RENIFORMIS	RHAGODISCUS SPLENDENS	SCAPHOLITUS FOSSILIS	SOLLASITES HORTICUS	STEPHANOLITHION LAFFITTEI	TETRAPODORHABDUS DECORUS	TRANOLITHUS EXIGUUS	TRANOLITHUS ORIONATUS	VEKSHINELLA DIBRACHIATUS	VEKSHINELLA DORFI	VEKSHINELLA ELLIPTICA	VEKSHINELLA IMBRICATA	WATZNAUERIA BARNESAE	WATZNAUERIA BIPORTA	ZYGODISCUS BICRESCENTICUS	ZYGODISCUS DEFLANDREI	ZYGODISCUS LACUNATUS	
MOLECAP HILL																									
MFN-2240	X	.	X	X	.	X	.	.	.	.	.	X	.	.	X	X	X	.	.	X	.	X	.	.	MFN-2240
MFN-2239	X	.	X	X	X	X	.	X	.	.	.	.	.	X	.	.	.	.	X	X	X	X	.	.	MFN-2239
MFN-2238	X	.	X	X	X	.	.	.	.	.	.	.	.	X	.	.	.	.	X	X	.	X	.	.	MFN-2238
MFN-2237	X	.	X	X	.	.	.	.	.	.	.	.	X	X	.	.	X	.	X	X	.	X	.	.	MFN-2237
MFN-2236	X	.	X	X	.	.	.	.	.	.	.	.	X	X	X	.	X	.	X	X	X	.	X	.	MFN-2236
MFN-2235	X	.	X	X	X	.	.	.	.	.	.	.	X	X	X	.	X	.	X	X	.	X	.	.	MFN-2235
MFN-2234	X	.	X	X	X	.	.	.	.	.	X	.	.	X	X	.	.	X	X	X	.	X	.	.	MFN-2234
MFN-2232	.	.	X	X	.	X	.	.	.	.	.	.	.	X	X	.	X	X	X	X	.	X	.	.	MFN-2232
MFN-2231	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	?	.	MFN-2231
MFN-2230	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	MFN-2230
MFN-2219	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	MFN-2219
MFN-2218	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	MFN-2218
MOLECAP QUARRY																									
MFN-235	.	.	X	X	X	.	.	.	.	.	.	.	.	X	.	.	.	X	X	X	.	X	.	.	MFN-235
MFN-234	.	.	X	X	X	.	.	.	.	.	.	.	.	X	X	.	X	.	.	X	.	.	.	.	MFN-234
MFN-233	X	.	X	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	X	.	.	X	.	MFN-233
MFN-232	.	.	X	X	X	.	.	.	X	.	.	.	.	.	X	.	X	.	.	X	.	X	X	.	MFN-232
MFN-231	.	.	X	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	.	MFN-231
MFN-230	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	MFN-230
ONE-TREE HILL																									
MFN-229	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	MFN-229
MFN-228	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	MFN-228
MFN-227	X	.	X	X	.	.	.	.	.	.	.	.	.	X	.	.	.	X	X	X	.	X	.	.	MFN-227
MFN-226	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.	MFN-226
MFN-225	X	?	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	X	.	X	.	.	MFN-225
GINGIN BROOK #4																									
MFN-2668	X	.	X	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	X	.	X	.	.	MFN-2668
MFN-2669	X	.	X	X	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	X	MFN-2669
MFN-2670	X	.	X	X	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	X	.	X	.	X	MFN-2670
AGATON #19																									
MFN-2482	X	.	X	X	X	X	.	X	.	X	.	.	X	.	.	.	.	.	.	X	.	X	X	.	MFN-2482
MFN-2483	X	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	MFN-2483
MFN-2484	.	.	X	X	X	X	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	X	X	.	MFN-2484
MFN-2485	X	.	X	X	X	.	.	.	.	.	.	.	?	.	.	.	.	.	.	X	.	X	X	X	MFN-2485
MFN-2486	X	.	X	X	X	X	.	.	.	X	.	X	X	.	.	.	.	.	.	X	.	.	X	.	MFN-2486
MFN-2487	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-2487
MFN-2488	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	MFN-2488

Checklist 3. Nannofossil distribution in Ginginup #1 corehole and Lancelin #2B borehole.

	ACTINOZYGUS REGULARIS	ACUTURRIS SCOTUS	AHMUELLERELLA OCTORADIATA	AMPHIZYGUS TESSELATUS	ARKHANGELSKIELLA CYMBIFORMIS	ARKHANGELSKIELLA ORTHOCANCELLATA	ARKHANGELSKIELLA SPECILLATA	AXOPODORHABDUS DIETZMANNI	BIDISCUS CRUCIATUS	BIDISCUS MONOCAVUS	BIDISCUS ROTATORIUS	BISCUTUM BUKRYI BUKRYI	BISCUTUM BUKRYI NANUM	BISCUTUM CF. BLACKII	BISCUTUM CORONUM	BISCUTUM MAGNUM	BISCUTUM MELANIAE	BISCUTUM NOTICULUM	BOLETUVELUM CANDENS	BOLETUVELUM FLABELLATUM	BRAARUDOSPHAERA BIGELOWII	BRAARUDOSPHAERA CF. AFRICANA	BROINSONIA AFF. PARCA	BROINSONIA BUKRYI	BROINSONIA CF. EXPANSA	BROINSONIA DENTATA	BROINSONIA EXPANSA	BROINSONIA HANDFIELDI	BROINSONIA PARCA	BROINSONIA PSEUDOPARCA	BROINSONIA STAYTONAE	CALCULITES BIPERFORATUS	CALCULITES OBSCURUS
LANCELIN #2B																																	
MFN-1268	.	X	X	.	.	X	X	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X
MFN-1269	X	X	X	.	.	X	X	.	.	.	.	.	.	.	.	X	X	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X
MFN-1270	.	X	X	.	.	X	X	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	X
GINGINUP #1																																	
MFN-1256	X	X	X	.	.	.	X	.	X	.	X	X	X	X	.	.	X	X	.	.	.	.	X	X	.	X	X	.	X	.	.	.	X
MFN-4424	.	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	X	.	X	.	.	.	X
MFN-1257	.	X	X	.	X	.	.	.	.	.	.	.	.	.	X	.	X	.	.	X	X	.	.	.	.	X	X	.	X	X	.	.	X
MFN-1258	.	X	X	.	.	.	X	.	X	.	.	.	.	.	X	.	X	.	.	X	X	.	.	X	.	X	X	.	.	.	.	.	X
MFN-1259	.	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	X	X	.	X	.	.	.	X
MFN-4425	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	X	X	X	X	X	.	X	.	.	.	X
MFN-1260	X	X	X	.	.	.	X	.	X	.	X	X	X	.	.	.	X	X	.	.	X	.	.	.	.	X	X	.	X	X	X	X	X
MFN-1271	.	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	X	X	.	X	X	.	X	X	.	.	X
MFN-1272	.	X	X	.	.	.	X	.	.	.	.	X	.	.	.	.	X	X	.	.	X	.	X	X	.	X	X	.	X	.	.	.	X
MFN-1261	.	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	X	.	X	X	.	X	X	.	X	X
MFN-4426	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X
MFN-4427	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X
MFN-1262	.	X	X	X	.	.	X	X	X	.	.	X	X	.	.	.	X	.	X	X	.	.	.	X	X	X	X	.	.	X	.	.	X
MFN-4428	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?	.	X	X	.	.	.	.	.	.
MFN-1263	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	X	.	.	X	.	.	X	.	.	X
MFN-1264	.	X	X	.	.	.	X	.	.	.	X	.	X	.	.	.	X	X	.	.	X	.	.	X	.	X	X	X	.	X	.	.	X
MFN-1265	X	X	X	X	.	.	X	.	.	X	X	X	.	.	.	.	X	.	X	X	.	.	.	X	.	X	X	X	.	X	.	.	X
MFN-1266	.	X	X	X	.	.	X	.	.	X	.	.	X	.	X	.	X	.	.	X	.	.	.	X	.	.	X	.	.	X	.	.	.
MFN-1267	.	.	X	X	.	.	X	.	.	X	.	X	X	X	X	.	X	X	.	.	.	.	.	X	.	X	X	.	.	X	.	.	.

Checklist 3 (continued)

	CALCULITES OVALIS	CHIASTOZYGUS AMPHIPONS	CHIASTOZYGUS FESSUS	CHIASTOZYGUS GARRISONII	CHIASTOZYGUS LITTERARIUS	CLINOZYGUS GÄRTNERI	CLINOZYGUS SYNQUADRIPERFORATUS	COROLLITHION EXIGUUM	COROLLITHION GEOMETRICUM	COROLLITHION RHOMBICUM RHOMBICUM	COROLLITHION RHOMBICUM SYMETRICUM	COROLLITHION SIGNUM	CRETARHABDUS CONICUS	CRETARHABDUS LORIEI	CRETARHABDUS SURRIRELLUS	CRIBROSPHAERELLA CIRCULA	CRIBROSPHAERELLA EHRENBERGII	CYCLAGELOSPHAERA COLUMNATA	CYCLAGELOSPHAERA MARGERELI	CYCLAGELOSPHAERA ROTACLYPEATA	CYLINDRALITHUS BIARCUS	CYLINDRALITHUS SERRATUS	EIFFELLITHUS AFF. EXIMIUS	EIFFELLITHUS EXIMIUS	EIFFELLITHUS TRABECULATUS	EIFFELLITHUS TURRISEIFFELI	EIFFELLITHUS? TRANSVERSUS	EPROLITHUS FLORALIS	GARTNERAGO OBLIQUUM	GARTNERAGO STRIATUM	GEPHYRORHABDUS CORONADVENTUS	GRANTARHABDUS CAMARUTUS	GRANTARHABDUS PUNCTATUS
LANCELIN #2B																																	
MFN-1268	X	.	X	.	X	.	.	X	.	.	.	.	X	.	.	.	X	.	X	.	.	X	.	X	.	X	.	.	X	.	X	.	X
MFN-1269	X	.	X	.	X	.	.	X	.	.	.	X	X	X	X	X	X	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.
MFN-1270	X	.	X	.	X	.	.	.	.	.	.	.	X	.	.	.	X	.	X	.	.	.	.	X	X	X	.	.	X	.	.	.	.
GINGINUP #1																																	
MFN-1256	.	X	X	.	X	X	X	X	.	X	.	X	X	.	X	X	X	X	X	X	X	X	X	X	X	X	.	.	X	X	.	X	X
MFN-4424	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	X	.	.	X	.	X	.	.
MFN-1257	X	.	X	.	X	.	X	X	.	.	.	X	X	.	X	.	X	X	X	.	.	.	.	X	.	X	.	.	X	.	X	X	.
MFN-1258	X	.	X	.	X	.	X	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	X	X	X	.	.	X	.	.	X	.
MFN-1259	X	.	X	.	X	.	.	X	.	.	.	.	.	.	X	.	X	.	.	.	X	.	.	X	X	X	.	.	X	.	.	X	.
MFN-4425	X	.	.	.	.	.	.	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	X	.	X	.	.	X	.	.	X	.
MFN-1260	X	X	X	.	X	.	X	X	X	X	.	.	X	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	X	.	.	X	.
MFN-1271	X	X	X	.	X	.	.	.	.	X	.	.	X	.	X	.	X	.	.	.	X	X	.	X	.	X	.	.	X	.	.	X	.
MFN-1272	X	.	X	.	X	.	.	.	.	X	.	X	.	.	X	.	X	.	.	.	.	X	X	X	X	X	.	.	X	.	.	.	.
MFN-1261	X	.	X	.	X	.	.	X	.	X	.	.	X	.	X	.	X	.	.	.	.	.	.	X	X	X	.	.	X	.	.	X	.
MFN-4426	X	.	.	.	.	.	.	X	X	X	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.
MFN-4427	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
MFN-1262	X	X	X	.	.	.	X	.	.	X	.	X	X	.	X	.	X	.	X	.	.	.	.	X	X	.	.	.	X	X	X	X	X
MFN-4428	X	.	.	.	.	.	.	X	.	.	.	X	.	.	X	.	X	.	.	.	.	.	.	X	.	X	.	.	X	.	.	X	.
MFN-1263	X	.	X	.	X	.	.	.	.	.	.	X	X	.	X	.	X	.	X	.	X	X	.	X	.	X	.	.	X	.	.	X	.
MFN-1264	X	.	X	X	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.	X	X	X	X	.	X	.	.	X	.	.	.	.
MFN-1265	X	X	X	X	X	.	X	X	X	X	X	.	X	.	X	X	X	.	.	.	X	X	.	X	X	X	.	X	X	.	X	X	X
MFN-1266	X	.	X	.	X	.	.	.	.	.	.	.	X	.	X	X	X	.	.	.	X	X	.	X	X	X	.	.	X	.	.	X	.
MFN-1267	.	.	X	X	X	.	X	X	.	X	.	X	X	.	X	X	X	.	.	X	X	X	X	X	X	X	X	X	X	.	X	.	X

Checklist 3 (continued)

	HAQIUS CIRCUMRADIATUS	HETERORHABDUS SINUOSUS	KAMPTNERIUS MAGNIFICUS	LAPIDEACASSIS CORNUTA	LAPIDEACASSIS FASCIATA	LAPIDEACASSIS MARIAE	LAPIDEACASSIS SIMPLEX	LAPIDEACASSIS SPP.	LITHASTRINUS GRILLI	LITHRAPHIDITES CARNIOLENSIS	LITHRAPHIDITES PRAEQUADRATUS	LOXOLITHUS ARMILLA	LUCIANORHABDUS CAYEUXII	LUCIANORHABDUS MALEFORMIS	MANIVITELLA GRONOSA	MANIVITELLA PEMMATOIDEA	MARTHASTERITES FURCATUS	MARTHASTERITES INCONSPICUUS	MICRORHABDULUS BELGICUS	MICRORHABDULUS DECORATUS	MICRORHABDULUS HELICOIDEUS	MICULA CONCAVA	MICULA STAUROPHORA	MISCEOMARGINATUS PLENIPORUS	MISCEOREPAGULUM TARBOULENSIS	MUNARIUS KEADYI	NEOCHIASTOZYGUS ACUTUS	NEOCHIASTOZYGUS ANTIQUUS	NEOCREPIDOLITHUS GINGINENSIS	OCTOCYLUS REINHARDTII	OTTAVIANUS GIANNUS	PARHABDOLITHUS EMBERGERI	PERCIVALIA CF. POROSA
LANCELIN #2B																																	
MFN-1268	.	.	X	X	.	.	.	.	.	X	.	X	X	.	X	X	.	.	.	X	.	X	X	X	.	.	.	.	X	.	.	.	.
MFN-1269	.	X	X	.	.	.	.	.	.	.	.	X	X	.	X	.	.	.	X	X	.	X	X	X	.	.	.	.	.	.	.	.	.
MFN-1270	.	X	X	.	.	.	.	.	.	X	.	X	X	X	X	X	.	.	X	X	X	X	X	X	.	.	.	.	.	.	.	X	X
GINGINUP #1																																	
MFN-1256	.	.	X	.	X	.	.	.	.	X	.	X	X	.	.	X	.	.	X	X	.	X	X	.	X	.	.	X	X	.	.	.	.
MFN-4424	.	.	X	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	.	.	X	X	.	.	.	.	.	.	.	.	.	.
MFN-1257	.	.	X	.	.	.	.	.	.	X	.	.	X	X	.	X	.	.	X	X	X	X	X	.	X	.	.	.	.	.	.	X	.
MFN-1258	.	X	X	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.
MFN-1259	.	.	X	.	.	.	X	.	.	X	.	.	X	X	.	.	.	X	X	.	X	X	X	.	.	.	.	.	.	.	.	.	.
MFN-4425	.	X	X	.	.	.	.	.	.	X	.	.	X	X	.	X	X	.	X	.	.	X	X	.	.	.	.	.	.	.	.	.	.
MFN-1260	.	.	X	X	X	X	.	.	X	.	.	X	X	X	.	X	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.
MFN-1271	.	X	X	.	.	X	.	.	.	X	.	.	X	X	.	.	X	.	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.
MFN-1272	.	X	X	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.
MFN-1261	.	X	X	.	.	X	.	.	.	X	.	X	X	X	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.
MFN-4426	.	.	X	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.
MFN-4427	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-1262	.	X	X	.	.	.	.	.	.	X	.	.	X	X	.	.	X	.	X	X	X	.	X	.	X	.	X	.	.	.	.	.	X
MFN-4428	.	X	X	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	X	.	X	X	.	.	.	X	.	.	.	.	X	.	.
MFN-1263	.	X	X	.	.	.	.	.	X	X	.	.	X	X	.	X	X	.	.	X	X	.	.	.	.	.	.	.	.	X	.	.	.
MFN-1264	.	X	X	.	.	.	.	.	.	X	.	X	X	X	.	X	X	.	X	X	X	X	X	.	.	X	.	.	X	X	X	X	.
MFN-1265	X	X	X	X	.	X	.	X	X	X	X	X	X	X	.	X	X	.	X	X	X	X	X	.	.	.	X	.	.	X	X	.	.
MFN-1266	X	X	X	.	.	.	.	X	.	X	.	X	X	X	X	X	X	.	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.
MFN-1267	X	X	X	X	.	.	.	.	X	X	.	.	.	.	X	X	X	.	X	X	X	X	X	.	.	.	.	.	.	.	.	X	.

Checklist 3 (continued)

	PERCIVALIA POROSA	PLACOZYGOLITHUS ROEGLII	PLACOZYGUS FIBULIFORMUS	PLACOZYGUS SIGMOIDES	PONTOSPHAERA MULTICARINATA	PREDISCOSPHAERA BUKRYI-STOVERI	PREDISCOSPHAERA CRETACEA	PREDISCOSPHAERA HONJOI	PREDISCOSPHAERA SPINOSA	REINHARDTITES AFF. LEVIS	REINHARDTITES ANTHOPHORUS	REINHARDTITES BIPERFORATUS	REINHARDTITES LEVIS	REINHARDTITES MIRABILIS	REPAGULUM PARVIDENTATUM	RETACAPSA SCHIZOBRACHIATA	RHABDOPHIDITES MOESLENSIS	RHAGODISCUS ANGUSTUS	RHAGODISCUS ASPER	RHAGODISCUS FISCHERI	RHAGODISCUS RENIFORMIS	RHAGODISCUS SPLENDENS	RUSSELLIA LASWELLI	SCAPHOLITUS FOSSILIS	SOLLASITES LOWEI	STEPHANOLITHION LAFFITTEI	TEICHORHABDUS ETHMOS	TETRAPODORHABDUS DECORUS	TRANOLITHUS EXIGUUS	TRANOLITHUS ORIONATUS	VEKSHINELLA AACHENA	VEKSHINELLA ARA	VEKSHINELLA CRISTATA
LANCELIN #2B																																	
MFN-1268	X	X	.	X	.	.	X	.	X	.	X	.	X	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.
MFN-1269	.	.	X	X	.	X	X	X	X	.	X	.	.	.	.	.	.	.	.	.	X	.	.	X	.	X	X	.	.	.	.	.	.
MFN-1270	.	.	.	?	.	.	X	.	X	X	X	.	X	.	.	.	.	X	.	.	.	X	.	X	.	X	.	X	X	.	X	X	.
GINGINUP #1																																	
MFN-1256	.	.	X	X	.	X	X	X	X	.	X	X	.	.	X	.	.	X	X	.	.	.	.	X	.	X	.	.	.	.	X	.	X
MFN-4424	X	.	.	?	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	X	.	.	.	.
MFN-1257	.	.	.	?	.	.	X	X	X	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.	X
MFN-1258	.	.	X	X	.	X	X	.	X	.	X	X	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
MFN-1259	X	.	.	.	.	.	X	.	X	.	X	X	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.
MFN-4425	.	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.
MFN-1260	.	.	.	.	.	.	X	X	.	.	X	.	.	.	X	.	.	X	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.
MFN-1271	.	.	X	X	.	X	X	.	X	.	X	.	.	.	.	.	.	X	.	.	X	.	.	X	.	.	.	.	X	.	.	.	X
MFN-1272	.	.	X	?	.	X	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	X
MFN-1261	.	.	X	?	.	.	X	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.
MFN-4426	.	.	X	.	.	.	X	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.
MFN-4427	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.	.	.	.	.	.
MFN-1262	.	.	X	X	X	.	X	.	X	.	X	X	.	.	.	.	.	X	X	X	X	.	.	X	X	X	.	.	.	.	X	X	.
MFN-4428	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
MFN-1263	.	.	X	.	.	.	X	.	X	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.
MFN-1264	.	.	.	.	.	.	X	.	X	.	X	X	.	.	X	.	X	X	.	.	X	.	X	X	.	.	.	.	.	.	.	.	.
MFN-1265	.	.	.	X	.	X	X	X	X	.	X	X	.	X	X	.	.	X	X	.	X	X	X	X	.	X	.	X	.	.	X	.	.
MFN-1266	.	.	X	.	.	.	X	.	X	.	X	X	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.
MFN-1267	.	.	X	.	.	.	X	.	X	.	X	X	.	.	.	X	.	X	X	.	X	X	.	X	.	X	.	X	.	.	X	.	.

Checklist 3 (continued)

	VEKSHINELLA DENTATA	VEKSHINELLA DIBRACHIATUS	VEKSHINELLA DORFI	VEKSHINELLA ELLIPTICA	VEKSHINELLA IMBRICATA	VEKSHINELLA SOLIDA	WATZNAUERIA BARNESAE	WATZNAUERIA BIPORTA	WATZNAUERIA CRUCIATA	ZEUGRHABDOLITHUS ACANTHUS	ZYGODISCUS ABBOTTI	ZYGODISCUS BICRESCENTICUS	ZYGODISCUS CLUBHOUSENSIS	ZYGODISCUS DEFLANDREI	ZYGODISCUS LACUNATUS	ZYGODISCUS PONTICULUS	
LANCELIN #2B																	
MFN-1268	.	.	X	.	X	.	X	.	.	.	.	X	.	X	X	.	MFN-1268
MFN-1269	.	.	.	.	X	.	X	.	.	.	X	X	.	.	.	.	MFN-1269
MFN-1270	.	.	.	.	X	.	X	X	.	.	X	X	.	.	X	.	MFN-1270
GINGINUP #1																	
MFN-1256	X	.	.	X	X	.	X	X	X	X	X	X	.	X	.	.	MFN-1256
MFN-4424	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	MFN-4424
MFN-1257	.	.	X	X	X	.	X	.	.	.	.	X	.	X	X	.	MFN-1257
MFN-1258	X	.	X	.	.	.	X	.	.	.	.	X	.	X	X	.	MFN-1258
MFN-1259	.	.	.	X	X	.	X	X	.	.	.	X	.	.	.	.	MFN-1259
MFN-4425	.	.	.	X	.	.	X	.	.	.	X	.	.	X	.	.	MFN-4425
MFN-1260	.	.	X	X	X	.	X	.	.	.	X	X	X	X	X	.	MFN-1260
MFN-1271	.	.	X	X	X	X	X	.	.	.	.	X	.	X	X	.	MFN-1271
MFN-1272	.	.	X	X	X	.	X	.	.	.	.	X	.	X	X	.	MFN-1272
MFN-1261	.	.	X	X	X	.	X	.	.	.	.	X	.	X	X	.	MFN-1261
MFN-4426	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	MFN-4426
MFN-4427	.	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	MFN-4427
MFN-1262	.	X	X	X	X	.	X	X	X	.	.	X	.	X	X	.	MFN-1262
MFN-4428	.	.	.	X	.	.	X	.	.	.	.	X	.	X	.	.	MFN-4428
MFN-1263	.	.	X	X	X	.	X	.	.	.	.	.	.	X	X	.	MFN-1263
MFN-1264	.	.	X	.	X	.	X	.	.	.	.	.	.	X	X	.	MFN-1264
MFN-1265	X	X	X	.	X	.	X	.	.	.	.	.	.	X	X	.	MFN-1265
MFN-1266	.	.	X	X	X	.	X	.	.	.	.	X	.	X	X	.	MFN-1266
MFN-1267	X	.	.	.	.	X	X	X	.	X	.	X	.	X	X	X	MFN-1267

Checklist 4. Nannofossil distribution in Breton Bay #1 and #5 coreholes, Perth Basin.

	ACTINOZYGUS REGULARIS	ACUTURRIS SCOTUS	AHMUELLERELLA OCTORADIATA	AMPHIZYGUS BROOKSII BROOKSII	AMPHIZYGUS TESSELATUS	ARKHANGELSKIELLA CYMBIFORMIS	ARKHANGELSKIELLA ORTHOCANCELLATA	ARKHANGELSKIELLA SPECILLATA	AXOPODORHABDUS DIETZMANNI	BIDISCUS CRUCIATUS	BIDISCUS MONOCAVUS	BIDISCUS ROTATORIUS	BIDISCUS SPP.	BISCUTUM BUKRYI BUKRYI	BISCUTUM CF. BLACKII	BISCUTUM CORONUM	BISCUTUM MAGNUM	BISCUTUM MELANIAE	BISCUTUM NOTICULUM	BOLETUVELUM CANDENS	BRAARUDOSPHAERA BIGELOWII	BRAARUDOSPHAERA CF. AFRICANA	BROINSONIA CF. EXPANSA	BROINSONIA DENTATA	BROINSONIA EXPANSA	BROINSONIA PARCA	BROINSONIA PSEUDOPARCA	CALCULITES OBSCURUS	CALCULITES OVALIS	CERATOLITHOIDES ACULEUS	CHIASTOZYGUS AMPHIPONS	CHIASTOZYGUS FESSUS
BRETON BAY #5																																
MFN-2666	X	X	X	.	.	X	.	X	.	.	.	.	X	.	.	X	.	X	X	.	.	.	.	.	.	X	.	X	.	.	.	.
MFN-2667	.	X	X	.	.	X	.	X	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	X
MFN-3025	X	X	X	.	.	X	.	.	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	X
MFN-3024	X	X	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	X	.	.
BRETON BAY #1																																
MFN-3023	.	X	x	.	.	X	.	X	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	?	.	.	.	.	.	X
MFN-3022	.	.	X	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	?	.	.	.	.	.	X
MFN-3021	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	?	.	X	.	X	.	.	.	.	.	.	X	.	.	.	X
MFN-3020	X	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	X	X	.	X	X	.	.	.	?	.	.	.	X	.	X
MFN-3019	X	X	X	.	.	X	.	X	X	.	.	.	.	.	.	.	.	X	X	.	X	.	.	.	.	.	.	.	.	X	.	X
MFN-3018	X	X	X	.	.	X	.	X	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	X	.	X	X	.	.	X
MFN-3017	.	.	X	.	.	X	.	X	.	.	.	.	X	.	.	.	X	X	X	.	.	.	.	.	.	X	.	X	.	.	.	X
MFN-3016	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	.	.	.	.	X	.	.	.	.	.	X
MFN-3015	.	X	X	.	.	X	.	X	.	.	.	.	.	.	.	X	X	X	X	.	.	.	.	?	.	.	.	.	.	.	.	X
MFN-3014	.	X	X	.	.	X	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	?	.	X	.	.	.	X
MFN-2660	X	X	X	.	.	X	X	.	.	.	.	X	X	.	.	.	X	.	X	X	X	.	.	.	.	X	.	.	.	.	.	X
MFN-3013	.	X	X	.	.	X	X	.	.	.	.	X	X	.	.	.	X	X	X	.	X	.	.	.	.	X	.	X	X	.	.	X
MFN-3012	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	X	X	X	X	.	.	.	.	.	.	X	.	.	.	.	.	X
MFN-3011	X	X	X	.	.	X	.	X	.	.	.	.	.	.	.	X	X	X	X	.	X	.	.	.	.	X	.	X	.	.	.	X
MFN-3010	.	X	X	.	.	.	.	X	.	.	.	.	.	.	.	.	X	X	X	.	.	.	.	.	.	X	.	X	X	.	.	X
MFN-3009	.	X	X	.	.	X	.	X	.	.	.	.	.	.	.	X	.	X	X	.	X	.	.	.	.	X	.	X	.	.	.	X
MFN-3008	.	X	X	.	.	X	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	.	.	.	.	X	.	X	X	.	.	X
MFN-3007	.	X	X	.	.	X	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	X
MFN-3006	.	X	X	.	.	X	.	.	.	.	.	X	X	.	.	X	.	.	.	.	X	.	.	X	.	.	.	X	.	.	.	X
MFN-3005	.	X	X	.	.	X	.	X	.	.	.	.	.	.	.	X	.	X	X	.	.	.	.	.	.	X	.	X	.	.	.	X
MFN-3004	.	X	X	.	.	.	.	X	.	.	.	.	.	.	.	X	.	X	X	.	.	.	.	.	.	X	.	X	X	.	.	X
MFN-3003	X	X	X	.	.	.	.	X	.	.	.	.	X	.	.	X	.	X	X	.	.	.	.	X	.	X	.	X	X	.	.	X
MFN-2661	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	X	.	X	.	X	.	.	.	X
MFN-3002	.	X	X	.	.	X	.	X	.	.	.	.	.	.	.	X	.	X	X	X	.	.	.	.	.	X	.	X	.	.	.	X
MFN-3001	X	X	X	.	.	.	X	X	.	.	.	.	.	.	.	.	X	X	X	.	.	.	.	.	.	X	.	X	.	.	.	.
MFN-3000	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.	.	.	X	.	X	.	.	.	.
MFN-2999	.	X	X	.	.	.	.	X	.	.	.	X	.	.	.	.	X	X	X	.	X	.	.	.	.	.	.	X	.	.	.	.
MFN-2662	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.
MFN-2998	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.
MFN-2997	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.
MFN-2996	X	X	X	.	.	.	.	.	.	X	X	X	.	X	.	X	X	X	.	X	X	.	.	.	.	X	.	X	.	X	X	.
MFN-2995	.	X	X	.	.	.	.	.	.	X	.	X	.	X	.	.	.	X	.	.	.	.	.	X	.	X	.	X	.	.	.	.
MFN-2663	.	X	.	.	.	.	?	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.
MFN-2994	X	X	X	X	.	.	.	X	X	.	.	.	X	.	.	X	X	X	.	.	.	.	.	.	.	X	.	X	.	X	.	.
MFN-2993	X	.	X	X	.	.	.	X	.	.	.	.	.	.	.	?	X	X	.	.	.	.	.	X	.	X	.	.	.	.	.	.
MFN-2992	X	.	X	.	X	.	.	X	.	.	.	.	.	.	.	?	X	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.
MFN-2991	.	.	X	X	X	.	.	X	.	.	.	.	.	.	.	X	X	X	.	.	.	.	.	X	.	X	.	.	.	.	.	.
MFN-2990	X	.	X	X	.	.	X	X	.	.	.	.	X	.	.	.	X	X	.	.	.	.	.	X	.	X	.	X	.	.	.	.
MFN-2989	X	.	X	X	.	.	.	X	X	.	.	X	.	.	.	?	X	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.
MFN-2664	.	X	X	.	.	.	X	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.	.
MFN-2988	X	X	X	.	.	.	.	X	.	.	.	X	X	.	.	X	X	.	.	.	.	.	.	X	.	X	.	X	.	.	.	.
MFN-2987	X	X	X	X	.	.	X	X	.	.	.	.	X	X	.	X	X	.	.	.	X	.	X	.	.	X	.	X	X	.	.	.
MFN-2986	X	X	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	X	.	X	X	.	.	.
MFN-2985	X	X	X	.	X	.	X	X	.	.	.	.	.	.	.	X	.	X	X	X	.	.	.	X	X	X	.	X	X	.	.	.
MFN-2984	.	X	X	.	X	.	.	X	.	.	.	.	.	.	.	?	.	X	.	.	X	X	X	X	X	.	X	X	X	.	.	.
MFN-2665	X	X	X	.	X	.	.	.	.	.	.	.	X	.	.	?	.	X	.	.	.	.	X	X	.	.	X	X	X	.	.	.

Checklist 4 (continued)

	CHIASTOZYGUS LITTERARIUS	CLINOZYGUS SYNQUADRIPERFORATUS	COROLLITHION EXIGUUM	COROLLITHION GEOMETRICUM	COROLLITHION RHOMBICUM RHOMBICUM	COROLLITHION RHOMBICUM SYMETRICUM	COROLLITHION SIGNUM	CRETARHABDUS CONICUS	CRETARHABDUS LORIEI	CRETARHABDUS SURRIRELLUS	CRIBROSPHAERELLA CIRCULA	CRIBROSPHAERELLA DANIAE	CRIBROSPHAERELLA EHRENBERGII	CYCLAGELOSPHAERA BERGERI	CYCLAGELOSPHAERA COLUMNATA	CYCLAGELOSPHAERA MARGERELI	CYCLAGELOSPHAERA PERFORATA	CYLINDRALITHUS BIARCUS	CYLINDRALITHUS SERRATUS	DODEKAPODORHABDUS NOELII	EIFFELLITHUS AFF. EXIMIUS	EIFFELLITHUS DISSIMILIS	EIFFELLITHUS EXIMIUS	EIFFELLITHUS TRABECULATUS	EIFFELLITHUS TURRISEIFFELI	GARTNERAGO OBLIQUUM	GARTNERAGO STRIATUM	GEPHYRORHABDUS CORONADVENTUS	GRANTARHABDUS CAMARUTUS	GRANTARHABDUS PUNCTATUS	HELICOLITHUS ANCEPS	HETERORHABDUS SINUOSUS	KAMPTNERIUS MAGNIFICUS
BRETON BAY #5																																	
MFN-2666	X	.	X	.	.	.	.	X	.	.	.	X	X	.	X	X	.	.	?	.	.	.	X	.	X	X	.	.	.	.	.	.	X
MFN-2667	X	.	X	.	X	.	.	X	.	X	.	X	X	.	.	X	.	.	.	.	.	X	.	X	X	X	.	.	X	.	.	X	X
MFN-3025	X	.	X	X	.	.	.	X	.	X	X	.	X	.	.	X	.	.	.	.	.	.	X	.	X	?	.	.	X	.	.	.	X
MFN-3024	.	.	.	.	X	.	.	X	X	X	.	X	X	.	.	.	.	.	.	.	.	.	X	.	X	?	.	.	X	.	.	X	X
BRETON BAY #1																																	
MFN-3023	X	.	X	.	X	.	.	X	.	X	.	X	X	.	.	X	.	.	.	.	.	X	.	X	X	.	.	.	.	.	.	.	X
MFN-3022	X	X	X	.	X	X	.	.	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	X	.	.	X	X
MFN-3021	X	.	.	.	X	.	.	X	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	X	.	.	X	X
MFN-3020	X	.	.	.	.	.	.	X	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	X
MFN-3019	X	.	X	.	X	.	.	X	.	X	.	X	X	.	.	.	.	.	X	.	.	.	X	.	X	X	.	.	X	.	.	.	X
MFN-3018	X	.	X	.	X	.	.	X	X	.	.	X	X	.	.	X	.	.	.	.	.	.	X	.	X	X	.	.	X	.	.	X	X
MFN-3017	X	.	.	X	.	.	.	X	.	.	.	X	X	.	.	X	.	.	X	.	.	.	.	.	X	X	.	.	X	.	.	X	X
MFN-3016	X	.	X	.	X	.	.	X	.	.	.	X	X	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	.	.	.	X	X
MFN-3015	X	.	X	.	.	.	.	X	X	X	.	X	X	.	.	.	.	.	X	.	.	.	.	.	X	X	.	.	X	.	.	.	X
MFN-3014	X	.	.	.	X	.	.	X	X	.	.	X	X	.	.	.	.	.	X	.	.	.	X	.	X	X	.	.	X	.	.	.	X
MFN-2660	X	.	X	X	X	.	.	X	X	.	.	X	X	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	X	.	.	.	X
MFN-3013	X	.	.	X	X	.	.	X	X	X	.	X	X	.	.	.	.	.	.	.	.	.	X	.	X	X	X	.	.	.	.	.	X
MFN-3012	X	.	X	.	X	.	.	X	X	X	.	X	X	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	X	.	.	.	X
MFN-3011	X	.	X	.	X	.	.	X	.	.	.	X	X	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	X	.	.	.	X
MFN-3010	X	.	.	.	.	.	.	X	X	.	.	X	X	.	.	X	.	.	.	.	.	.	X	.	X	X	.	.	X	.	.	.	X
MFN-3009	X	.	.	.	X	.	.	.	.	X	.	X	X	.	.	X	.	.	.	.	.	.	.	.	X	X	.	.	X	.	.	X	X
MFN-3008	X	.	.	.	.	.	.	X	.	.	.	X	X	.	.	X	.	.	.	.	.	.	X	.	X	X	.	.	.	.	.	X	X
MFN-3007	X	.	.	.	.	.	.	X	X	.	.	X	X	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	X	.	.	.	X
MFN-3006	X	.	.	X	X	.	.	X	X	X	.	X	X	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	X	.	.	.	X
MFN-3005	X	.	.	.	.	.	.	X	X	X	.	X	X	.	.	X	.	X	.	.	.	.	.	.	X	X	.	.	.	.	.	.	X
MFN-3004	X	.	.	X	X	.	.	X	.	.	.	X	X	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	X	.	.	.	X
MFN-3003	X	.	.	X	.	.	.	X	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	X	.	.	X	X
MFN-2661	X	.	.	.	X	X	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	X	.	.	X	X
MFN-3002	X	.	X	.	X	.	.	X	.	X	.	?	X	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	X	.	.	X	X
MFN-3001	.	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.	X	X	.	.	.	X	.	X	.	.	.	X	.	.	X	X
MFN-3000	X	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	X	.	.	.	.	X	X	X
MFN-2999	X	.	X	.	.	X	.	X	.	.	.	?	X	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	X	.	.	X	X
MFN-2662	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	X	X
MFN-2998	X	.	X	.	.	.	.	X	.	X	.	.	X	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.	X	X	.	X	X
MFN-2997	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	X	X	.	X	X
MFN-2996	X	.	.	.	.	.	.	X	.	X	.	?	.	.	.	.	.	.	.	X	.	.	X	.	X	X	.	.	X	X	.	.	X
MFN-2995	X	.	.	.	X	X	.	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	X	X	.	.	X
MFN-2663	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	X	X	.	X	X	.	.	.	X
MFN-2994	X	.	.	.	.	.	.	X	.	X	.	.	X	X	.	.	.	.	.	X	X	.	.	.	X	X	.	.	X	.	.	X	X
MFN-2993	X	.	X	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	X	X	.	.	X	.	.	X	X
MFN-2992	.	.	X	.	.	.	.	.	.	X	.	.	X	.	.	X	.	X	.	.	.	.	X	.	X	X	.	X	.	.	.	.	X
MFN-2991	X	.	.	.	.	.	.	X	X	.	.	.	X	.	X	.	.	X	.	.	.	.	X	.	X	X	.	.	X	X	.	X	X
MFN-2990	X	.	X	X	.	.	X	X	.	X	.	.	X	.	.	.	.	X	.	.	.	.	X	.	X	X	.	.	X	.	.	X	X
MFN-2989	X	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	X	X	.	X	X
MFN-2664	X	.	X	X	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.	X
MFN-2988	X	.	.	.	.	.	.	X	X	X	.	.	X	.	.	.	?	X	.	.	.	.	X	.	X	X	.	X	X	.	.	X	X
MFN-2987	X	.	.	.	.	.	.	X	X	X	X	.	X	.	X	.	.	X	.	.	.	.	X	.	X	X	.	.	X	X	.	X	X
MFN-2986	X	.	.	.	X	.	.	X	.	X	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	X	.	.	.	.	X	X	X
MFN-2985	X	X	.	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	X	X	.	X	X	.	.	.	X
MFN-2984	X	.	.	.	.	.	X	X	.	X	.	.	X	.	.	.	.	X	.	.	.	.	X	X	X	X	.	X	.	.	.	X	X
MFN-2665	X	.	.	.	X	.	.	X	.	X	.	.	X	.	.	.	.	X	.	X	.	.	X	.	X	X	.	X	.	.	.	X	X

Checklist 4 (continued)

	LAPIDEACASSIS CF. MARIAE	LAPIDEACASSIS CORNUTA	LAPIDEACASSIS MARIAE	LAPIDEACASSIS SIMPLEX	LAPIDEACASSIS SPP.	LITHRAPHIDITES CARNIOLENSIS	LITHRAPHIDITES GROSSOPECTINATUS	LITHRAPHIDITES KENNETHI	LITHRAPHIDITES PRAEQUADRATUS	LITHRAPHIDITES QUADRATUS	LOXOLITHUS ARMILLA	LUCIANORHABDUS CAYEUXII	LUCIANORHABDUS MALEFORMIS	MANIVITELLA GRONOSA	MANIVITELLA PEMMATOIDEA	MARKALIUS ASTROPORUS	MARTHASTERITES FURCATUS	MARTHASTERITES INCONSPICUUS	MICRORHABDULUS BELGICUS	MICRORHABDULUS DECORATUS	MICRORHABDULUS HELICOIDEUS	MICULA CONCAVA	MICULA MURUS	MICULA PRAEMURUS	MICULA STAUROPHORA	MISCEOMARGINATUS PLENIPORUS	MISCEOREPAGULUM TARBOULENSIS	MONOMARGINATUS PECTINATUS	MONOMARGINATUS QUATERNARIUS	NEPHROLITHUS CORYSTUS	NEPHROLITHUS FREQUENS	OTTAVIANUS GIANNUS	PARHABDOLITHUS EMBERGERI
BRETON BAY #5																																	
MFN-2666	.	.	.	.	.	.	X	X	X	X	.	.	.	X	X	X	.	.	X	X	.	X	.	.	X	.	.	X	X	.	X	.	.
MFN-2667	.	.	.	.	.	X	.	.	X	X	.	.	.	X	.	X	.	X	.	X	.	X	.	.	X	.	.	.	.	.	X	.	X
MFN-3025	.	.	.	.	.	X	X	.	X	.	.	X	.	.	X	X	.	.	X	X	.	.	.	.	X	.	.	.	.	.	X	.	.
MFN-3024	.	.	.	.	X	X	.	.	X	X	.	X	.	X	X	.	.	.	X	X	.	.	.	.	X	.	.	.	.	X	X	.	.
BRETON BAY #1																																	
MFN-3023	.	.	.	.	X	X	.	.	X	X	.	.	.	X	.	X	.	.	X	.	.	X	.	.	X	.	.	.	.	X	X	.	.
MFN-3022	.	.	.	.	X	X	.	.	X	X	.	X	.	.	X	X	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	.	.
MFN-3021	.	.	.	.	.	X	.	.	X	X	.	X	.	.	.	X	.	.	X	.	.	X	.	.	X	.	.	.	.	.	X	.	.
MFN-3020	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.	.	.	X	.	.	.	.	.	X	.	.
MFN-3019	.	.	.	.	.	X	.	.	X	X	X	.	.	X	X	.	.	X	X	X	.	.	X	X	X	.	.	.	.	.	X	.	.
MFN-3018	.	.	.	.	.	X	.	.	X	.	.	X	.	X	X	X	.	.	.	X	.	X	.	.	X	.	.	.	.	X	.	.	.
MFN-3017	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	X	.	.	.	X	.	X	.	.	X	.	.	.	X	X	.	.	.
MFN-3016	.	.	.	.	.	X	.	.	.	.	.	X	X	X	.	.	.	.	X	X	.	X	.	.	X	.	.	.	X	X	.	.	.
MFN-3015	.	.	.	.	X	X	.	.	.	.	.	X	.	.	X	.	.	.	X	X	.	X	.	.	X	X	.	.	X	X	?	.	.
MFN-3014	.	.	.	.	X	X	.	.	.	.	.	X	.	X	X	X	.	.	X	.	.	X	.	.	X	.	.	X	X	.	.	.	.
MFN-2660	X	.	.	.	X	X	.	.	.	.	.	X	.	.	.	X	.	X	.	X	.	X	.	.	X	.	.	.	X	.	.	X	.
MFN-3013	.	.	.	.	X	X	.	.	X	.	.	X	.	X	X	.	.	.	X	.	.	X	.	.	X	.	.	.	X	X	.	.	.
MFN-3012	.	.	X	.	X	X	.	.	.	.	.	X	.	X	X	.	.	.	.	.	.	X	.	.	X	.	.	.	X	.	.	.	.
MFN-3011	.	.	.	X	X	X	.	.	.	.	.	X	.	X	X	.	.	.	X	X	.	X	.	.	X	.	.	.	X	X	.	.	.
MFN-3010	.	.	.	.	X	.	.	.	.	.	.	X	.	X	X	X	.	.	.	.	X	X	.	.	X	.	.	.	.	X	.	.	.
MFN-3009	.	.	.	.	.	X	.	.	X	.	.	X	.	.	X	.	.	.	X	X	.	X	.	.	X	.	.	.	X	.	.	.	.
MFN-3008	.	.	.	.	.	X	.	.	.	.	.	X	.	.	X	.	.	.	X	.	.	X	.	.	X	.	.	.	X	X	.	.	.
MFN-3007	.	.	.	.	.	X	.	.	?	.	.	X	.	.	X	.	.	.	X	X	.	X	.	.	X	.	.	.	.	.	.	.	.
MFN-3006	.	.	.	.	.	X	.	.	X	.	.	X	.	X	X	.	.	.	X	.	.	X	.	.	X	.	.	.	.	.	.	.	.
MFN-3005	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	X	.	.	X	X	.	.	.	.	.	.	.
MFN-3004	.	.	.	.	X	X	.	.	.	.	.	X	.	X	.	X	.	.	X	.	.	X	.	.	X	.	.	.	X	X	.	.	.
MFN-3003	.	.	.	.	X	X	.	.	.	.	.	X	.	.	X	X	.	.	X	.	.	X	.	.	X	.	.	.	X	X	.	.	.
MFN-2661	.	.	.	.	.	X	.	.	.	.	.	X	.	.	X	.	.	.	X	.	X	X	.	.	X	X	.	.	.	.	.	.	.
MFN-3002	.	.	.	.	X	X	.	.	?	.	.	X	.	X	X	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	.	.	.
MFN-3001	.	.	.	.	.	X	.	.	.	.	.	X	.	X	X	.	.	.	X	.	.	X	.	.	X	.	.	.	X	.	.	.	X
MFN-3000	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	X	.	.	.	?	.	.	.	.
MFN-2999	.	X	.	.	.	X	.	.	.	.	.	X	.	.	X	.	.	.	X	X	.	X	.	.	X	X	.	X	?	.	.	.	.
MFN-2662	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2998	.	.	.	.	X	X	.	.	.	.	.	X	.	.	X	X	.	.	X	.	.	.	.	.	X	.	.	X	.	.	.	.	.
MFN-2997	.	.	.	.	.	X	.	.	.	.	.	X	.	.	X	X	.	.	X	.	.	X	.	.	.	X	.	.	.	.	.	.	.
MFN-2996	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	.	.	.	X	X	.	X	.	.	X	X	.	X	X	.	.	.	.
MFN-2995	.	.	.	.	.	X	.	.	.	.	.	X	.	X	X	.	.	X	X	X	.	X	.	.	X	X	.	.	.	.	.	.	X
MFN-2663	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.
MFN-2994	.	X	.	.	.	X	.	.	.	.	.	X	.	.	X	.	X	.	.	.	.	X	.	.	X	X	.	X	.	.	.	.	.
MFN-2993	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	X	.	X	X	.	.	X	?	.	X	X	.	.	.	.
MFN-2992	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.	X	.	X	?	.	.	.	X
MFN-2991	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.	.	.	.
MFN-2990	.	X	.	.	.	X	.	.	.	.	.	X	.	X	X	.	.	.	.	.	.	X	.	.	X	X	.	.	X	.	.	.	.
MFN-2989	.	.	.	.	.	X	.	.	.	.	.	X	.	.	X	.	.	.	.	X	.	X	.	.	X	X	X	X	X	.	.	.	.
MFN-2664	.	X	.	.	X	X	.	.	.	.	.	.	X	.	.	.	.	X	X	.	.	X	.	.	X	X	.	.	X	.	.	.	.
MFN-2988	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	X	.	.	X	.	.	X	X	.	.	.	.	.	.	.
MFN-2987	.	.	X	.	.	X	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	.	X	.
MFN-2986	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.	X	X	X	.	X	.	.	.	.
MFN-2985	X	.	.	.	X	X	.	.	.	.	.	X	X	.	.	.	.	.	X	.	.	X	.	.	X	X	.	.	X	.	.	.	.
MFN-2984	X	.	.	.	.	X	.	.	.	.	.	X	X	.	.	.	.	.	X	X	.	.	.	.	X	.	.	.	.	.	.	.	.
MFN-2665	.	.	.	.	.	X	.	.	.	.	.	X	X	.	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.

Checklist 4 (continued)

	PERCIVALIA CF. POROSA	PERCIVALIA POROSA	PLACOZYGOLITHUS ROEGLII	PLACOZYGUS FIBULIFORMUS	PLACOZYGUS SIGMOIDES	PREDISCOSPHAERA BUKRYI-STOVERI	PREDISCOSPHAERA CRETACEA	PREDISCOSPHAERA GRANDIS	PREDISCOSPHAERA HONJOI	PREDISCOSPHAERA MAJUNGAE	PREDISCOSPHAERA SPINOSA	QUADRUM GARTNERI	QUADRUM GOTHICUM	REINHARDTITES AFF. LEVIS	REINHARDTITES ANTHOPHORUS	REINHARDTITES BIPERFORATUS	REINHARDTITES LEVIS	REPAGULUM PARVIDENTATUM	RETACAPSA SCHIZOBRACHIATA	RHABDOPHIDITES MOESLENSIS	RHAGODISCUS AFF. RENIFORMIS	RHAGODISCUS ANGUSTUS	RHAGODISCUS ASPER	RHAGODISCUS RENIFORMIS	RHAGODISCUS SPLENDENS	SCAPHOLITUS FOSSILIS	SERIBISCUTUM PRIMITIVUM	SOLLASITES HORTICUS	SOLLASITES LOWEI	STEPHANOLITHION LAFFITTEI	TEICHORHABDUS ETHMOS	TETRAPODORHABDUS DECORUS	TORTOLITHUS HALLII
BRETON BAY #5																																	
MFN-2666	.	.	.	X	.	X	X	.	.	X	X	.	.	.	.	.	.	.	.	X	.	X	.	X	.	X	.	.	X	X	.	X	.
MFN-2667	.	.	.	X	.	X	X	X	.	X	X	.	.	.	.	.	.	.	.	.	.	X	X	X	.	X	.	.	.	.	.	X	.
MFN-3025	.	.	.	X	.	.	X	.	.	X	X	.	.	.	X	.	?	.	.	.	.	X	.	X	.	X	.	.	.	X	.	X	.
MFN-3024	.	.	.	X	.	X	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	.	.	.	X	.
BRETON BAY #1																																	
MFN-3023	.	.	.	X	.	.	X	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	X	.	X	.
MFN-3022	.	.	.	X	.	X	X	.	.	.	X	.	.	.	.	X	.	.	.	X	.	X	.	X	.	X	.	.	.	.	.	X	.
MFN-3021	.	.	.	X	.	.	X	.	.	.	X	.	.	.	X	X	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	X	.
MFN-3020	.	.	.	.	.	.	X	X	.	X	X	.	.	.	?	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.
MFN-3019	.	.	.	X	.	.	X	X	.	X	X	.	.	.	.	.	.	.	X	.	.	X	.	X	X	X	.	.	.	X	.	X	.
MFN-3018	.	.	.	X	.	.	X	X	.	X	X	.	.	.	X	X	X	.	.	.	.	X	.	.	X	X	.	.	.	.	.	X	.
MFN-3017	.	.	.	X	.	X	X	X	.	.	X	.	.	.	X	.	X	.	.	.	.	X	X	X	.	X	.	.	.	.	.	X	.
MFN-3016	.	.	.	X	X	X	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	X	X	.	.	X	.	.	.	.	.	X	.
MFN-3015	.	.	.	X	.	X	.	X	.	.	X	.	.	.	X	X	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	X	.
MFN-3014	.	.	.	X	.	X	X	X	.	X	X	.	.	.	X	X	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	X	.
MFN-2660	.	.	.	X	.	X	X	X	.	.	X	.	X	.	X	X	X	.	.	.	.	X	.	X	.	.	.	.	.	.	.	X	.
MFN-3013	.	.	.	X	X	X	X	?	.	.	X	.	.	.	X	X	X	.	.	.	.	X	X	.	X	.	.	.	.	.	.	X	.
MFN-3012	.	.	.	X	.	.	X	X	.	.	X	.	X	.	X	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.
MFN-3011	.	.	.	X	.	X	X	X	.	.	X	.	.	.	X	.	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	X	.
MFN-3010	.	.	.	X	X	.	X	X	.	.	.	.	.	.	X	?	X	.	.	.	.	X	X	X	.	X	.	.	.	.	.	X	.
MFN-3009	.	.	.	X	X	.	X	X	.	.	X	.	.	X	X	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	X	.
MFN-3008	.	.	.	X	X	.	X	X	.	.	X	.	.	X	X	.	X	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.
MFN-3007	.	.	.	X	X	.	X	X	.	.	X	.	.	.	X	X	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	X	.
MFN-3006	.	.	.	X	X	.	X	X	.	.	X	.	.	.	X	.	X	.	.	.	.	X	X	.	.	X	.	.	.	.	.	X	.
MFN-3005	.	.	.	X	X	X	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	X	X	X	.	X	.	.	.	.	.	X	.
MFN-3004	.	.	.	X	X	.	X	.	.	.	X	.	.	.	X	.	X	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	.
MFN-3003	.	.	.	X	.	.	X	.	.	.	X	.	.	.	X	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	X	.
MFN-2661	.	.	.	X	X	.	X	X	.	.	X	.	.	.	X	X	X	.	X	.	.	X	X	.	.	X	.	.	.	.	.	X	.
MFN-3002	.	.	.	X	X	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	X	.
MFN-3001	.	.	.	X	.	.	X	.	.	.	X	.	.	.	X	.	X	.	.	.	.	X	.	X	.	X	.	.	.	X	.	X	.
MFN-3000	.	.	.	X	.	X	X	.	X	.	.	.	.	X	X	.	X	.	.	.	.	X	.	X	.	.	.	.	.	.	.	X	.
MFN-2999	.	.	.	X	?	X	.	.	X	.	X	.	X	.	X	.	X	.	.	.	.	X	.	X	.	.	.	X	.	.	.	X	X
MFN-2662	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	X	.	X	.	.	.
MFN-2998	.	.	.	X	.	X	X	.	.	.	X	.	.	.	X	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.
MFN-2997	X	.	.	X	.	X	X	.	.	.	.	.	X	.	X	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-2996	.	.	.	X	?	X	X	.	.	.	X	.	X	X	X	.	X	X	X	.	.	X	.	.	X	X	.	X	.	.	X	X	.
MFN-2995	.	.	.	X	.	X	X	.	X	.	X	.	?	.	X	.	X	X	.	.	.	X	X	?	.	X	.	X	X	.	X	X	.
MFN-2663	X	.	.	.	.	.	X	.	.	.	X	.	.	X	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	X	.
MFN-2994	.	.	.	X	X	.	X	.	.	.	.	.	X	.	X	.	.	.	X	.	X	.	.	.	.	X	.	.	.	.	.	X	.
MFN-2993	.	.	X	X	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	X	.
MFN-2992	.	.	X	X	?	.	X	.	X	.	X	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
MFN-2991	X	.	.	.	?	X	X	X	X	.	X	.	X	.	X	.	.	X	X	.	.	X	.	.	.	X	.	.	.	.	.	X	.
MFN-2990	X	.	X	.	?	.	.	.	.	.	X	.	.	.	X	.	.	X	.	.	.	X	.	.	X	.	.	X	.	X	.	X	.
MFN-2989	.	.	X	.	.	.	X	.	.	.	X	.	.	X	X	.	.	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.
MFN-2664	X	.	.	.	.	.	X	.	.	.	X	.	.	X	X	.	.	X	.	.	.	X	.	.	.	.	?	X	.	X	.	X	.
MFN-2988	.	.	X	.	.	X	.	.	.	.	X	.	.	X	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	X	.
MFN-2987	.	X	X	.	.	.	X	.	X	.	X	.	.	X	X	.	.	X	X	.	.	X	.	X	X	.	.	X	.	X	X	X	.
MFN-2986	.	.	.	X	.	.	X	.	.	.	X	.	.	X	X	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	.	X	.
MFN-2985	.	.	.	.	.	.	X	.	.	.	X	.	.	X	X	X	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	X	.
MFN-2984	.	.	.	.	.	.	X	.	.	.	X	.	.	?	X	X	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.
MFN-2665	.	.	.	X	.	.	X	.	.	.	X	X	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.

Checklist 4 (continued)

	TRANOLITHUS EXIGUUS	TRANOLITHUS GABALUS	TRANOLITHUS ORIONATUS	VEKSHINELLA AACHENA	VEKSHINELLA ARA	VEKSHINELLA DENTATA	VEKSHINELLA DIBRACHIATUS	VEKSHINELLA DORFI	VEKSHINELLA ELLIPTICA	VEKSHINELLA IMBRICATA	VEKSHINELLA SOLIDA	WATZNAUERIA BARNESAE	WATZNAUERIA BIPORTA	ZEUGRHABDOLITHUS ACANTHUS	ZYGODISCUS ABBOTTI	ZYGODISCUS BICRESCENTICUS	ZYGODISCUS DEFLANDREI	ZYGODISCUS LACUNATUS	
BRETON BAY #5																			
MFN-2666	.	.	.	X	.	.	.	.	X	.	.	X	.	X	.	.	X	.	MFN-2666
MFN-2667	X	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	X	.	MFN-2667
MFN-3025	X	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	MFN-3025
MFN-3024	X	.	?	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	MFN-3024
BRETON BAY #1																			
MFN-3023	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	X	.	MFN-3023
MFN-3022	X	.	.	X	.	.	X	.	X	X	X	X	.	X	.	.	X	.	MFN-3022
MFN-3021	.	.	X	.	.	.	.	.	X	.	.	X	.	.	.	.	X	.	MFN-3021
MFN-3020	.	.	X	X	.	.	.	.	.	.	.	X	X	.	.	.	X	.	MFN-3020
MFN-3019	.	.	X	.	.	.	.	.	X	.	.	X	.	.	.	.	X	.	MFN-3019
MFN-3018	X	.	X	X	.	.	.	.	.	.	.	X	.	.	.	X	X	.	MFN-3018
MFN-3017	.	.	X	X	.	.	.	.	X	.	.	X	.	.	.	X	X	.	MFN-3017
MFN-3016	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	X	X	.	MFN-3016
MFN-3015	.	.	X	X	.	.	.	.	X	.	.	X	.	.	.	X	X	.	MFN-3015
MFN-3014	X	.	X	.	.	.	.	.	.	.	.	X	X	.	.	X	X	.	MFN-3014
MFN-2660	.	.	X	.	.	.	.	.	X	.	.	X	X	.	.	X	X	.	MFN-2660
MFN-3013	X	.	X	X	.	.	.	.	.	.	.	X	.	.	.	X	X	.	MFN-3013
MFN-3012	X	.	X	X	.	.	.	.	X	.	.	X	.	.	.	X	X	.	MFN-3012
MFN-3011	.	.	X	X	.	.	.	.	X	.	.	X	X	.	.	X	X	.	MFN-3011
MFN-3010	.	.	X	X	.	.	.	.	X	.	.	X	.	.	.	X	X	.	MFN-3010
MFN-3009	.	.	X	X	.	.	.	.	X	.	.	X	.	.	.	X	X	.	MFN-3009
MFN-3008	X	.	X	X	.	.	.	.	X	.	.	X	X	.	.	.	.	.	MFN-3008
MFN-3007	.	.	X	X	.	.	.	.	X	.	.	X	.	.	.	X	X	.	MFN-3007
MFN-3006	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	X	.	.	MFN-3006
MFN-3005	X	.	X	X	.	.	.	.	.	.	.	X	.	.	.	X	X	.	MFN-3005
MFN-3004	.	.	X	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	MFN-3004
MFN-3003	X	.	X	X	.	.	.	.	X	.	.	X	.	.	.	X	X	.	MFN-3003
MFN-2661	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	X	.	MFN-2661
MFN-3002	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	X	X	.	MFN-3002
MFN-3001	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X	.	.	MFN-3001
MFN-3000	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	MFN-3000
MFN-2999	.	.	.	.	X	.	.	.	.	.	.	X	X	.	.	.	X	.	MFN-2999
MFN-2662	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	MFN-2662
MFN-2998	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X	.	.	MFN-2998
MFN-2997	.	.	.	.	X	.	.	.	.	.	.	X	X	.	.	X	.	.	MFN-2997
MFN-2996	.	.	.	.	X	.	.	.	X	.	.	X	X	.	.	X	.	.	MFN-2996
MFN-2995	X	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X	.	X	MFN-2995
MFN-2663	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	MFN-2663
MFN-2994	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	MFN-2994
MFN-2993	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X	.	.	MFN-2993
MFN-2992	.	.	.	.	X	.	.	.	.	.	.	X	X	.	X	.	.	.	MFN-2992
MFN-2991	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X	.	X	MFN-2991
MFN-2990	.	.	.	.	X	.	.	.	X	.	.	X	.	.	X	X	.	X	MFN-2990
MFN-2989	.	.	.	.	X	.	.	.	.	.	.	X	X	.	.	X	.	.	MFN-2989
MFN-2664	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	MFN-2664
MFN-2988	X	.	.	.	X	.	.	.	.	.	.	X	X	.	X	X	.	X	MFN-2988
MFN-2987	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	X	.	.	MFN-2987
MFN-2986	X	.	.	.	X	.	.	X	X	.	.	X	X	.	.	X	X	X	MFN-2986
MFN-2985	X	.	.	X	X	X	.	.	.	.	.	X	X	.	.	X	.	.	MFN-2985
MFN-2984	.	.	X	.	X	.	.	.	X	.	.	X	X	.	.	.	.	X	MFN-2984
MFN-2665	.	X	X	.	X	.	.	.	.	.	.	X	.	.	.	X	.	.	MFN-2665

Checklist 5. Nannofossil distribution in outcrops at Toolonga Hills and Alinga Point, southern Carnarvon Basin.

	ACUTURRIS SCOTUS	AHMUELLERELLA OCTORADIATA	AMPHIZYGUS TESSELATUS	ARKHANGELSKIELLA CYMBIFORMIS	ARKHANGELSKIELLA SPECILLATA	BISCUTUM BUKRYI BUKRYI	BISCUTUM BUKRYI NANUM	BISCUTUM CORONUM	BISCUTUM MELANIAE	BISCUTUM NOTICULUM	BROINSONIA AFF. PARCA	BROINSONIA BUKRYI	BROINSONIA CF. EXPANSA	BROINSONIA DENTATA	BROINSONIA EXPANSA	BROINSONIA PARCA	BROINSONIA PSEUDOPARCA	CALCULITES OBSCURUS	CALCULITES OVALIS	CHIASTOZYGUS LITTERARIUS	CRETARHABDUS CONICUS	CRETARHABDUS SURRIRELLUS	CRIBROCORONA GALLICA	CRIBROSPHAERELLA CIRCULA	CRIBROSPHAERELLA EHRENBERGII	CYCLAGELOSPHAERA ROTACLYPEATA	CYLINDRALITHUS BIARCUS	EIFFELLITHUS AFF. EXIMIUS	EIFFELLITHUS EXIMIUS	EIFFELLITHUS TRABECULATUS	EIFFELLITHUS TURRISEIFFELI	EPROLITHUS FLORALIS	GARTNERAGO OBLIQUUM
ALINGA POINT																																	
MFN-2471	.	.	.	.	X	.	.	.	.	.	.	.	X	X	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.
MFN-2470	.	.	.	.	X	.	.	.	.	.	X	.	.	X	.	.	.	X	.	.	X	.	.	.	X	.	.	.	X	.	X	.	X
MFN-2469	.	X	.	.	X	.	.	.	.	.	X	.	.	X	.	.	.	X	X	.	.	.	X	.	X	.	.	.	.	.	.	.	X
MFN-2468	.	.	.	.	X	.	.	X	.	.	X	.	.	X	.	.	.	X	X	.	.	.	.	.	X	.	X	.	X	.	.	.	X
MFN-2467	X	X	.	.	X	.	.	.	X	.	X	.	.	X	X	.	.	X	X	.	.	X	.	.	X	.	X	.	X	.	X	.	X
MFN-2466	.	X	.	.	.	.	.	.	X	.	X	.	.	.	X	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	.	X
MFN-2465	X	X	.	.	X	.	.	.	X	.	.	.	.	.	X	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X
MFN-2464	X	X	X	.	X	.	.	.	.	.	X	.	.	.	X	.	.	X	X	.	.	X	.	X	.	.	.	.	X	.	.	.	X
MFN-2463	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	.	X
MFN-2462	X	X	.	.	X	.	.	.	.	.	X	X	X	.	X	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X
MFN-2461	X	X	.	.	X	.	X	.	X	.	X	.	X	X	X	.	X	?	X	.	.	X	.	.	.	.	X	.	X	.	.	.	.
MFN-2460	X	X	.	.	X	.	.	.	X	.	X	.	.	X	X	.	X	.	.	.	.	X	.	.	.	.	.	.	X	X	.	.	X
MFN-2459	.	X	.	.	X	.	.	.	.	.	X	.	.	.	X	.	X	X	X	.	.	X	.	.	.	.	X	X	X	.	.	.	X
MFN-2458	.	X	.	?	X	.	.	.	.	.	.	.	.	.	X	.	X	X	X	.	.	X	.	.	.	.	X	.	X	.	.	.	X
MFN-2457	.	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	.	X	.	.	.	.	X	.	X	.	.	.	X
MFN-2456	X	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X
MFN-2455	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.	X
MFN-2454	?	.	.	.	X	.	.	.	X	.	.	.	.	.	X	.	X	.	.	.	.	X	.	.	X	.	X	.	X	.	.	.	.
MFN-2453	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	?	.	.	.	X	.	.	.	.	X	.	X	.	.	.	X
MFN-2452	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.	X
MFN-2451	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X
MFN-2450	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.	X
MFN-2449	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.	X
MFN-2448	X	X	.	.	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	X	.	.	X	.	X	.	X	.	.	.	X
MFN-2447	.	.	.	.	X	.	.	?	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	X	.	X	.	X	.	.	.	X
MFN-2446	.	X	.	.	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	X	.	X	.	X	X	.	X	X
MFN-2445	.	X	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	X	.	X	.	X	X	.	.	X
MFN-2444	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	?	?	.	.	X	.	.	.	.	X	.	X	X	.	.	X
MFN-2443	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TOOLONGA HILLS																																	
MFN-2566	.	.	.	.	.	.	.	?	X	.	X	.	.	X	.	.	.	X	.	.	.	X	.	.	X	X	.	.	X	.	.	.	.
MFN-2565	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.
MFN-2564	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.
MFN-2563	.	X	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	.	X	.	.	.	.
MFN-2562	.	X	.	.	X	.	.	.	X	X	X	.	.	.	.	.	.	X	.	.	.	X	.	.	X	.	.	.	X	.	X	.	X
MFN-2561	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	.	X	.	.	.	X	.	.	.	.
MFN-2560	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X
MFN-2559	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
MFN-2558	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	X	.	X	.	.	.	.
MFN-2557	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	?	X	.	.	X	.	.	.	.	X	.	X	.	.	.	X
MFN-2556	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	X	.	.	.	X	.	.	.	X
MFN-2555	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	X	.	.
MFN-2554	X	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.	X
MFN-2553	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	X
MFN-2552	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	X	.	X	.	X	.	X
MFN-2551	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	?	.	.	.	X	.	.	.	.	X	.	X	.	.	.	.
MFN-2550	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.	X
MFN-2549	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	X
MFN-2548	X	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	X	.	X	.	X	.	.	.	X

Checklist 5 (continued)

	GEPHYRORHABDUS CORONADVENTUS	GRANTARHABDUS CAMARUTUS	HAQIUS CIRCUMRADIATUS	HETERORHABDUS SINUOSUS	KAMPTNERIUS MAGNIFICUS	LAPIDEACASSIS CF. MARIAE	LAPIDEACASSIS MARIAE	LAPIDEACASSIS SPP.	LITHASTRINUS GRILLI	LITHRAPHIDITES CARNIOLENSIS	LUCIANORHABDUS CAYEUXII	LUCIANORHABDUS MALEFORMIS	MANIVITELLA PEMMATOIDEA	MICRORHABDULUS BELGICUS	MICRORHABDULUS HELICOIDEUS	MICULA CONCAVA	MICULA STAUROPHORA	PETRARHABDUS COPULATUS	PLACOZYGUS FIBULIFORMUS	PLACOZYGUS SIGMOIDES	PREDISCOSPHAERA BUKRYI-STOVERI	PREDISCOSPHAERA CRETACEA	PREDISCOSPHAERA HONJOI	PREDISCOSPHAERA SPINOSA	QUADRUM GARTNERI	REINHARDTITES ANTHOPHORUS	REINHARDTITES BIPERFORATUS	RHAGODISCUS ANGUSTUS	RHAGODISCUS RENIFORMIS	SERIBISCUTUM PRIMITIVUM	STEPHANOLITHION LAFFITTEI	TETRAPODORHABDUS DECORUS	TRANOLITHUS GABALUS
ALINGA POINT																																	
MFN-2471	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
MFN-2470	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.
MFN-2469	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.
MFN-2468	.	.	.	.	X	X	.	.	X	.	X	.	.	.	.	.	.	.	.	?	.	X	.	.	.	X	X	X	X	.	.	X	.
MFN-2467	.	.	.	X	X	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.
MFN-2466	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.
MFN-2465	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	X	X	.	.	.	.	.	.
MFN-2464	X	.	.	X	X	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	X	X	X	.	X	X	.	X	.	.	.	.
MFN-2463	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	X	.	.	.	.	.	.
MFN-2462	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	X	.
MFN-2461	X	.	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.
MFN-2460	?	.	.	.	X	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.	.	.
MFN-2459	.	.	.	X	X	.	.	.	.	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.
MFN-2458	X	.	.	X	X	.	.	.	.	.	X	X	.	X	.	.	.	.	.	.	X	X	.	X	.	X	X	.	.	.	.	X	.
MFN-2457	X	.	.	X	X	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	X	X	.	X	.	X	X	.	.	.	.	.	.
MFN-2456	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.
MFN-2455	.	.	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?	.	.	.	.	.	.	.
MFN-2454	.	.	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.
MFN-2453	.	.	.	X	X	.	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.
MFN-2452	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.
MFN-2451	.	.	.	X	X	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	.	.	.	X	X	.	.	.	.	.	.
MFN-2450	.	.	.	X	X	.	.	.	.	X	X	.	.	.	.	X	.	?	.	.	.	X	.	.	.	X	X	.	.	.	.	.	.
MFN-2449	X	.	.	X	X	X	.	.	.	X	X	.	.	.	X	X	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.
MFN-2448	X	.	.	X	X	.	.	.	.	X	.	.	X	X	X	.	.	.	.	.	.	X	.	.	.	X	.	.	X	.	.	.	.
MFN-2447	X	.	.	X	X	.	.	.	.	X	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	X	X	.	.	.	.	.	.
MFN-2446	X	.	.	X	X	.	.	X	.	X	.	.	X	X	X	.	X	.	.	.	.	X	.	X	X	X	X	?	.	.	?	.	.
MFN-2445	X	.	X	X	X	.	.	X	?	X	.	.	X	X	.	.	?	.	.	.	X	X	.	X	X	?	?	.	.	.	?	.	X
MFN-2444	X	.	.	X	X	.	X	.	.	.	.	.	X	X	X	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.	.	.
MFN-2443	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TOOLONGA HILLS																																	
MFN-2566	.	.	.	X	X	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.
MFN-2565	.	.	.	X	X	.	.	.	.	.	X	.	.	.	.	X	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.
MFN-2564	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
MFN-2563	.	.	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-2562	.	.	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.
MFN-2561	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.
MFN-2560	.	.	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	X	.	.	.	.	.	.
MFN-2559	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2558	.	.	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.
MFN-2557	.	.	.	X	X	.	.	.	.	.	X	.	X	.	X	.	X	.	.	.	.	X	.	X	.	X	X	.	.	.	.	.	.
MFN-2556	.	.	.	X	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	.	.
MFN-2555	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.
MFN-2554	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.
MFN-2553	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-2552	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-2551	.	.	.	X	X	.	.	.	.	.	X	.	X	.	.	X	X	.	.	.	.	X	.	.	.	.	.	.	.	?	.	.	.
MFN-2550	.	.	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.
MFN-2549	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-2548	.	.	.	X	X	.	.	.	.	.	X	.	X	.	X	.	X	.	.	.	.	X	.	.	.	X	X	.	.	X	.	X	.

Checklist 5 (continued)

	TRANOLITHUS ORIONATUS	WATZNAUERIA BARNESAE	WATZNAUERIA BIPORTA	ZYGODISCUS BICRESCENTICUS	ZYGODISCUS LACUNATUS	
ALINGA POINT						
MFN-2471	.	X	.	.	.	MFN-2471
MFN-2470	.	X	X	.	X	MFN-2470
MFN-2469	.	.	.	.	X	MFN-2469
MFN-2468	.	X	X	.	.	MFN-2468
MFN-2467	.	X	.	.	X	MFN-2467
MFN-2466	.	X	X	.	.	MFN-2466
MFN-2465	.	X	.	.	X	MFN-2465
MFN-2464	.	X	.	.	X	MFN-2464
MFN-2463	.	X	.	.	.	MFN-2463
MFN-2462	.	X	.	.	.	MFN-2462
MFN-2461	.	X	.	.	X	MFN-2461
MFN-2460	?	X	.	.	X	MFN-2460
MFN-2459	X	.	.	.	.	MFN-2459
MFN-2458	.	X	X	.	.	MFN-2458
MFN-2457	X	X	X	.	X	MFN-2457
MFN-2456	.	X	X	.	.	MFN-2456
MFN-2455	.	X	.	.	.	MFN-2455
MFN-2454	X	X	.	.	.	MFN-2454
MFN-2453	X	X	.	.	.	MFN-2453
MFN-2452	X	X	.	.	.	MFN-2452
MFN-2451	.	X	X	.	.	MFN-2451
MFN-2450	X	X	X	.	.	MFN-2450
MFN-2449	.	.	.	.	X	MFN-2449
MFN-2448	X	.	.	.	.	MFN-2448
MFN-2447	.	X	.	.	.	MFN-2447
MFN-2446	X	.	.	X	X	MFN-2446
MFN-2445	X	X	.	X	X	MFN-2445
MFN-2444	.	X	.	.	.	MFN-2444
MFN-2443	.	X	.	.	.	MFN-2443
TOOLONGA HILLS						
MFN-2566	.	X	.	.	.	MFN-2566
MFN-2565	.	X	.	.	.	MFN-2565
MFN-2564	X	X	.	.	.	MFN-2564
MFN-2563	.	X	.	.	.	MFN-2563
MFN-2562	.	X	X	.	.	MFN-2562
MFN-2561	.	X	.	.	.	MFN-2561
MFN-2560	.	X	.	.	.	MFN-2560
MFN-2559	.	X	.	.	.	MFN-2559
MFN-2558	.	.	.	.	X	MFN-2558
MFN-2557	X	.	.	.	X	MFN-2557
MFN-2556	.	X	.	.	X	MFN-2556
MFN-2555	X	.	.	.	.	MFN-2555
MFN-2554	.	.	.	.	.	MFN-2554
MFN-2553	.	X	.	.	.	MFN-2553
MFN-2552	.	X	.	.	.	MFN-2552
MFN-2551	.	X	.	.	X	MFN-2551
MFN-2550	.	X	.	.	X	MFN-2550
MFN-2549	.	X	.	.	.	MFN-2549
MFN-2548	.	.	.	.	X	MFN-2548

Checklist 6. Nannofossil distribution in outcrops at Pillarawa Hill, Hamelin Pool, NW Coastal Highway near Wooramel and Yaringa North Station, southern Carnarvon Basin.

	ACUTURRIS SCOTUS	AHMUELLERELLA OCTORADIATA	ARKHANGELSKIELLA SPECILLATA	BISCUTUM MELANIAE	BRAARUDOSPHAERA BIGELOWII	BRAARUDOSPHAERA CF. AFRICANA	BRAARUDOSPHAERA DISCULA	BROINSONIA AFF. PARCA	BROINSONIA CF. EXPANSA	BROINSONIA DENTATA	BROINSONIA EXPANSA	BROINSONIA PARCA	BROINSONIA PSEUDOPARCA	CALCULITES OBSCURUS	CALCULITES OVALIS	CHIASTOZYGUS FESSUS	CHIASTOZYGUS LITTERARIUS	COROLLITHION EXIGUUM	CRETARHABDUS CONICUS	CRETARHABDUS SURIRELLUS	CRIBROSPHAERELLA EHRENBERGII	CYCLAGELOSPHAERA MARGERELI	CYLINDRALITHUS BIARCUS	CYLINDRALITHUS SERRATUS	EIFFELLITHUS AFF. EXIMIUS	EIFFELLITHUS EXIMIUS	EIFFELLITHUS TURRISEIFFELI	EPROLITHUS FLORALIS	GARTNERAGO OBLIQUUM	HETERORHABDUS SINUOSUS	KAMPTNERIUS MAGNIFICUS	LAPIDEACASSIS CORNUTA	LAPIDEACASSIS MARIAE
YARINGA NORTH																																	
MFN-274	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-273	.	X	.	X	.	X	.	.	.	?	.	X	X	X	X	.	.	.	X	.	.	.	X	.	.	X	.	.	X	.	X	.	.
MFN-272	.	X	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	X	.	.	X	X	X	.	.	X	.	X	.	.
MFN-271	.	.	.	X	.	.	.	.	.	.	X	X	.	X	X	.	.	.	.	X	.	.	.	.	.	.	X	.	X	X	.	.	.
MFN-270	.	X	.	X	X	.	.	.	.	?	.	X	.	X	X	.	X	.	.	.	X	.	X	X	.	X	X	.	X	.	X	.	.
MFN-269	.	.	.	X	.	.	.	.	.	X	.	.	.	X	X	.	.	.	.	.	.	.	X	X	.	X	.	.	X	.	X	.	.
MFN-268	.	.	X	X	X	.	.	.	.	X	X	X	.	X	X	.	.	.	.	.	X	X	X	X	.	X	X	.	X	.	X	.	.
NW C. HIGHWAY																																	
MFN-397	.	X	.	X	X	.	.	.	.	.	.	X	.	.	X	.	.	.	.	X	X	.	.	.	.	X	X	.	X	X	X	.	.
MFN-396	.	.	.	.	X	.	.	.	.	X	.	.	.	.	X	.	.	.	.	X	X	.	.	.	.	X	X	.	X	.	X	.	.
MFN-395	.	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	X	.	.
MFN-394	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	X	.	.	.	.	.	X	.	X	.	X	.	.
MFN-393	.	X	X	X	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	X	X	.	.	.	.	X	X	.	X	X	.	.	.
MFN-392	.	X	.	.	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	X	X	.	.	.	.	.	X	.	.	X	X	.	.
MFN-391	.	X	X	.	.	.	.	.	.	.	.	X	.	X	X	.	.	.	.	.	X	.	.	.	X	.	X	.	X	.	X	.	.
MFN-390	.	X	.	X	.	.	.	.	.	X	.	X	.	X	X	.	.	.	.	X	X	.	.	.	.	X	X	.	X	X	X	.	.
HAMELIN POOL																																	
MFN-404	.	.	.	.	X	.	.	.	X	X	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	X	X	.	X	.	.	.	.
MFN-403	.	.	.	.	X	.	.	.	.	.	.	X	.	.	X	.	.	.	.	X	X	.	.	.	.	X	X	.	X	.	X	.	.
MFN-402	.	X	.	X	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.
MFN-401	.	X	X	X	X	.	.	.	.	X	.	X	.	X	X	X	X	.	.	.	X	.	.	.	.	X	.	.	X	.	X	.	.
MFN-400	.	.	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.
MFN-399	.	X	X	.	X	.	.	.	.	X	.	X	.	X	X	.	.	.	.	.	X	.	.	.	.	X	X	.	X	.	X	.	.
MFN-398	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	X	.	.	.	.
PILLARAWA HILL																																	
MFN-267	.	X	X	X	X	.	.	X	.	X	.	X	.	X	X	.	.	.	.	X	X	X	.	.	.	X	X	.	X	.	X	X	.
MFN-266	.	X	.	X	.	.	.	X	.	.	.	X	.	X	X	.	.	.	.	.	X	.	.	.	.	X	.	.	X	.	X	.	.
MFN-265	.	X	.	X	X	X	.	X	X	.	X	?	X	X	X	.	.	.	.	.	X	X	.	.	.	X	.	.	X	.	X	.	X
MFN-264	.	X	X	X	.	.	.	.	.	X	X	.	.	X	X	X	.	.	X	X	X	.	.	.	.	X	X	.	X	.	X	.	.
MFN-263	.	X	X	.	.	.	.	.	.	X	X	.	X	X	.	X	.	.	.	X	X	.	.	.	.	X	X	.	X	.	X	.	.
MFN-262	.	X	X	X	.	.	.	.	.	X	X	.	X	X	.	.	.	.	.	X	X	.	.	.	.	X	.	.	X	.	X	.	.
MFN-261	.	X	X	X	.	.	.	.	.	.	X	.	X	X	X	.	.	.	.	X	X	.	X	X	.	X	X	.	X	.	X	.	.
MFN-260	.	X	X	.	.	.	.	.	.	?	X	.	X	X	X	.	.	X	.	X	X	.	X	X	.	X	.	.	X	.	X	.	.
MFN-259	.	.	X	.	.	.	.	.	.	.	.	.	X	X	X	X	.	.	.	X	.	.	X	X	.	X	.	.	X	.	X	.	.
MFN-258	.	X	X	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	.	.	.	X	.	.	X	X	X	.	.
MFN-257	.	X	X	X	.	.	.	.	.	.	X	.	X	X	.	X	.	.	.	X	X	.	X	X	.	X	X	.	X	X	X	.	.
MFN-256	.	X	X	X	.	.	.	.	.	X	X	.	X	X	.	.	.	.	.	X	X	.	X	.	.	X	X	.	X	.	X	.	.
MFN-255	X	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	X	X	.	X	.	.	X	.	X	.	.
MFN-254	X	X	X	X	.	.	.	.	.	.	.	.	X	.	X	X	.	.	.	.	X	.	.	.	.	X	.	.	X	.	X	.	.
MFN-253	.	X	.	X	.	.	X	.	.	.	.	.	.	X	.	X	.	.	X	X	.	.	.	.	.	X	X	X	X	.	.	.	.
MFN-252	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Checklist 6 (continued)

	LITHASTRINUS GRILLI	LITHRAPHIDITES CARNIOLENSIS	LUCIANORHABDUS CAYEUXII	LUCIANORHABDUS MALEFORMIS	MANIVITELLA PEMMATOIDEA	MARKALIUS ASTROPORUS	MICRORHABDULUS DECORATUS	MICRORHABDULUS HELICOIDEUS	MICULA STAUROPHORA	PARHABDOLITHUS EMBERGERI	PETRARHABDUS COPULATUS	PLACOZYGUS FIBULIFORMUS	PLACOZYGUS SIGMOIDES	PREDISCOSPHAERA CRETACEA	PREDISCOSPHAERA SPINOSA	QUADRUM DESCRIPTUM	QUADRUM GARTNERI	REINHARDTITES ANTHOPHORUS	REINHARDTITES BIPERFORATUS	RHAGODISCUS SPLENDENS	SCAPHOLITUS FOSSILIS	STEPHANOLITHION LAFFITTEI	TRANOLITHUS GABALUS	TRANOLITHUS ORIONATUS	VEKSHINELLA ELLIPTICA	VEKSHINELLA IMBRICATA	WATZNAUERIA BARNESAE	ZYGODISCUS BICRESCENTICUS	ZYGODISCUS DEFLANDREI
YARINGA NORTH																													
MFN-274	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-273	.	.	X	.	.	.	.	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-272	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.
MFN-271	.	.	X	.	.	.	.	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.
MFN-270	.	X	X	X	.	.	.	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.
MFN-269	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.
MFN-268	.	X	X	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.
NW C. HIGHWAY																													
MFN-397	.	.	X	.	.	.	.	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.
MFN-396	X	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	.	.	.	.	X	.	.
MFN-395	.	.	X	.	.	.	.	X	X	.	.	.	.	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-394	.	.	X	.	.	.	.	.	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.	.	X	.	.
MFN-393	.	.	X	X	.	.	.	.	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.	.	X	.	.
MFN-392	.	X	X	X	.	.	.	.	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.	.	X	.	.
MFN-391	.	X	X	.	.	X	.	.	X	.	.	.	.	X	X	X	.	X	.	.	.	.	.	.	.	.	X	.	.
MFN-390	.	.	X	.	.	.	.	.	X	.	.	.	.	X	X	X	.	X	.	.	.	.	.	.	.	X	X	.	.
HAMELIN POOL																													
MFN-404	.	.	X	.	.	.	.	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.
MFN-403	.	.	X	.	.	.	.	.	.	.	.	.	.	X	X	X	.	X	.	.	.	.	.	.	.	X	X	.	.
MFN-402	.	.	X	.	.	.	.	.	X	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	.	.	X	.	.
MFN-401	.	.	X	.	.	.	.	.	X	.	.	X	.	X	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.
MFN-400	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.
MFN-399	.	.	X	.	.	.	.	.	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.	.	X	.	.
MFN-398	.	.	X	X	.	.	.	.	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.	.	X	.	.
PILLARAWA HILL																													
MFN-267	.	X	X	X	.	.	X	.	.	.	.	.	.	X	X	X	.	X	.	.	.	.	.	X	X	X	X	X	X
MFN-266	.	X	X	X	.	.	X	.	X	.	.	.	.	X	X	X	.	X	X	.	.	.	X	.	.	.	X	X	X
MFN-265	.	X	X	.	.	.	.	.	X	.	.	.	.	X	X	X	.	X	X	.	.	.	.	.	.	.	X	X	.
MFN-264	.	.	X	X	.	.	X	.	X	.	.	X	.	X	.	.	.	X	.	.	.	.	.	.	X	.	X	X	X
MFN-263	.	.	X	.	.	.	.	X	X	.	.	.	?	X	.	.	X	X	.	.	.	.	.	.	.	.	X	X	X
MFN-262	.	.	X	.	.	.	.	X	X	.	.	.	?	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.
MFN-261	.	.	X	X	.	.	.	X	X	.	?	.	.	X	.	.	.	X	.	.	.	X	.	.	.	.	X	X	.
MFN-260	.	.	X	X	.	.	.	X	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.
MFN-259	.	X	X	X	X	.	.	X	X	.	.	.	?	X	.	.	.	X	.	.	.	.	.	.	.	.	X	X	.
MFN-258	.	X	X	X	X	.	.	.	X	.	.	.	?	X	.	.	.	X	X	.	.	.	.	.	.	.	X	X	.
MFN-257	.	.	X	X	X	.	.	.	X	.	.	.	?	X	X	.	.	X	.	.	.	.	.	.	.	.	X	X	.
MFN-256	.	X	X	X	X	.	.	.	X	.	.	.	.	X	.	X	.	X	.	.	X	.	.	.	.	X	X	X	.
MFN-255	X	.	X	X	.	.	.	X	X	.	.	.	.	X	X	.	.	X	.	.	.	.	.	.	.	.	X	.	.
MFN-254	.	X	X	X	.	.	.	.	X	.	.	.	.	X	.	.	.	X	X	.	.	.	.	.	.	.	X	X	.
MFN-253	.	.	.	.	X	.	.	X	X	X	.	.	.	X	X	.	.	.	X	X	.	X	.	.	.	.	X	X	.
MFN-252	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Checklist 7. Nannofossil distribution in the Upper Cretaceous carbonates at C-Y Creek, Giralia Anticline, northern Carnarvon Basin.

	ACTINOZYGUS REGULARIS	ACUTURRIS SCOTUS	AHMUELLERELLA OCTORADIATA	ANGULOFENESTRELLITHUS SNYDERI	ARKHANGELSKIELLA CYMBIFORMIS	ARKHANGELSKIELLA ORTHOCANCELLATA	ARKHANGELSKIELLA SPECILLATA	AXOPODORHABDUS DIETZMANNI	BIDISCUS CRUCIATUS	BIDISCUS MONOCAVUS	BIDISCUS ROTATORIUS	BIDISCUS SPP.	BISCUTUM BUKRYI BUKRYI	BISCUTUM CF. BLACKII	BISCUTUM CORONUM	BISCUTUM MAGNUM	BISCUTUM MELANIAE	BOLETUVELUM CANDENS	BOLETUVELUM FLABELLATUM	BOLETUVELUM WISEI	BRAARUDOSPHAERA BIGELOWII	BRAARUDOSPHAERA DISCULA	BROINSONIA BUKRYI	BROINSONIA DENTATA	BROINSONIA EXPANSA	BROINSONIA PARCA	BROINSONIA PSEUDOPARCA	CALCULITES OBSCURUS	CALCULITES OVALIS	CERATOLITHOIDES ACULEUS	CHIASTOZYGUS AMPHIPONS	CHIASTOZYGUS FESSUS	CHIASTOZYGUS LITTERARIUS
MFN-359	.	.	X	.	X	X	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-358	.	.	X	.	X	X	X	.	.	.	.	.	.	.	.	.	X	.	.	.	X	X	.	.	.	.	.	.	.	.	.	X	X
MFN-357	X	.	.	.	X	.	X	.	.	X	X	.	.	X	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.
MFN-356	.	.	X	.	X	X	X	X	.	X	X	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.
MFN-355	.	.	X	X	X	X	X	X	X	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X	.	X	.
MFN-354	.	.	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.
MFN-353	X	.	X	X	X	X	X	.	X	.	X	.	.	.	.	.	X	.	.	.	X	.	.	.	.	X	.	.	.	X	.	X	.
MFN-352	.	.	X	X	X	X	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	X
MFN-351	.	.	X	.	X	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	X	X	.	X	.	.	.	.	X
MFN-350	X	.	X	.	X	X	X	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	X	X	.	.
MFN-349	.	.	X	X	X	X	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	X	X	.	X
MFN-348	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
MFN-347	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.
MFN-346	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.
MFN-345	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.
MFN-334	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.
MFN-333	.	.	X	.	.	.	X	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.
MFN-332	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.
MFN-331	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.
MFN-330	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.
MFN-329	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.
MFN-328	.	X	X	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	.	X	.	X
MFN-327	.	X	X	.	.	X	X	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.
MFN-326	.	X	.	.	.	X	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.
MFN-325	.	X	X	X	.	X	X	X	X	.	X	X	X	.	.	.	X	X	.	.	.	.	.	.	.	X	.	X	.	X	.	X	.
MFN-324	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.
MFN-323	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	X	X	X	.
MFN-322	.	.	X	.	X	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.
MFN-321	.	.	X	.	.	.	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	?	.	.	.	.	.
MFN-320	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	.	X	.	X	X	X	.
MFN-319	.	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.
MFN-313	.	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	X
MFN-312	.	.	X	.	.	.	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	X
MFN-311	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X
MFN-310	.	.	X	.	.	X	X	.	.	.	.	.	X	.	.	.	X	.	X	X	.	.	.	.	.	X	.	X	.	X	X	.	.
MFN-309	.	.	X	.	.	X	X	X	.	.	.	.	X	.	.	?	X	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.
MFN-308	X	X	X	.	.	.	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	X	.	X	.	X	X	.	.	.	.
MFN-307	.	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	X	.	X	X	.
MFN-306	X	.	X	.	.	.	X	.	X	.	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	X	.	.	.	.	.	X	.
MFN-305	?	.	X	.	.	.	.	.	.	.	.	.	.	.	.	?	X	.	.	.	.	.	.	X	X	X	.	X	X	.	X	X	.
MFN-304	.	X	X	.	.	.	X	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	X	X	X	X	.	?	X	.	.	.	.
MFN-303	X	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?	X	.	X	.	.	.	.	.	X
MFN-302	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?	.	X	.	.	.	.	.	.	?	X	.	.	.	.	.	X	X	X
MFN-301	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
MFN-300	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Checklist 7 (continued)

	CLINOZYGUS SYNQUADRIPERFORATUS	COROLLITHION EXIGUUM	COROLLITHION GEOMETRICUM	COROLLITHION RHOMBICUM RHOMBICUM	COROLLITHION RHOMBICUM SYMETRICUM	COROLLITHION SIGNUM	CRETARHABDUS CONICUS	CRETARHABDUS LORIEI	CRETARHABDUS SURRIRELLUS	CRIBROCORONA GALLICA	CRIBROSPHAERELLA CIRCULA	CRIBROSPHAERELLA EHRENBERGII	CYCLAGELOSPHAERA COLUMNATA	CYCLAGELOSPHAERA MARGERELI	CYCLAGELOSPHAERA PERFORATA	CYLINDRALITHUS BIARCUS	CYLINDRALITHUS SERRATUS	DODEKAPODORHABDUS NOELII	EIFFELLITHUS AFF. EXIMIUS	EIFFELLITHUS EXIMIUS	EIFFELLITHUS TRABECULATUS	EIFFELLITHUS TURRISEIFFELI	EPROLITHUS FLORALIS	GARTNERAGO OBLIQUUM	GARTNERAGO STRIATUM	GEPHYRORHABDUS CORONADVENTUS	GRANTARHABDUS CAMARUTUS	HAQIUS CIRCUMRADIATUS	HELICOLITHUS ANCEPS	HETERORHABDUS SINUOSUS	KAMPTNERIUS MAGNIFICUS	LAPIDEACASSIS CORNUTA	LAPIDEACASSIS MARIAE
MFN-359	X	.	.	.	.	.	X	.	X	.	X	X	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	X	.	.	.
MFN-358	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	X	.	.	.
MFN-357	.	.	.	.	.	.	X	.	X	.	.	X	.	X	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.
MFN-356	.	.	.	.	.	.	X	X	X	.	.	X	.	X	.	X	X	.	.	X	.	X	.	.	.	.	X	.	.	X	.	.	.
MFN-355	X	X	.	.	.	.	X	.	X	.	.	X	.	X	.	X	X	X	.	.	.	X	.	X	.	.	X	.	.	X	.	.	X
MFN-354	.	X	.	.	.	.	X	.	X	X	.	X	.	.	.	X	X	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.
MFN-353	.	.	.	X	X	.	X	.	X	.	.	X	.	X	.	X	X	X	.	.	X	X	.	X	.	X	.	.	.	X	.	X	X
MFN-352	X	X	.	X	X	.	X	.	X	.	.	X	.	X	X	X	X	X	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.
MFN-351	.	X	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.
MFN-350	.	.	.	.	.	.	X	X	X	.	.	X	.	.	.	X	X	.	.	X	.	X	.	.	.	.	X	.	.	.	.	.	.
MFN-349	.	X	X	.	.	.	X	.	X	.	.	X	.	.	.	X	X	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.
MFN-348	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-347	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.
MFN-346	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.
MFN-345	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	X	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-334	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.
MFN-333	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.
MFN-332	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.
MFN-331	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	X	.	.	.
MFN-330	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.
MFN-329	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	X	X	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.
MFN-328	.	X	.	X	.	.	X	.	X	.	X	X	.	.	.	.	.	.	X	.	.	X	.	X	.	.	X	.	.	X	X	.	X
MFN-327	.	.	.	.	X	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	X	.	X	.	.	X	.	.	.	X	.	.
MFN-326	.	.	X	.	.	.	X	.	X	X	.	X	.	.	.	X	X	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.
MFN-325	.	X	.	X	.	.	X	.	X	.	.	X	.	.	.	X	X	.	.	.	.	X	.	.	X	.	X	.	.	X	X	.	X
MFN-324	.	X	.	.	.	.	X	.	X	.	.	X	.	X	.	X	.	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.
MFN-323	.	.	.	.	.	.	X	.	X	.	.	X	.	X	.	X	.	.	.	.	.	X	.	X	.	.	.	.	.	X	.	.	.
MFN-322	.	X	.	.	.	.	X	.	X	.	X	X	.	X	.	X	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-321	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.	X	X	.	.	.	X	.	.	.	X	.	.	.	X	.	.	.
MFN-320	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.	X	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	X
MFN-319	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.
MFN-313	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	X	.	.	.	.	.	X	.	X	.	.	.	.	.	X	.	.	.
MFN-312	.	X	.	.	.	.	X	.	.	.	.	X	.	.	.	.	X	.	X	.	.	X	.	.	.	.	X	.	.	.	.	.	.
MFN-311	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.	.	.	X	.	.	.
MFN-310	.	X	.	.	.	.	X	.	X	.	.	X	.	X	.	X	.	.	.	X	.	X	.	X	.	?	X	.	.	X	X	.	.
MFN-309	.	X	.	.	.	.	X	.	X	.	X	X	.	X	.	.	X	.	.	.	X	X	.	X	.	.	X	.	.	X	.	.	.
MFN-308	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	X	X	.	.
MFN-307	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	.
MFN-306	.	.	.	.	.	.	X	.	X	.	.	X	X	X	.	X	X	.	.	X	.	X	.	X	X	X	.	.	.	X	X	X	.
MFN-305	.	.	.	.	.	X	.	.	X	.	.	X	.	.	.	X	.	.	.	X	.	X	.	X	.	.	.	X	.	X	X	.	.
MFN-304	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	X	X	.	.
MFN-303	.	.	.	.	.	.	.	.	X	.	X	X	.	.	.	X	.	.	.	X	.	X	X	X	.	X	.	.	.	X	X	.	.
MFN-302	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	X	.	.	.	X	.	X	.	X	.	.	X	X	.	X	X	.	.
MFN-301	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	X	.	.	X	.	X	X	X	.	.	.	X	.	.	.	.	.
MFN-300	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	X	.	.	.	.	.

Checklist 7 (continued)

	LAPIDEACASSIS SIMPLEX	LAPIDEACASSIS SPP.	LAPIDEACASSIS UNCINATA	LITHASTRINUS GRILLI	LITHRAPHIDITES CARNIOLENSIS	LITHRAPHIDITES GROSSOPECTINATUS	LITHRAPHIDITES PRAEQUADRATUS	LITHRAPHIDITES QUADRATUS	LOXOLITHUS ARMILLA	LUCIANORHABDUS CAYEUXII	LUCIANORHABDUS MALEFORMIS	MANIVITELLA GRONOSA	MANIVITELLA PEMMATOIDEA	MARKALIUS ASTROPORUS	MARTHASTERITES FURCATUS	MARTHASTERITES INCONSPICUUS	MICRORHABDULUS BELGICUS	MICRORHABDULUS DECORATUS	MICRORHABDULUS HELICOIDEUS	MICULA CONCAVA	MICULA MURUS	MICULA STAUROPHORA	MISCEOMARGINATUS PLENIPORUS	MISCEOREPAGULUM TARBOULENSIS	NEOCREPIDOLITHUS GINGINENSIS	NEOCREPIDOLITHUS NEOCRASSUS	NEPHROLITHUS FREQUENS	OCTOCYLUS REINHARDTII	PARHABDOLITHUS EMBERGERI	PERCIVALIA CF. POROSA	PERCIVALIA POROSA	PETRARHABDUS COPULATUS	PLACOZYGUS FIBULIFORMUS
MFN-359	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	X	.	.	X	X	.	.	.	.	.	.	.	.	.	.	X
MFN-358	.	.	.	.	X	.	.	X	.	.	.	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	X	.	.	.	.	.	X
MFN-357	.	.	.	.	X	X	X	X	.	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	X	.	.	.	.	.	.	X
MFN-356	.	.	X	.	X	.	.	.	X	.	.	X	X	X	.	X	.	X	.	X	.	X	.	.	.	.	.	.	.	.	.	X	X
MFN-355	.	.	.	.	X	.	X	.	X	.	.	X	X	X	.	X	X	.	.	X	.	X	.	.	.	.	.	X	.	.	.	.	X
MFN-354	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	X	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X
MFN-353	.	X	.	.	X	.	X	.	X	.	.	X	X	X	.	X	.	X	.	X	.	X	.	.	.	.	.	.	.	.	.	.	X
MFN-352	.	.	.	.	X	.	.	.	.	.	.	X	X	X	.	.	X	X	.	X	.	X	.	.	.	.	.	.	.	.	.	.	X
MFN-351	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
MFN-350	.	.	.	.	X	.	.	.	.	.	.	X	X	.	.	X	.	X	.	X	.	X	.	.	.	X	.	.	.	.	.	.	X
MFN-349	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	X	X	.	X	.	.	.	.	.	X	.	.	.	.	.	.	X
MFN-348	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-347	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-346	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.
MFN-345	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	X
MFN-334	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X
MFN-333	X	.	.	?	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	X
MFN-332	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	X	X
MFN-331	.	.	.	.	X	.	.	.	.	X	.	X	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-330	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X
MFN-329	.	X	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.	.	.	.	X
MFN-328	.	.	.	.	X	.	.	.	X	X	.	.	X	X	.	.	.	X	.	X	.	X	.	.	.	X	.	.	.	.	.	X	X
MFN-327	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	X	.	.	X	X
MFN-326	.	X	.	.	X	.	.	.	.	X	.	.	X	.	.	.	X	X	.	X	.	X	.	.	.	X	.	.	.	.	X	.	X
MFN-325	.	.	X	.	X	.	.	.	X	X	.	X	X	.	.	X	X	X	.	X	.	X	.	.	X	X	.	.	.	.	.	X	X
MFN-324	.	X	.	.	X	.	.	.	.	X	.	.	X	X	.	.	X	X	.	X	.	X	.	.	.	.	.	.	X	.	.	X	X
MFN-323	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	X	.	.	X	.	X	.	.	.	.	.	.	X	.	.	X	X
MFN-322	.	.	.	.	X	.	.	.	.	X	.	X	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.	.	.	X	X
MFN-321	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	X
MFN-320	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	X	X	.	.	.	.	.	.	.	.	X	X
MFN-319	.	X	.	.	X	.	.	.	.	X	.	X	X	?	.	X	.	X	.	X	.	X	.	.	.	.	.	.	.	X	.	X	X
MFN-313	.	.	.	.	X	.	.	.	X	X	.	X	X	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.	.	.	X	X
MFN-312	.	X	.	X	X	.	.	.	.	X	.	X	X	.	.	.	X	.	.	X	.	X	.	.	.	.	.	.	.	.	.	?	X
MFN-311	.	.	.	.	X	.	.	.	.	.	.	X	X	.	.	.	X	.	.	X	.	X	X	.	.	.	.	.	.	X	.	X	X
MFN-310	.	X	X	.	X	.	.	.	X	X	.	X	X	.	.	.	X	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	X
MFN-309	.	.	X	.	X	.	X	.	.	X	.	X	X	.	.	X	X	X	X	X	.	X	.	X	.	.	.	.	.	.	.	X	X
MFN-308	.	X	.	X	X	.	.	.	.	X	X	.	X	.	.	.	.	.	X	X	.	X	.	.	.	.	.	.	X	.	.	.	.
MFN-307	.	.	.	X	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-306	.	.	.	X	X	.	.	.	.	X	.	X	X	.	X	X	X	X	X	X	.	X	.	.	.	.	.	.	.	.	X	?	.
MFN-305	.	.	.	X	X	.	.	.	.	X	.	.	X	.	.	.	X	.	.	X	.	X	.	.	.	.	.	.	.	.	.	?	X
MFN-304	.	X	.	X	.	.	.	.	.	X	.	.	X	.	X	.	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	X
MFN-303	.	.	.	X	X	.	.	.	.	.	.	.	X	.	X	.	X	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.	?
MFN-302	.	.	.	X	X	.	.	.	.	.	.	.	X	.	X	.	X	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-301	.	.	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.	X	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.
MFN-300	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Checklist 7 (continued)

	PLACOZYGUS SIGMOIDES	PONTOSPHAERA MULTICARINATA	PREDISCOSPHAERA BUKRYI-STOVERI	PREDISCOSPHAERA CRETACEA	PREDISCOSPHAERA GRANDIS	PREDISCOSPHAERA HONJOI	PREDISCOSPHAERA MAJUNGAE	PREDISCOSPHAERA SPINOSA	QUADRUM DESCRIPTUM	QUADRUM GARTNERI	QUADRUM GOTHICUM	QUADRUM TRIFIDUM	REINHARDTITES AFF. LEVIS	REINHARDTITES ANTHOPHORUS	REINHARDTITES BIPERFORATUS	REINHARDTITES LEVIS	REINHARDTITES MIRABILIS	REPAGULUM PARVIDENTATUM	RETACAPSA SCHIZOBRACHIATA	RHAGODISCUS AFF. RENIFORMIS	RHAGODISCUS ANGUSTUS	RHAGODISCUS ASPER	RHAGODISCUS FISCHERI	RHAGODISCUS RENIFORMIS	RHAGODISCUS SPLENDENS	SCAPHOLITUS FOSSILIS	SOLLASITES HORTICUS	STEPHANOLITHION LAFFITTEI	TEICHORHABDUS ETHMOS	TETRAPODORHABDUS DECORUS	TRANOLITHUS EXIGUUS	TRANOLITHUS ORIONATUS	TUBODISCUS BREVIS
MFN-359	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	X	.	.	X	.	X	.	.	.
MFN-358	.	.	.	X	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
MFN-357	.	.	.	X	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.
MFN-356	.	.	X	X	.	.	.	X	.	.	.	.	.	X	X	X	X	.	.	.	X	X	.	.	.	.	.	.	X	X	.	.	.
MFN-355	.	.	X	X	.	.	.	X	.	.	.	.	X	X	.	.	.	X	.	.	X	X	.	X	X	.	.	X	X	X	.	.	X
MFN-354	.	.	.	X	.	X	.	.	.	.	.	.	.	.	X	X	.	.	.	.	X	.	.	.	.	.	.	.	X	X	.	.	.
MFN-353	.	.	X	X	.	.	.	X	.	.	.	.	.	X	.	X	.	.	.	.	X	.	X	.	.	.	X	.	X	X	.	.	.
MFN-352	X	.	X	X	.	.	.	X	.	.	.	.	.	.	.	X	X	.	.	.	.	.	X	.	.	X	X	X	X	X	.	.	.
MFN-351	.	.	.	X	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
MFN-350	.	.	.	X	X	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	X	X	.	.	X	X	.	.	.	X	.	.	.
MFN-349	.	X	.	X	.	.	.	X	.	.	.	X	X	X	.	X	.	.	.	.	X	X	.	.	X	X	.	X	X	.	.	.	.
MFN-348	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-347	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-346	.	.	.	X	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-345	.	.	.	X	.	.	.	X	X	.	X	X	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	?	.	X	.	.
MFN-334	.	.	.	X	.	.	.	X	.	.	.	.	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-333	X	.	.	X	X	.	.	X	.	.	X	.	X	.	.	X	.	.	.	.	X	.	.	.	.	X	.	.	?	.	.	.	.
MFN-332	.	.	.	X	.	.	.	X	.	.	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-331	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
MFN-330	.	.	.	X	X	.	.	X	.	.	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.
MFN-329	X	.	.	X	.	.	.	X	.	.	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.
MFN-328	X	.	.	X	X	X	X	X	.	.	X	.	.	.	.	X	.	.	.	.	X	X	.	.	X	X	.	.	?	.	.	.	.
MFN-327	X	.	.	X	.	.	.	X	.	.	X	X	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
MFN-326	.	.	.	X	.	.	.	X	.	.	X	X	X	.	.	X	.	.	.	.	X	.	.	.	X	X	X	X	?	X	.	.	.
MFN-325	.	.	X	X	.	.	X	X	.	.	X	X	X	X	.	X	.	.	X	.	X	X	.	.	X	X	X	X	.	X	.	.	.
MFN-324	.	.	.	X	.	X	.	.	.	.	X	X	X	X	.	X	.	.	.	.	.	.	.	.	X	X	.	X	.	.	.	.	.
MFN-323	.	.	.	X	X	.	.	X	.	.	X	X	X	X	.	X	.	.	.	.	X	.	.	.	X	X	.	X	X	.	.	.	.
MFN-322	.	.	.	X	.	.	.	X	.	.	X	X	X	X	.	X	.	.	.	.	.	.	.	.	.	X	?	X	.	.	.	.	.
MFN-321	.	.	.	X	.	.	.	X	X	.	.	.	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
MFN-320	?	.	.	X	.	.	X	X	.	.	X	.	X	X	.	?	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
MFN-319	.	.	.	X	X	.	.	.	.	.	X	X	X	X	.	?	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.
MFN-313	X	.	X	X	.	.	.	X	.	.	X	.	X	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.
MFN-312	.	.	.	X	X	.	.	X	.	.	.	X	X	X	.	X	.	.	.	.	X	.	.	.	X	X	.	X	.	X	.	.	.
MFN-311	?	.	.	X	.	.	.	.	.	.	.	.	X	X	.	X	.	.	.	.	X	.	.	.	.	X	.	X	.	X	.	.	.
MFN-310	.	.	X	.	X	.	.	X	.	.	X	.	X	X	.	.	.	.	.	.	.	X	.	.	X	X	X	X	X	.	.	.	.
MFN-309	.	.	.	X	.	.	.	X	.	.	X	X	X	X	.	X	.	X	X	.	X	X	.	.	X	X	X	X	.	.	.	.	.
MFN-308	?	.	X	X	.	.	.	X	.	.	.	.	.	X	X	.	.	X	.	.	X	.	.	X	.	X	.	X	.	.	X	X	.
MFN-307	?	.	.	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X	.
MFN-306	?	.	.	X	.	X	.	X	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	.	X	.	.	X	.	.	.	X	.
MFN-305	?	.	.	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.
MFN-304	?	.	.	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	?	X	.	X	.	.	.	X	.
MFN-303	.	.	.	X	.	.	.	X	.	X	.	.	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.
MFN-302	.	.	.	X	.	.	.	X	.	X	.	.	.	?	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
MFN-301	.	.	.	X	.	.	.	.	.	X	.	.	.	.	?	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-300	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Checklist 7 (continued)

	VEKSHINELLA AACHENA	VEKSHINELLA ARA	VEKSHINELLA DENTATA	VEKSHINELLA DIBRACHIATUS	VEKSHINELLA DORFI	VEKSHINELLA ELLIPTICA	VEKSHINELLA IMBRICATA	WATZNAUERIA BARNESAE	WATZNAUERIA BIPORTA	WATZNAUERIA CRUCIATA	ZEUGRHABDOLITHUS ACANTHUS	ZYGODISCUS BICRESCENTICUS	ZYGODISCUS DEFLANDREI	ZYGODISCUS LACUNATUS	
MFN-359	.	.	X	.	.	X	.	X	.	.	.	.	.	.	MFN-359
MFN-358	.	.	.	.	.	.	.	X	.	.	.	.	.	.	MFN-358
MFN-357	X	.	.	.	.	.	.	X	.	X	.	.	.	.	MFN-357
MFN-356	.	.	.	.	.	.	X	X	.	.	.	X	X	.	MFN-356
MFN-355	X	.	.	.	.	.	X	X	.	.	.	X	X	.	MFN-355
MFN-354	.	.	.	.	.	.	X	X	.	.	.	X	.	.	MFN-354
MFN-353	.	.	.	X	.	.	X	X	.	.	.	X	.	.	MFN-353
MFN-352	X	.	X	.	.	X	X	X	.	.	?	X	.	.	MFN-352
MFN-351	.	.	.	.	.	.	X	.	.	.	.	.	.	.	MFN-351
MFN-350	.	.	.	.	.	.	X	X	.	.	.	X	.	.	MFN-350
MFN-349	.	.	.	.	.	X	X	X	.	.	.	X	X	.	MFN-349
MFN-348	.	.	.	.	.	.	.	.	.	.	.	.	.	.	MFN-348
MFN-347	.	.	.	.	.	.	.	X	.	.	.	.	.	.	MFN-347
MFN-346	.	.	.	.	.	.	.	X	.	.	.	.	.	.	MFN-346
MFN-345	.	.	.	.	.	.	X	X	.	.	.	.	.	.	MFN-345
MFN-334	.	.	.	.	.	.	.	X	.	.	.	.	.	.	MFN-334
MFN-333	.	.	.	.	.	.	X	X	.	.	.	X	X	.	MFN-333
MFN-332	.	.	.	.	.	.	X	X	.	.	.	.	.	.	MFN-332
MFN-331	.	.	.	.	.	.	.	X	.	.	.	.	.	.	MFN-331
MFN-330	.	.	.	.	.	.	.	X	.	.	.	.	.	.	MFN-330
MFN-329	.	.	.	.	.	.	X	X	.	.	.	.	.	.	MFN-329
MFN-328	X	.	.	.	.	.	X	X	.	.	.	X	.	.	MFN-328
MFN-327	.	.	.	.	X	.	X	X	.	.	.	X	.	.	MFN-327
MFN-326	.	.	.	.	.	.	X	X	.	.	.	X	X	.	MFN-326
MFN-325	X	X	.	X	.	X	X	X	.	.	.	X	X	.	MFN-325
MFN-324	.	.	.	.	.	.	X	X	.	.	.	.	.	.	MFN-324
MFN-323	.	.	.	.	.	.	X	.	.	.	.	X	X	X	MFN-323
MFN-322	.	.	.	.	.	.	X	.	.	.	.	X	X	.	MFN-322
MFN-321	.	.	.	.	.	.	X	X	.	.	.	.	.	.	MFN-321
MFN-320	.	.	.	.	.	.	X	X	.	.	.	X	X	.	MFN-320
MFN-319	.	.	.	.	.	.	X	X	.	.	.	X	X	.	MFN-319
MFN-313	X	.	X	.	.	.	X	X	X	.	.	X	X	.	MFN-313
MFN-312	.	.	.	.	.	.	X	.	.	.	.	X	X	.	MFN-312
MFN-311	.	.	.	.	.	.	X	X	X	.	.	X	X	.	MFN-311
MFN-310	.	.	X	.	.	.	X	X	X	.	X	X	X	.	MFN-310
MFN-309	X	.	X	.	.	X	X	X	X	.	?	X	.	.	MFN-309
MFN-308	.	.	.	.	.	.	X	X	X	.	.	.	X	.	MFN-308
MFN-307	.	.	.	.	.	.	.	X	.	.	.	X	X	.	MFN-307
MFN-306	X	.	.	X	.	.	.	X	X	.	.	X	X	.	MFN-306
MFN-305	.	.	.	.	.	.	X	X	.	.	.	X	X	.	MFN-305
MFN-304	.	.	.	.	.	.	X	X	.	.	.	X	X	.	MFN-304
MFN-303	.	.	.	.	.	.	.	X	.	.	.	X	.	X	MFN-303
MFN-302	.	.	.	.	.	.	.	X	.	.	.	X	.	X	MFN-302
MFN-301	.	.	.	.	.	.	.	X	.	.	.	.	.	.	MFN-301
MFN-300	.	.	.	.	.	.	.	X	?	.	.	.	?	.	MFN-300

Checklist 8. Nannofossil distribution in three outcrops of Korojon Calcarenite and Miria Marl, Giralia Anticline, northern Carnarvon Basin.

	ACTINOZYGUS REGULARIS	ACUTURRIS SCOTUS	AHMUELLERELLA OCTORADIATA	AMPHIZYGUS TESSELATUS	ANGULOFENESTRELLITHUS SNYDERI	ARKHANGELSKIELLA CYMBIFORMIS	ARKHANGELSKIELLA ORTHOCANCELLATA	ARKHANGELSKIELLA SPECILLATA	AXOPODORHABDUS DIETZMANNI	BIDISCUS CRUCIATUS	BIDISCUS ROTATORIUS	BIDISCUS SPP.	BISCUTUM BUKRYI BUKRYI	BISCUTUM CORONUM	BISCUTUM MAGNUM	BISCUTUM MELANIAE	BISCUTUM NOTICULUM	BOLETUVELUM FLABELLATUM	BRAARUDOSPHAERA AMPUTANS	BRAARUDOSPHAERA BIGELOWII	BRAARUDOSPHAERA CF. AFRICANA	BRAARUDOSPHAERA DISCULA	BROINSONIA DENTATA	BROINSONIA PARCA	CALCULITES OBSCURUS	CERATOLITHOIDES ACULEUS	CERATOLITHOIDES KAMPTNERI	CHIASTOZYGUS AMPHIPONS	CHIASTOZYGUS FESSUS	CHIASTOZYGUS LITTERARIUS	COROLLITHION EXIGUUM	COROLLITHION RHOMBICUM RHOMBICUM	COROLLITHION RHOMBICUM SYMETRICUM
TWB82 SECTION																																	
MFN-2325	X	.	.	.	.	X	X	X	.	.	.	X	.	.	.	X	X	.	.	X	X	.	.	.	X	X	X	.	X	X	X	.	X
MFN-2324	X	.	.	.	.	X	X	X	.	.	.	.	.	.	.	X	.	.	.	X	.	X	.	.	.	.	.	.	.	X	X	.	.
MFN-2323	X	X	X	.	.	X	X	X	.	.	.	.	.	.	.	X	X	.	.	X	X	.	.	.	.	X	X	.	X	.	.	.	.
MFN-2322	X	X	X	.	.	X	X	X	.	.	.	X	.	.	.	X	X	.	.	X	.	.	.	.	X	X	X	.	X	X	.	.	.
MFN-2321	X	X	X	.	.	X	X	X	X	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X	X	.	.
MFN-2320	X	.	X	.	.	X	X	X	.	.	X	X	.	.	.	X	X	.	.	X	.	.	.	.	.	X	X	.	.	X	X	X	.
MFN-2319	X	X	X	.	.	X	X	X	X	.	X	X	X	.	.	X	X	.	.	X	.	.	.	.	.	X	.	X	X	.	X	.	.
MFN-2318	X	X	X	.	.	X	X	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	.	.	X	.	X	.	.
MFN-2317	X	.	X	.	.	X	X	X	X	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	.	.	X	.	X	.	.
MFN-2316	X	X	X	.	.	X	X	X	.	.	X	X	.	.	.	X	X	.	.	X	X	.	.	.	.	X	.	.	X	.	X	.	.
MFN-2315	X	X	X	.	.	X	.	X	X	.	X	X	.	.	.	X	X	.	.	X	.	.	.	.	.	X	.	.	X	.	X	X	.
MFN-2314	X	X	X	X	X	X	X	X	X	.	X	X	.	.	.	X	X	.	.	X	.	.	.	.	.	X	.	.	X	.	X	.	X
MFN-2313	X	.	X	.	X	X	X	X	X	.	.	X	.	?	.	X	X	.	.	X	.	.	X	.	X	X	.	.	X	.	X	.	.
TOB83 SECTION																																	
MFN-2655	X	.	.	.	.	X	X	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.
MFN-2654	X	.	.	.	.	X	X	X	.	.	.	.	.	.	.	X	X	?	.	.	.	.	.	.	.	?	.	.	.	X	.	.	.
MFN-2653	X	.	.	.	.	X	X	X	X	.	.	.	.	.	.	.	X	.	.	X	X	X	.	.	.	X	X	.	.	X	.	.	.
MFN-2652	X	.	.	.	.	X	X	X	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.
MFN-2651	.	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.
MFN-2650	X	X	X	.	.	X	X	X	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	X	.	.	.	X	X	.	.
MFN-2649	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.
MFN-2648	X	.	X	.	.	X	.	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	.	.	.	X	X	.	X
MFN-2647	X	.	X	.	.	X	X	X	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.	.
MFN-2646	X	X	X	.	.	X	X	X	X	.	.	.	.	.	.	.	X	.	.	X	.	.	.	X	.	X	?	.	.	X	.	.	.
MFN-2645	X	.	.	.	.	X	X	X	X	.	X	X	.	.	X	X	.	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.	.
MFN-2644	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.	.
MFN-2643	X	.	.	.	.	X	.	X	X	.	.	.	.	.	.	X	X	.	.	X	X	.	.	.	.	X	.	.	.	X	.	.	.
MFN-2642	X	X	X	.	X	X	.	X	X	?	X	.	.	.	.	X	X	.	.	.	.	.	.	X	.	X	.	.	.	X	.	.	.
MFN-2641	X	.	X	.	X	X	X	X	X	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	X	X	.	.	.	X	X	.	.
MFN-2640	X	X	X	.	X	X	X	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.	.
MFN-2639	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	X	.	.	.	X	.	.	.
MFN-2638	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	X	.	.	.	X	.	.	.
CY83 SECTION																																	
MFN-2685	X	X	.	.	.	X	X	X	.	.	.	.	.	.	.	X	X	.	.	X	X	X	.	.	.	X	X	.	.	X	.	.	.
MFN-2684	X	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	X	.	.	X	.	X	.	.	.	.	X	.	.	X	.	.	.
MFN-2683	X	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	X	.	.	.
MFN-2682	X	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	X	.	.	X	.	X	.	.	.	.	.	.	.	X	.	.	.
MFN-2681	X	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	X	.	.	.	X	.	.	.
MFN-2680	X	.	.	.	.	X	X	X	.	.	.	.	.	.	.	X	X	.	.	X	.	X	.	.	.	X	.	.	.	X	.	.	.
MFN-2679	X	.	X	.	.	X	X	X	X	.	.	.	.	.	.	.	X	.	X	X	.	.	.	.	.	X	.	.	.	X	.	.	.
MFN-2678	X	.	X	.	.	X	X	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	.	.	.	X	.	X	.
MFN-2677	X	X	X	.	.	X	X	X	.	.	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	X	.	.	.	X	.	X	.
MFN-2676	X	.	X	.	X	X	X	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	X	X	.	.	.	X	.	.	.
MFN-2675	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	X	.	X	.	.	.	X	.	.	.
MFN-2674	X	X	X	.	X	.	.	X	?	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	X	.	.	.
MFN-2673	.	X	X	.	X	X	.	X	X	.	.	.	.	.	.	.	X	.	.	X	.	X	.	X	.	.	.	.	.	X	.	.	.
MFN-2672	X	.	X	.	X	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	X	X	.	.	.	X	.	.	.
MFN-2671	X	.	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	X	.	.

Checklist 8 (continued)

	CRETARHABDUS CONICUS	CRETARHABDUS LORIEI	CRETARHABDUS SURRIRELLUS	CRIBROCORONA GALLICA	CRIBROSPHAERELLA DANIAE	CRIBROSPHAERELLA EHRENBERGII	CYCLAGELOSPHAERA BERGERI	CYCLAGELOSPHAERA MARGERELI	CYCLAGELOSPHAERA PERFORATA	CYLINDRALITHUS BIARCUS	CYLINDRALITHUS SERRATUS	EIFFELLITHUS AFF. EXIMIUS	EIFFELLITHUS DISSIMILIS	EIFFELLITHUS EXIMIUS	EIFFELLITHUS TRABECULATUS	EIFFELLITHUS TURRISEIFFELI	GARTNERAGO OBLIQUUM	GARTNERAGO STRIATUM	GRANTARHABDUS CAMARUTUS	HAQIUS CIRCUMRADIATUS	HELICOLITHUS ANCEPS	HETERORHABDUS SINUOSUS	KAMPTNERIUS MAGNIFICUS	LAPIDEACASSIS CF. MARIAE	LAPIDEACASSIS CORNUTA	LAPIDEACASSIS FASCIATA	LAPIDEACASSIS MARIAE	LAPIDEACASSIS SPP.	LITHRAPHIDITES CARNIOLENSIS	LITHRAPHIDITES KENNETHI	LITHRAPHIDITES PRAEQUADRATUS	LITHRAPHIDITES QUADRATUS	LOXOLITHUS ARMILLA
TWB82 SECTION																																	
MFN-2325	X	.	X	.	.	X	.	X	.	.	.	.	.	.	X	X	X	.	X	.	.	.	.	.	.	.	.	.	X	.	X	X	.
MFN-2324	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.	X	.	.	.	.	.	.	X	.	.	X	.
MFN-2323	X	X	X	X	X	X	.	X	.	.	.	.	.	.	X	X	X	.	X	.	.	X	X	.	.	.	.	X	X	.	X	X	.
MFN-2322	X	X	X	X	.	X	.	.	.	.	X	.	.	.	X	X	X	.	.	.	.	X	.	.	.	.	.	.	X	.	X	X	.
MFN-2321	X	.	X	X	.	X	.	X	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	X	.
MFN-2320	X	.	.	X	X	X	.	X	.	.	.	.	.	.	.	X	?	.	X	.	.	.	.	.	.	.	.	.	X	.	X	X	.
MFN-2319	X	X	X	X	.	X	.	X	X	.	.	.	X	.	X	X	.	.	X	.	X	.	.	.	.	.	.	.	X	X	X	X	.
MFN-2318	X	X	X	X	.	X	.	X	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	X	X	.
MFN-2317	X	.	X	X	.	X	.	X	.	.	.	.	.	X	X	X	X	.	X	.	.	X	.	.	.	X	.	.	X	.	X	X	.
MFN-2316	X	.	X	.	.	X	X	.	.	.	.	.	.	X	X	X	X	.	X	.	.	.	X	.	.	.	.	.	X	.	X	X	X
MFN-2315	X	.	X	.	.	X	.	.	.	.	.	X	.	X	.	X	X	.	X	.	.	.	.	.	.	.	X	.	X	.	X	X	.
MFN-2314	X	X	X	.	.	X	.	X	.	.	.	.	.	X	.	X	.	.	.	.	.	X	X	.	X	.	.	X	X	.	X	.	.
MFN-2313	X	.	X	.	.	X	.	X	.	.	.	.	.	.	X	X	X	.	X	.	.	X	.	.	X	.	X	.	X	.	X	.	.
TOB83 SECTION																																	
MFN-2655	X	X	X	X	.	X	X	.	.	.	.	X	.	.	.	X	.	.	.	X	.	X	.	.	.	.	.	.	.	.	X	X	.
MFN-2654	X	.	X	X	.	X	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	X	.
MFN-2653	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	X	X	.	X	X	.
MFN-2652	X	X	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	X	.
MFN-2651	X	X	.	X	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	X	.
MFN-2650	X	X	X	.	.	X	X	.	.	.	.	.	.	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	X	.	X	X	.
MFN-2649	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.
MFN-2648	X	.	X	.	.	X	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	X	.	.	X	X	.	.	X	.
MFN-2647	X	.	X	.	.	X	.	.	.	.	.	.	.	.	X	X	.	.	X	.	.	X	.	.	.	.	.	.	X	.	X	X	.
MFN-2646	X	.	.	.	.	X	.	X	.	.	.	.	.	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	X	.	X	X	.
MFN-2645	X	.	X	.	.	X	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	X	.	X	.	.
MFN-2644	X	.	X	.	.	X	X	.	.	.	.	.	.	.	X	X	.	.	X	.	.	X	.	.	.	.	.	.	X	.	X	.	.
MFN-2643	X	.	X	.	X	X	X	.	.	.	.	.	.	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	X	.	X	.	.
MFN-2642	X	X	X	X	X	X	.	X	.	.	X	.	.	.	X	X	X	.	X	.	.	X	.	.	X	.	.	.	X	.	X	.	.
MFN-2641	X	X	X	.	.	X	X	X	.	.	X	.	.	X	X	X	?	?	X	.	.	.	.	X	X	.	.	X	X	.	X	.	.
MFN-2640	X	X	X	.	.	X	.	X	.	.	.	.	.	.	.	X	X	.	.	.	.	X	.	.	.	.	.	.	X	.	X	.	.
MFN-2639	X	X	X	.	.	X	.	.	.	.	X	.	.	.	.	X	.	.	.	X	.	X	.	X	.	.	.	X	X	.	.	.	.
MFN-2638	X	X	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	X	.	X	.	.	.	X	X	.	.	.	.
CY83 SECTION																																	
MFN-2685	X	.	X	X	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	?	X	.
MFN-2684	X	.	X	.	.	X	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	X	.	X	X	.
MFN-2683	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	X	.	.	.	.	.	.	X	.	X	X	.
MFN-2682	X	X	X	X	.	X	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	X	.	.	.	.	.	.	X	.	.	X	.
MFN-2681	.	X	X	?	.	X	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.
MFN-2680	X	X	X	.	.	X	.	.	.	.	.	.	.	X	X	X	X	.	.	.	.	X	.	.	.	.	.	.	.	.	X	X	.
MFN-2679	X	X	X	.	.	X	.	.	.	.	.	.	.	X	X	X	.	.	.	.	.	X	.	.	.	.	.	.	X	.	X	X	.
MFN-2678	X	X	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	X	.	X	X	.
MFN-2677	X	X	X	X	.	X	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	X	.	.	.	.	.	.	X	.	X	X	.
MFN-2676	X	X	X	.	.	X	.	.	.	X	X	.	.	X	.	X	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	.	.
MFN-2675	X	X	.	.	.	X	.	.	.	X	X	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	X	X	.	.	.	.
MFN-2674	X	.	X	X	.	X	.	X	.	.	X	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	X	X	.	.	.	.
MFN-2673	X	.	X	.	.	X	.	.	.	X	X	.	.	.	.	X	?	.	.	.	.	X	.	X	.	.	.	.	X	.	.	.	.
MFN-2672	X	.	X	X	.	X	.	X	.	X	X	.	.	.	.	X	?	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.
MFN-2671	X	X	.	X	.	X	.	.	.	X	X	.	.	X	.	X	.	.	.	.	.	X	.	.	.	.	.	X	X	.	.	.	.

Checklist 8 (continued)

	LUCIANORHABDUS CAYEUXII	MANIVITELLA GRONOSA	MANIVITELLA PEMMATOIDEA	MANIVITELLA REDIMICULATUS	MARKALIUS ASTROPORUS	MARTHASTERITES INCONSPICUUS	MICRORHABDULUS BELGICUS	MICRORHABDULUS DECORATUS	MICRORHABDUS HELICOIDEUS	MICULA AFF. MURUS	MICULA CONCAVA	MICULA MURUS	MICULA PRAEMURUS	MICULA PRINSI	MICULA STAUROPHORA	MISCEOREPAGULUM TARBOULENSIS	NEPHROLITHUS CORYSTUS	NEPHROLITHUS FREQUENS	PARHABDOLITHUS EMBERGERI	PETRARHABDUS COPULATUS	PLACOZYGOLITHUS ROEGLII	PLACOZYGUS FIBULIFORMUS	PLACOZYGUS SIGMOIDES	PONTOSPHAERA MULTICARINATA	PREDISCOSPHAERA BUKRYI-STOVERI	PREDISCOSPHAERA CRETACEA	PREDISCOSPHAERA GRANDIS	PREDISCOSPHAERA HONJOI	PREDISCOSPHAERA MAJUNGAE	PREDISCOSPHAERA SPINOSA	QUADRUM TRIFIDUM	REINHARDTITES AFF. LEVIS	REINHARDTITES ANTHOPHORUS
TWB82 SECTION																																	
MFN-2325	.	.	X	.	X	X	X	X	.	.	.	X	X	?	X	.	.	X	.	.	.	X	X	X	X	X	X	.	X	X	.	.	.
MFN-2324	.	.	.	.	.	.	.	X	.	X	.	.	.	.	X	.	.	X	.	.	.	X	.	.	.	X	.	.	.	X	.	.	.
MFN-2323	.	X	X	.	X	X	.	X	.	.	X	X	?	X	X	.	.	X	X	.	.	X	.	.	X	X	X	.	X	X	.	.	.
MFN-2322	.	X	X	.	X	X	.	.	.	X	X	.	.	?	X	.	.	X	X	.	.	X	.	.	.	X	X	.	X	X	.	.	X
MFN-2321	.	X	X	.	.	X	.	.	.	X	X	.	.	.	X	.	.	X	.	.	.	X	.	.	X	X	.	.	X	X	.	.	.
MFN-2320	X	.	.	.	X	X	X	X	.	X	X	.	.	.	X	.	.	X	X	.	.	.	.	X	X	X	X	.	.	X	.	.	.
MFN-2319	.	X	X	X	X	.	X	X	.	X	X	.	.	.	X	X	.	X	X	.	.	X	X	X	X	X	X	.	X	X	.	.	.
MFN-2318	.	X	X	.	.	X	.	X	.	X	X	.	X	.	X	.	.	.	.	.	.	X	X	.	X	X	.	.	X	X	.	.	.
MFN-2317	X	X	X	.	X	.	.	X	.	X	X	.	.	.	X	.	.	X	X	.	.	X	X	X	X	X	X	.	.	X	.	.	.
MFN-2316	X	X	X	.	X	.	X	.	X	.	X	.	.	.	X	.	.	X	X	.	.	X	.	X	X	X	X	.	.	X	.	X	.
MFN-2315	.	X	X	.	X	.	X	X	.	.	X	.	.	.	X	.	.	X	.	.	X	X	X	X	X	X	X	.	.	X	.	.	X
MFN-2314	.	X	X	.	X	X	X	.	.	.	X	.	.	.	X	.	.	.	X	.	.	X	X	X	X	X	X	.	.	X	.	X	.
MFN-2313	.	.	X	.	.	X	X	.	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	X	X	X	.	.	.	X	.	.	.
TOB83 SECTION																																	
MFN-2655	.	X	X	.	.	.	.	.	.	.	X	.	X	X	X	.	.	.	.	X	.	X	X	.	.	X	X	.	X	X	.	.	.
MFN-2654	.	X	X	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	.	X	X	.	X	X	.	.	X
MFN-2653	.	X	X	.	X	X	.	.	.	.	X	.	.	.	X	.	.	X	.	.	.	X	X	X	X	X	X	.	X	X	.	.	X
MFN-2652	.	X	X	.	.	.	.	X	.	.	.	X	X	.	X	.	.	X	.	.	.	X	X	.	.	X	.	.	X	X	.	.	.
MFN-2651	.	X	.	.	X	.	.	.	.	X	X	.	.	.	X	.	.	.	.	.	.	X	X	.	.	X	.	.	.	X	.	.	.
MFN-2650	.	X	X	.	X	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	.	X	.	.	X	X	.	.	X	X	.	.	X
MFN-2649	.	X	X	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X	.	.	X	X	.	.	.
MFN-2648	.	X	.	.	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	X	X	.	X	X	.	.	.	X	.	.	.
MFN-2647	.	X	X	.	.	.	X	.	.	X	X	.	.	.	X	.	.	X	.	.	.	X	.	X	X	X	.	.	X	X	.	.	.
MFN-2646	.	X	X	.	.	.	.	X	.	.	X	.	.	.	X	.	.	X	X	.	.	X	.	.	X	X	X	X	X	X	.	.	X
MFN-2645	.	X	X	.	.	.	.	.	.	X	X	.	.	.	X	.	.	.	X	.	.	X	X	X	X	X	X	X	X	X	.	.	.
MFN-2644	.	X	X	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	.	X	X	.	X	.	X	.	.	.
MFN-2643	.	X	X	.	.	.	X	X	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	X	X	X	.	.	.	X	.	.	.
MFN-2642	.	X	X	.	.	.	.	.	.	X	X	.	.	.	X	.	.	.	X	.	.	X	.	.	X	X	X	X	.	X	?	.	.
MFN-2641	.	X	X	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	X	.	.	X	.	.	X	X	X	X	X	X	.	X	.
MFN-2640	.	X	X	.	.	.	.	X	.	.	X	.	.	.	X	.	X	.	.	.	.	X	X	X	.	X	.	.	X	X	.	.	.
MFN-2639	X	X	X	.	X	.	.	.	.	?	X	.	X	.	X	.	.	.	.	.	.	X	X	.	.	X	.	X	.	X	.	.	X
MFN-2638	X	X	X	.	.	.	.	.	.	.	X	.	.	.	X	.	X	.	X	.	.	.	.	.	.	X	.	.	.	X	.	.	.
CY83 SECTION																																	
MFN-2685	.	X	X	.	X	X	.	.	.	.	X	X	.	X	X	.	.	X	X	?	.	X	X	.	.	X	X	X	X	X	.	.	.
MFN-2684	.	X	X	.	X	X	.	X	.	.	X	X	.	?	X	.	.	.	.	.	.	X	.	.	.	X	X	.	X	X	.	.	.
MFN-2683	.	X	X	.	X	.	.	X	.	.	X	X	.	.	X	.	.	X	.	.	.	X	.	.	.	X	X	.	X	X	.	.	.
MFN-2682	.	X	X	.	.	.	.	X	.	.	X	X	.	.	X	.	.	X	.	.	.	X	X	.	X	X	X	.	X	X	.	.	.
MFN-2681	.	X	X	.	X	.	.	.	.	X	X	.	.	.	X	.	.	X	X	.	.	X	X	.	.	X	.	.	.	X	.	.	.
MFN-2680	.	.	.	.	.	.	X	X	.	X	X	.	.	.	X	.	.	.	.	.	.	X	.	?	X	X	X	.	X	X	.	.	.
MFN-2679	.	X	X	.	X	X	X	X	.	X	X	.	.	.	X	.	.	.	.	.	.	X	.	?	.	X	X	X	.	X	.	.	X
MFN-2678	.	X	X	.	.	.	.	X	.	X	X	.	.	.	X	.	.	X	.	.	.	X	X	X	.	X	X	X	.	X	.	.	.
MFN-2677	.	X	X	.	.	.	.	X	.	X	.	.	.	.	X	.	.	X	.	.	.	X	X	X	.	X	.	.	.	X	.	X	.
MFN-2676	X	X	X	.	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	X	X	.	.	X	.	.	.
MFN-2675	X	X	X	.	X	X	X	X	.	.	X	.	.	.	X	.	X	.	.	.	.	X	.	.	X	X	.	X	.	X	.	.	.
MFN-2674	.	X	X	.	.	.	X	.	.	.	X	.	.	.	.	.	X	X	.	.	.	X	.	.	X	X	.	.	.	X	.	.	.
MFN-2673	.	X	X	.	X	X	X	.	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	?	X	X	.	.	.	X	.	.	X
MFN-2672	.	X	X	.	X	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	?	X	X	.	X	.	X	.	.	.
MFN-2671	.	X	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	?	X	X	X	.	.	X	.	.	.

Checklist 8 (continued)

	REINHARDTITES BIPERFORATUS	REINHARDTITES LEVIS	REINHARDTITES MIRABILIS	RETACAPSA SCHIZOBRACHIATA	RHAGODISCUS ANGUSTUS	RHAGODISCUS ASPER	RHAGODISCUS FISCHERI	RHAGODISCUS RENIFORMIS	RHAGODISCUS SPLENDENS	SCAPHOLITUS FOSSILIS	SOLLASITES HORTICUS	SOLLASITES LOWEI	STEPHANOLITHION LAFFITTEI	TEICHORHABDUS ETHMOS	TETRAPODORHABDUS DECORUS	TRANOLITHUS EXIGUUS	TRANOLITHUS GABALUS	TRANOLITHUS ORIONATUS	VEKSHINELLA AACHENA	VEKSHINELLA ARA	VEKSHINELLA DENTATA	VEKSHINELLA DIBRACHIATUS	VEKSHINELLA DORFI	VEKSHINELLA ELLIPTICA	VEKSHINELLA IMBRICATA	VEKSHINELLA? DELICATUS	WATZNAUERIA BARNESAE	WATZNAUERIA BIPORTA	ZEUGRHABDOLITHUS ACANTHUS	ZYGODISCUS BICRESCENTICUS	ZYGODISCUS DEFLANDREI	ZYGODISCUS LACUNATUS
TWB82 SECTION																																
MFN-2325	.	X	.	.	.	X	.	X	X	X	.	.	X	X	X	.	.	.	X	.	.	.	.	X	.	.	X	.	X	.	X	.
MFN-2324	.	.	.	.	X	.	.	X	.	X	.	.	.	.	.	.	.	?	.	.	.	.	.	X	.	.	X	.	.	.	.	.
MFN-2323	.	X	.	.	X	X	.	X	X	X	.	.	.	X	X	X	X	X	X	.	X	.	.	X	.	.	X	.	X	.	X	.
MFN-2322	.	.	.	.	X	X	.	X	.	X	.	.	X	X	X	.	.	.	X	.	.	.	.	X	.	.	X	X	.	.	.	.
MFN-2321	.	.	.	.	X	.	.	X	X	X	.	.	X	.	X	.	.	X	X	.	.	.	.	X	.	.	X	.	.	.	.	.
MFN-2320	X	X	.	.	X	.	.	X	X	X	.	.	.	X	X	.	.	.	X	.	.	.	.	X	.	.	X	X	.	.	.	.
MFN-2319	.	.	X	X	X	X	.	X	X	X	.	.	X	.	X	.	.	.	X	.	.	X	.	X	X	X	X	X	X	.	.	.
MFN-2318	.	.	.	.	X	.	.	X	.	.	X	.	X	.	X	X	.	.	X	.	.	.	.	X	.	.	X	X	X	.	.	.
MFN-2317	.	?	.	.	X	.	.	X	X	X	X	.	X	.	X	.	.	X	X	.	.	.	.	X	.	.	X	.	.	.	.	.
MFN-2316	.	X	X	.	X	X	.	X	X	X	X	.	X	X	X	.	.	.	X	.	.	.	.	X	X	.	X	X	X	.	.	.
MFN-2315	.	X	.	X	X	X	.	X	X	X	.	.	X	X	X	X	.	.	X	.	X	.	.	X	.	.	X	X	.	.	.	X
MFN-2314	.	X	.	.	X	.	.	X	X	X	X	.	X	.	X	.	.	.	X	.	.	.	.	X	X	.	X	X	.	X	.	.
MFN-2313	.	X	.	X	X	X	.	X	X	X	X	.	X	.	X	.	.	.	X	.	.	.	.	X	.	.	X	X	.	X	.	.
TOB83 SECTION																																
MFN-2655	X	.	.	.	X	.	.	.	X	.	.	.	X	X	X	X	.	.	X	.	.	.	.	X	.	.	X	X	X	.	.	.
MFN-2654	X	.	.	.	X	X	X	.	X	.	.	.	X	X	X	.	.	X	X	.	.	.	.	.	.	.	X	X	X	.	.	.
MFN-2653	.	.	.	X	X	X	.	X	X	.	.	.	X	.	X	X	.	.	X	.	.	.	.	X	X	.	X	.	.	.	.	.
MFN-2652	.	.	.	.	X	X	.	X	X	X	.	.	.	?	X	.	.	X	.	.	.	.	.	.	.	.	X	X	.	.	.	.
MFN-2651	.	.	.	.	X	X	.	.	.	.	.	.	.	X	X	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.
MFN-2650	.	X	.	X	X	.	.	X	X	X	.	.	.	.	X	X	.	.	?	.	.	.	.	X	.	.	X	.	X	.	.	.
MFN-2649	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.
MFN-2648	X	.	.	X	X	.	.	X	.	X	X	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	X	X	X	.	.	.
MFN-2647	.	.	.	.	.	X	.	X	.	.	.	.	.	.	X	X	.	.	?	X	.	X	.	X	.	.	X	.	X	.	.	.
MFN-2646	.	X	.	X	X	X	.	X	X	.	.	.	.	X	X	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.
MFN-2645	.	X	.	.	X	.	.	X	X	.	.	X	.	.	X	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.
MFN-2644	.	X	.	.	X	.	.	X	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.	X	.	.
MFN-2643	.	.	.	.	X	.	.	X	X	.	.	.	X	.	X	.	.	.	X	.	.	.	.	.	.	.	X	X	.	.	.	.
MFN-2642	.	X	.	.	X	.	.	X	.	.	.	.	.	X	X	X	.	.	X	.	.	.	.	X	.	.	X	X	.	X	.	.
MFN-2641	.	X	.	X	X	X	.	X	X	X	X	.	X	.	X	X	X	.	X	.	.	.	.	X	.	.	X	X	.	X	.	.
MFN-2640	X	X	.	.	.	X	.	X	.	.	.	.	.	X	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	X	.	.
MFN-2639	.	X	.	.	X	X	.	.	.	.	.	.	.	X	X	X	?	?	X	.	.	.	.	.	.	.	X	.	.	X	.	.
MFN-2638	.	X	.	.	X	.	.	X	X	.	.	.	.	X	X	X	.	.	X	.	.	.	.	.	.	.	X	.	.	X	.	.
CY83 SECTION																																
MFN-2685	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.
MFN-2684	.	.	.	X	X	X	.	X	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.
MFN-2683	.	X	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.
MFN-2682	.	.	.	.	X	.	.	X	X	.	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.
MFN-2681	.	X	.	.	X	X	.	X	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.
MFN-2680	.	.	.	.	X	X	.	X	X	.	.	.	.	X	X	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.
MFN-2679	.	.	.	X	X	X	.	X	.	.	.	.	.	X	X	X	.	.	X	.	.	.	.	.	.	.	X	X	.	.	.	.
MFN-2678	.	.	.	.	X	X	.	X	.	.	.	.	.	X	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.
MFN-2677	X	X	.	.	X	X	.	X	X	.	.	.	X	X	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	X	.	.
MFN-2676	.	X	.	.	.	X	.	X	.	.	.	.	.	X	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	X	.	.
MFN-2675	X	X	.	.	.	X	.	.	.	.	.	.	.	X	X	X	X	X	?	.	.	.	.	.	.	.	X	.	.	X	.	.
MFN-2674	X	X	.	.	.	X	.	X	X	.	X	.	.	X	X	X	?	X	?	.	.	.	.	.	.	.	X	.	.	X	.	.
MFN-2673	X	X	.	.	X	.	.	.	X	X	X	.	X	.	X	X	.	X	?	.	.	.	.	X	.	.	X	X	.	X	.	.
MFN-2672	.	X	.	.	X	.	.	X	X	.	.	.	.	.	X	X	.	.	?	.	.	.	.	.	.	.	X	.	.	X	.	.
MFN-2671	.	X	.	.	X	X	.	X	.	.	.	.	.	X	X	.	.	.	?	.	.	.	.	.	.	.	X	X	.	X	.	.

Checklist 9. Nannofossil distribution in three Rough Range wells, Hope Island #1, Tortoise #1 and Pasco #1 wells, northern Carnarvon Basin.

	ACTINOZYGUS REGULARIS	ACUTURRIS SCOTUS	AHMUELLERELLA OCTORADIATA	AMPHIZYGUS BROOKSII BROOKSII	AMPHIZYGUS TESSELATUS	ARKHANGELSKIELLA CYMBIFORMIS	ARKHANGELSKIELLA ORTHOCANCELLATA	ARKHANGELSKIELLA SPECILLATA	BIDISCUS ROTATORIUS	BISCUTUM CORONUM	BISCUTUM MELANIAE	BISCUTUM NOTICULUM	BRAARUDOSPHAERA BIGELOWII	BROINSONIA AFF. PARCA	BROINSONIA BUKRYI	BROINSONIA DENTATA	BROINSONIA EXPANSA	BROINSONIA PARCA	BROINSONIA PSEUDOPARCA	CALCULITES OBSCURUS	CALCULITES OVALIS	CERATOLITHOIDES ACULEUS	CHIASTOZYGUS FESSUS	CHIASTOZYGUS GARRISONII	CHIASTOZYGUS LITTERARIUS	COROLLITHION EXIGUUM	COROLLITHION SIGNUM	CRETARHABDUS CONICUS	CRETARHABDUS SURRIRELLUS	CRIBROSPHAERELLA CIRCULA	CRIBROSPHAERELLA EHRENBERGII	CYCLAGELOSPHAERA BERGERI	CYLINDRALITHUS BIARCUS
PASCO #1																																	
MFN-87	.	.	X	.	.	X	.	.	.	.	X	.	X	.	.	.	.	.	.	X	.	X	X	.	.	.	.	X	.	.	X	.	X
MFN-88	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	X	.	X	.	X
TORTOISE #1																																	
MFN-91	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	X	X	X	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.
MFN-92	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.
MFN-93	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.
MFN-94	.	.	X	.	.	.	.	X	.	.	X	.	.	.	X	X	X	X	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.
MFN-95	.	.	.	.	.	.	.	X	.	.	X	.	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.
MFN-96	.	.	X	.	.	.	.	.	.	.	X	.	.	.	X	.	X	.	X	.	.	.	.	.	.	X	.	X	.	.	.	.	.
HOPE ISLE #1																																	
MFN-156	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	X	X	.	.	.	.	.	.	X	X	.	X	.	.
MFN-157	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	X	X	X	.	.	.	X	.	X	X	.	X	.	.
MFN-158	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	X	X	X	X	.	.	.	.	X	.	.	X	.	.
MFN-159	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-160	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	?	.	.	.	.	X	.	.	.	.	.	.	.	X	.	X	.	X
MFN-161	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.
MFN-162	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RRS #1																																	
MFN-1986	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	X	.	.	X	.	.
MFN-1987	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	X	X	X	.	.	X	.	.	X	X	.	X	X	.
MFN-278	.	X	X	.	.	.	X	X	.	.	X	.	.	.	.	.	.	X	.	X	.	X	.	.	X	X	.	X	X	X	X	.	.
MFN-279	X	X	X	.	.	.	.	X	X	.	X	.	.	X	.	X	X	X	.	X	X	.	.	X	X	.	.	X	X	X	X	.	X
MFN-1988	.	?	X	.	.	.	.	X	.	.	X	.	.	X	X	X	.	X	.	X	X	.	.	.	.	.	.	.	.	.	X	.	.
MFN-1989	.	?	X	X	X	.	.	.	.	X	X	X	.	X	.	X	.	.	X	X	.	.	.	.	.	.	.	X	X	.	X	.	X
MFN-1990	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	X	.	X
MFN-1979	.	.	X	.	.	.	.	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	.	X	.	X	.	X
MFN-4429	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	X	.	.	X	.	X	.	X
MFN-1236	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	X
MFN-4430	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.
MFN-1980	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	X	X	X	X	.	X	.	X
MFN-1981	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	X	X	.	.	.	X
MFN-1982	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	X	X	X	.	.	X	.	X	.	.
MFN-1983	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.
MFN-1984	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.
MFN-1985	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ROUGH RANGE #4																																	
MFN-275	.	.	X	.	.	X	.	X	.	.	X	.	.	.	.	.	.	X	.	X	X	X	.	.	.	.	.	X	X	.	X	.	X
MFN-276	X	X	.	.	X	.	.	.	X	.	X	X	.	.	.	.	.	X	.	.	.	X	.	.	X	.	.	.	X	.	X	.	.
ROUGH RANGE #8																																	
MFN-4431	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	X

Checklist 9 (continued)

	CYLINDRALITHUS SERRATUS	EIFFELLITHUS AFF. EXIMIUS	EIFFELLITHUS EXIMIUS	EIFFELLITHUS TRABECULATUS	EIFFELLITHUS TURRISEIFFELI	EPROLITHUS FLORALIS	GARTNERAGO OBLIQUUM	GARTNERAGO STRIATUM	GEPHYRORHABDUS CORONADVENTUS	GRANTARHABDUS CAMARUTUS	HAQIUS CIRCUMRADIATUS	HELICOLITHUS ANCEPS	HETERORHABDUS SINUOSUS	KAMPTNERIUS MAGNIFICUS	LITHASTRINUS GRILLI	LITHRAPHIDITES CARNIOLENSIS	LITHRAPHIDITES PRAEQUADRATUS	LITHRAPHIDITES QUADRATUS	LUCIANORHABDUS CAYEUXII	LUCIANORHABDUS MALEFORMIS	MANIVITELLA GRONOSA	MANIVITELLA PEMMATOIDEA	MARKALIUS ASTROPORUS	MARTHASTERITES FURCATUS	MARTHASTERITES INCONSPICUUS	MICRORHABDULUS BELGICUS	MICRORHABDULUS DECORATUS	MICRORHABDULUS HELICOIDEUS	MICULA CONCAVA	MICULA MURUS	MICULA STAUROPHORA	NEOCREPIDOLITHUS NEOCRASSUS	PARHABDOLITHUS EMBERGERI
PASCO #1																																	
MFN-87	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	X	.	.	.	.	.	.	X	X	X	.	.
MFN-88	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.
TORTOISE #1																																	
MFN-91	.	.	X	.	X	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	X	.	.
MFN-92	.	.	X	.	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.
MFN-93	.	.	X	.	X	.	X	.	.	.	.	.	X	X	X	X	.	.	.	.	.	.	.	X	.	.	.	.	X	.	X	.	.
MFN-94	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.	X	.	.	.	.	X	.	.	.	.
MFN-95	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.	X	X	.	.	.	.	.	X	.	.
MFN-96	.	.	X	.	X	.	X	.	.	.	.	.	.	X	X	X	.	.	X	.	.	.	.	X	.	.	.	.	.	.	X	.	.
HOPE ISLE #1																																	
MFN-156	X	.	.	.	X	.	X	.	.	.	.	.	.	X	.	X	.	.	X	.	.	X	.	.	X	.	.	.	.	.	X	.	.
MFN-157	X	.	.	.	X	.	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	X	X	.	.	.	.	.	.	.	X	.	.
MFN-158	X	.	.	.	X	.	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.	X	.	.	.	.	.	.	.	.	X	.	.
MFN-159	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-160	X	.	X	.	X	X	X	.	.	.	.	.	X	.	.	.	.	.	X	X	.	X	.	X	.	.	.	X	.	.	X	.	.
MFN-161	.	.	X	.	X	X	X	.	.	.	X	.	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.
MFN-162	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RRS #1																																	
MFN-1986	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	?	.	X	.	.	X	.	.	.	.	.	.	X	.	X	.	.
MFN-1987	X	.	.	.	X	.	X	.	.	.	.	.	X	.	.	.	.	.	X	.	.	X	X	.	.	X	X	.	.	.	X	.	.
MFN-278	X	.	X	.	X	.	X	.	.	X	.	.	X	X	.	X	.	.	X	.	.	X	.	.	X	X	X	.	X	.	X	.	.
MFN-279	X	.	X	.	X	.	X	.	.	.	.	.	X	X	?	.	.	.	X	X	.	X	.	X	.	X	.	.	X	.	X	.	.
MFN-1988	X	.	X	.	.	X	X	.	.	.	.	.	.	X	X	X	.	.	X	X	.	X	.	X	.	.	.	.	.	.	X	.	.
MFN-1989	X	.	X	.	X	.	X	.	.	.	.	.	X	X	X	X	?	.	X	X	.	.	.	X	.	X	.	.	.	.	X	.	.
MFN-1990	X	.	X	.	.	X	X	.	X	X	X	.	X	X	X	X	.	.	.	.	.	X	.	X	X	X	X	X	.	.	X	.	X
MFN-1979	X	.	X	.	X	X	X	.	X	.	X	.	X	X	.	X	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.
MFN-4429	.	.	X	.	.	X	X	.	X	.	X	X	.	X	.	X	.	.	.	.	.	X	.	X	.	.	.	X	.	.	.	.	X
MFN-1236	.	.	X	.	X	X	X	.	.	.	.	.	.	X	.	X	.	.	.	.	X	X	.	X	.	.	.	.	.	.	.	.	X
MFN-4430	.	.	X	.	X	X	X	.	X	.	X	X	X	X	.	X	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	X
MFN-1980	.	.	X	.	X	X	X	.	.	.	X	.	X	X	.	X	.	.	.	.	X	X	.	.	X	.	.	X	.	.	.	.	.
MFN-1981	.	.	X	.	X	X	X	.	X	.	.	.	.	X	X	X	.	.	.	.	.	X	.	.	.	.	X	X	.	.	.	.	X
MFN-1982	.	X	.	X	X	X	X	X	X	.	X	.	.	X	?	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	X
MFN-1983	.	.	.	.	X	X	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
MFN-1984	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-1985	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ROUGH RANGE #4																																	
MFN-275	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.	.	.	X	.	.
MFN-276	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	X	.	.	.	.	.	.	X	.	X	X	.
ROUGH RANGE #8																																	
MFN-4431	.	.	X	.	X	X	X	.	X	.	X	.	X	X	.	X	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	X	X

Checklist 9 (continued)

	PETRARHABDUS COPULATUS	PLACOZYGUS FIBULIFORMUS	PLACOZYGUS SIGMOIDES	PREDISCOSPHAERA BUKRYI-STOVERI	PREDISCOSPHAERA CRETACEA	PREDISCOSPHAERA GRANDIS	PREDISCOSPHAERA SPINOSA	QUADRUM DESCRIPTUM	QUADRUM GARTNERI	QUADRUM GOTHICUM	QUADRUM TRIFIDUM	REINHARDTITES AFF. LEVIS	REINHARDTITES ANTHOPHORUS	REINHARDTITES BIPERFORATUS	REINHARDTITES LEVIS	RETACAPSA SCHIZOBRACHIATA	RHAGODISCUS ANGUSTUS	RHAGODISCUS ASPER	RHAGODISCUS RENIFORMIS	RHAGODISCUS SPLENDENS	SCAPHOLITUS FOSSILIS	SOLLASITES HORTICUS	STEPHANOLITHION LAFFITTEI	TETRAPODORHABDUS DECORUS	TRANOLITHUS EXIGUUS	TRANOLITHUS GABALUS	TRANOLITHUS ORIONATUS	VEKSHINELLA AACHENA	VEKSHINELLA DORFI	VEKSHINELLA ELLIPTICA	VEKSHINELLA IMBRICATA	WATZNAUERIA BARNESAE	WATZNAUERIA BIPORTA
PASCO #1																																	
MFN-87	.	X	.	.	X	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
MFN-88	.	X	.	.	X	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	X	X	.
TORTOISE #1																																	
MFN-91	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.
MFN-92	.	.	?	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
MFN-93	.	.	?	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
MFN-94	.	.	?	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
MFN-95	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
MFN-96	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.
HOPE ISLE #1																																	
MFN-156	.	X	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	X	X	.
MFN-157	X	X	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	X	X	X	.
MFN-158	.	X	.	.	X	.	X	.	.	X	.	X	X	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	X	.
MFN-159	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-160	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
MFN-161	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
MFN-162	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RRS #1																																	
MFN-1986	.	X	X	.	X	.	X	.	.	X	.	X	X	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	X	.
MFN-1987	.	X	X	.	X	.	X	.	.	X	X	X	X	.	.	X	X	.	.	.	X	.	X	.	.	.	X	.	.	X	.	X	.
MFN-278	X	X	?	X	.	X	X	.	.	X	X	X	X	.	X	X	.	.	.	.	.	X	X	X	.	.	X	.	.	X	.	X	X
MFN-279	.	.	.	.	X	.	X	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	X	.	X	.
MFN-1988	X	.	.	.	X	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.
MFN-1989	X	.	?	.	X	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	X	.	X	X
MFN-1990	.	.	.	.	X	.	.	.	X	.	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.
MFN-1979	.	.	.	.	X	.	.	.	X	.	.	.	.	X	.	X	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	X	.
MFN-4429	.	.	.	.	X	.	X	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	X	X
MFN-1236	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	X	X	.	.	.	.	X	X
MFN-4430	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	X	X
MFN-1980	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	X	X	.	.	X	.	.	.	.	X	.
MFN-1981	.	.	.	.	X	.	X	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.	.	.	X	X
MFN-1982	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	X	.	.	.	.	X	X	.	.	X	.	.	.	.	X	X
MFN-1983	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
MFN-1984	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
MFN-1985	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
ROUGH RANGE #4																																	
MFN-275	X	X	.	.	X	.	.	X	.	X	X	X	X	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	X	X	X	X	.
MFN-276	X	X	.	.	X	.	.	.	.	X	.	X	X	.	X	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	X	.
ROUGH RANGE #8																																	
MFN-4431	.	X	.	.	X	.	X	.	X	.	.	.	.	.	.	.	X	.	.	.	X	.	X	.	.	.	X	.	.	.	.	X	X

Checklist 9 (continued)

	ZYGODISCUS BICRESCENTICUS	ZYGODISCUS DEFLANDREI	ZYGODISCUS LACUNATUS	
PASCO #1				
MFN-87	.	X	.	MFN-87
MFN-88	X	.	.	MFN-88
TORTOISE #1				
MFN-91	X	X	.	MFN-91
MFN-92	X	X	.	MFN-92
MFN-93	X	X	.	MFN-93
MFN-94	X	X	.	MFN-94
MFN-95	X	X	.	MFN-95
MFN-96	.	.	.	MFN-96
HOPE ISLE #1				
MFN-156	X	X	.	MFN-156
MFN-157	X	X	.	MFN-157
MFN-158	.	.	X	MFN-158
MFN-159	.	.	.	MFN-159
MFN-160	.	.	X	MFN-160
MFN-161	X	X	X	MFN-161
MFN-162	.	.	.	MFN-162
RRS #1				
MFN-1986	.	.	.	MFN-1986
MFN-1987	X	X	.	MFN-1987
MFN-278	X	X	.	MFN-278
MFN-279	X	X	.	MFN-279
MFN-1988	X	X	X	MFN-1988
MFN-1989	X	.	.	MFN-1989
MFN-1990	.	.	X	MFN-1990
MFN-1979	X	.	X	MFN-1979
MFN-4429	X	.	X	MFN-4429
MFN-1236	X	.	X	MFN-1236
MFN-4430	X	.	X	MFN-4430
MFN-1980	X	.	X	MFN-1980
MFN-1981	X	.	.	MFN-1981
MFN-1982	.	X	X	MFN-1982
MFN-1983	.	.	.	MFN-1983
MFN-1984	.	.	.	MFN-1984
MFN-1985	.	.	.	MFN-1985
ROUGH RANGE				
MFN-275	X	.	.	MFN-275
MFN-276	X	.	.	MFN-276
ROUGH RANGE #8	.	.	.	
MFN-4431	X	X	.	MFN-4431

Checklist 10. Nannofossil distribution in Dirk Hartog wells, Cape Cuvier #1 (south Carnarvon Basin) and Giralia (BMR) #5 and in samples from an excavation near No. 10 Bore, Giralia Anticline, northern Carnarvon Basin.

	ACTINOZYGUS REGULARIS	ACUTURRIS SCOTUS	AHMUELLERELLA OCTORADIATA	AMPHIZYGUS TESSELATUS	ARKHANGELSKIELLA CYMBIFORMIS	ARKHANGELSKIELLA ORTHOCANCELLATA	ARKHANGELSKIELLA SPECILLATA	BIDISCUS ROTATORIUS	BISCUTUM CORONUM	BISCUTUM MELANIAE	BISCUTUM NOTICULUM	BRAARUDOSPHAERA BIGELOWII	BROINSONIA AFF. PARCA	BROINSONIA BUKRYI	BROINSONIA CF. EXPANSA	BROINSONIA DENTATA	BROINSONIA EXPANSA	BROINSONIA PARCA	BROINSONIA PSEUDOPARCA	CALCULITES OBSCURUS	CALCULITES OVALIS	CERATOLITHOIDES ACULEUS	CHIASTOZYGUS FESSUS	CHIASTOZYGUS GARRISONII	CHIASTOZYGUS LITTERARIUS	COROLLITHION RHOMBICUM SYMETRICUM	COROLLITHION SIGNUM	CRETARHABDUS CONICUS	CRETARHABDUS SURRIRELLUS	CRIBROSPHAERELLA DANIAE	CRIBROSPHAERELLA EHRENBERGII	CYCLAGELOSPHAERA MARGERELI	CYLINDRALITHUS BIARCUS
GIRALIA #5																																	
MFN-512	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.	.	.	X	.	.	X	.	.
MFN-513	.	.	.	.	X	X	X	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	X	X	.	X	.	.
MFN-514	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	X	.	.	X	.	.
MFN-515	.	.	.	.	X	.	X	.	.	.	.	.	.	.	X	.	.	X	.	X	.	.	.	.	.	.	.	.	X	.	X	.	X
MFN-516	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	X	.	X	.	.	.	X	.	X
MFN-517	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	X	X	.	.	.	X
MFN-518	.	.	.	.	.	.	X	.	.	X	.	.	.	X	X	.	X	.	X	.	.	.	.	.	.	.	.	.	X	.	X	.	X
MFN-519	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
MFN-520	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.
MFN-521	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	X	.	.
MFN-522	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-523	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-524	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-525	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-526	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NEAR #10 BORE																																	
MFN-2690	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	X	.	X	X	.
MFN-2689	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.	.	X
MFN-2688	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.
CAPE CUVIER #1																																	
MFN-1213	X	.	.	.	X	X	X	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	X	.	X	.	.
MFN-1214	.	.	X	.	X	X	X	.	.	X	.	X	.	.	.	.	.	X	.	X	X	.	.	.	X	X	.	X	X	X	X	.	.
MFN-1215	.	.	X	X	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	X	.	.	X	X	.	.	X	X
MFN-1216	.	X	X	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	X	X	.	X	.	X	.	.	.	X	.	X	X	.
MFN-1217	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.
DIRK HARTOG #1																																	
MFN-409	.	.	.	.	X	X	X	.	.	X	.	.	.	.	.	.	.	?	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.
MFN-410	X	.	X	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	X	X	.	.	.	.	X	.	.	X	X	X	X	.	.
DIRK HARTOG #4																																	
MFN-412	.	.	X	.	X	X	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.
MFN-413	X	.	.	.	X	.	X	X	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.	X	.	.	X	X	.	X	.	X
MFN-414	.	X	X	.	.	.	X	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	X	X	.	X	.	.
DIRK HARTOG #17B																																	
MFN-415	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	X	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.
MFN-416	.	.	.	.	.	.	X	.	X	X	.	.	X	.	X	X	X	X	.	X	X	.	X	X	X	.	.	.	.	.	X	.	.
MFN-417	X	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	X	.	.	.	X	.	X	.	.
MFN-418	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Checklist 10 (continued)

	CYLINDRALITHUS NUDUS	CYLINDRALITHUS SERRATUS	EIFFELLITHUS EXIMIUS	EIFFELLITHUS TRABECULATUS	EIFFELLITHUS TURRISEIFFELI	EPROLITHUS FLORALIS	GARTNERAGO OBLIQUUM	GEPHYRORHABDUS CORONADVENTUS	HAQIUS CIRCUMRADIATUS	HELICOLITHUS ANCEPS	HETERORHABDUS SINUOSUS	KAMPTNERIUS MAGNIFICUS	LAPIDEACASSIS CORNUTA	LAPIDEACASSIS SIMPLEX	LAPIDEACASSIS SPP.	LITHASTRINUS GRILLI	LITHRAPHIDITES CARNIOLENSIS	LITHRAPHIDITES GROSSOPECTINATUS	LITHRAPHIDITES QUADRATUS	LUCIANORHABDUS CAYEUXII	LUCIANORHABDUS MALEFORMIS	MANIVITELLA GRONOSA	MANIVITELLA PEMMATOIDEA	MARKALIUS ASTROPORUS	MARTHASTERITES FURCATUS	MARTHASTERITES INCONSPICUUS	MICRORHABDULUS BELGICUS	MICRORHABDULUS DECORATUS	MICRORHABDULUS HELICOIDEUS	MICULA CONCAVA	MICULA MURUS	MICULA STAUROPHORA	MONOMARGINATUS QUATERNARIUS
GIRALIA #5																																	
MFN-512	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	X	.	.	.	.	.	.	.	.	X	.
MFN-513	.	X	.	.	X	.	X	.	.	.	X	.	.	.	.	.	X	.	.	X	.	.	X	.	.	.	.	.	X	.	.	X	.
MFN-514	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	X	.
MFN-515	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	X	.
MFN-516	.	.	X	.	X	.	X	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	.	.	X	X	.	.	X	.	.	X	.
MFN-517	.	.	X	.	X	.	X	.	.	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	X	.
MFN-518	.	.	X	.	.	.	X	.	.	.	X	X	.	.	.	X	.	X	.	X	.	.	.	.	X	.	.	.	X	.	.	X	.
MFN-519	.	.	X	.	X	.	X	.	.	.	.	X	.	.	.	X	X	.	.	.	.	.	.	.	X	.	.	.	X	.	.	X	.
MFN-520	.	.	X	.	.	X	X	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	X	.	.	X	.	.	X	.	.	X	.
MFN-521	.	.	X	.	X	X	X	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
MFN-522	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-523	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-524	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-525	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
MFN-526	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NEAR #10 BORE																																	
MFN-2690	X	.	X	.	.	X	X	X	X	X	X	.	.	.	.	X	X	X	.	.	.	X	X	.	X	.	X	.	.	.	.	X	.
MFN-2689	.	.	X	X	X	X	X	X	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	X	.	.	.	.	X	.
MFN-2688	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
CAPE CUVIER #1																																	
MFN-1213	.	.	.	?	X	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	.	X	X	X	.	.	.	.	X	X	.	X	.
MFN-1214	.	X	.	.	X	.	.	.	.	.	.	.	X	X	X	.	X	.	.	X	.	.	X	.	.	.	.	.	X	X	.	X	X
MFN-1215	.	.	X	.	X	.	X	X	X	.	.	X	.	.	.	.	X	.	.	X	.	.	X	X	.	.	.	.	.	X	.	X	.
MFN-1216	X	.	X	.	X	.	X	.	.	.	X	X	.	.	.	.	X	.	.	X	X	.	X	.	.	.	X	.	X	.	.	X	.
MFN-1217	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DIRK HARTOG #1																																	
MFN-409	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.
MFN-410	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	X	.	.	X	.	.	X	.	.	.	.	X	.	.	.	X	.

DIRK HARTOG #4																																	
MFN-412	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X	.
MFN-413	.	X	X	.	X	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	X	X	.	.	.	.	X	.	.	X	.
MFN-414	.	X	.	.	X	.	X	.	.	.	X	X	.	.	.	.	X	.	.	X	.	X	.	.	.	.	.	.	.	.	?	X	.
DIRK HARTOG #17B																																	
MFN-415	.	X	X	.	X	.	X	.	.	.	.	X	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	X	X	.	X	.
MFN-416	X	.	X	.	X	.	.	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	X	.
MFN-417	.	.	X	.	X	.	X	.	.	.	.	X	.	.	.	.	.	.	.	X	X	.	X	.	.	.	.	.	X	.	.	X	.
MFN-418	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Checklist 10 (continued)

	PARHABDOLITHUS EMBERGERI	PETRARHABDUS COPULATUS	PLACOZYGUS FIBULIFORMUS	PLACOZYGUS SIGMOIDES	PREDISCOSPHAERA BUKRYI-STOVERI	PREDISCOSPHAERA CRETACEA	PREDISCOSPHAERA SPINOSA	QUADRUM DESCRIPTUM	QUADRUM GARTNERI	QUADRUM GOTHICUM	QUADRUM TRIFIDUM	REINHARDTITES AFF. LEVIS	REINHARDTITES ANTHOPHORUS	REINHARDTITES BIPERFORATUS	REINHARDTITES LEVIS	REINHARDTITES MIRABILIS	RHAGODISCUS AFF. RENIFORMIS	RHAGODISCUS ANGUSTUS	RHAGODISCUS SPLENDENS	SCAPHOLITUS FOSSILIS	STEPHANOLITHION LAFFITTEI	TEICHORHABDUS ETHMOS	TETRAPODORHABDUS DECORUS	TRANOLITHUS ORIONATUS	VEKSHINELLA ELLIPTICA	VEKSHINELLA IMBRICATA	WATZNAUERIA BARNESAE	WATZNAUERIA BIPORTA	ZYGODISCUS BICRESCENTICUS	ZYGODISCUS DEFLANDREI	ZYGODISCUS LACUNATUS
GIRALIA #5																															
MFN-512	.	.	X	.	.	X	.	.	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.
MFN-513	.	.	.	.	.	X	X	.	.	X	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.
MFN-514	.	X	.	.	.	X	.	.	.	.	.	X	X	.	?	.	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.
MFN-515	.	.	.	.	.	X	.	.	.	.	.	X	X	.	X	.	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.
MFN-516	.	.	.	.	.	X	.	.	.	.	.	.	X	X	.	.	.	.	.	.	X	.	.	.	.	.	X	.	X	X	X
MFN-517	.	.	.	.	.	X	.	.	.	.	.	.	X	X	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.
MFN-518	.	.	.	.	.	.	X	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	X	.
MFN-519	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	.
MFN-520	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.
MFN-521	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	?	X	.
MFN-522	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-523	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-524	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.
MFN-525	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	?	.
MFN-526	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NEAR #10 BORE																															
MFN-2690	.	.	.	.	.	.	X	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	X	.	X	.	.
MFN-2689	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.
MFN-2688	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	X	.	.	.
CAPE CUVIER #1																															
MFN-1213	.	.	X	X	.	X	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	X	.	X	.	.	.	.
MFN-1214	.	.	X	.	.	X	X	.	.	X	.	X	X	.	X	.	.	X	.	.	X	.	X	.	.	.	X	.	X	.	.
MFN-1215	X	.	X	.	.	X	X	X	.	.	.	.	X	X	.	.	X	X	X	.	X	.	X	X	.	.	X	.	X	.	.
MFN-1216	X	.	.	?	.	X	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	X	.	.	X	.	X	X	.
MFN-1217	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.
DIRK HARTOG #1																															
MFN-409	.	.	X	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	.	.	.	.
MFN-410	.	.	X	.	.	X	X	.	.	.	.	X	X	.	.	.	.	.	.	X	.	X	X	X	.	.	X	.	X	.	.
DIRK HARTOG #4																															
MFN-412	X	.	X	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.
MFN-413	.	.	X	.	.	X	.	.	.	X	.	X	X	X	.	.	.	.	.	.	.	.	X	X	.	.	X	.	X	.	.
MFN-414	X	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	X	.	.	X	.	X	.	.
DIRK HARTOG #17B																															
MFN-415	X	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	X	.	X
MFN-416	X	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.
MFN-417	.	.	.	.	.	X	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	X	.	.	X	.	X	.	.
MFN-418	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.

Checklist 11. Nannofossil distribution in cores from Delambre #1, DSDP sites 288 and 289, and in surface samples from the Papuan Basin.

	ACTINOZYGUS REGULARIS	AHMUELLERELLA OCTORADIATA	AMPHIZYGUS TESSELATUS	ARKHANGELSKIELLA CYMBIFORMIS	ARKHANGELSKIELLA ORTHOCANCELLATA	ARKHANGELSKIELLA SPECILLATA	BIDISCUS ROTATORIUS	BIDISCUS SPP.	BISCUTUM MELANIAE	BROINSONIA EXPANSA	BROINSONIA PARCA	CALCULITES OVALIS	CERATOLITHOIDES ACULEUS	CERATOLITHOIDES KAMPTNERI	CHIASTOZYGUS LITTERARIUS	COROLLITHION EXIGUUM	CRETARHABDUS CONICUS	CRETARHABDUS SURIRELLUS	CRIBROCORONA GALLICA	CRIBROSPHAERELLA EHRENBERGII	CYLINDRALITHUS BIARCUS	CYLINDRALITHUS NUDUS	CYLINDRALITHUS SERRATUS	DODEKAPODORHABDUS NOELII	EIFFELLITHUS AFF. EXIMIUS	EIFFELLITHUS EXIMIUS	EIFFELLITHUS TURRISEIFFELI	EPROLITHUS FLORALIS	GARTNERAGO OBLIQUUM	HELICOLITHUS ANCEPS	HETERORHABDUS SINUOSUS	KAMPTNERIUS MAGNIFICUS	LAPIDEACASSIS SPP.
DSDP SITE 288																																	
MFN-3037A	.	.	X	X	.	.	.	.	.	.	.	.	X	.	.	.	X	X	X	X	.	.	X	.	.	.	X	.	.	.	X	.	.
MFN-3037B	X	.	.	X	.	X	.	.	X	.	.	.	X	.	.	.	X	X	.	X	.	.	X	.	.	.	X	.	.	.	.	.	.
MFN-3038	.	.	.	X	?	X	.	.	.	.	.	.	X	.	.	X	X	X	X	X	X	.	X	.	.	.	X	.	.	X	.	.	.
MFN-3039B	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	X	X	.	X	.	.	X	.	.	.	X	.	.	.	X	.	.
MFN-3040	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	.	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.
MFN-3040B	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	X	X	.	X	.	.	X	.	.	.	X	.	.	.	X	.	.
MFN-3042	.	.	.	X	X	X	.	.	.	.	.	.	X	.	.	.	X	X	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.
MFN-3043B	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	X	.	.	X	X	.	X	.	.	.	X	.	.	.	.	.	.
MFN-3045B	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	X	X	.	X	X	X	X	.	.	.	X	.	.	.	X	.	.
MFN-3048A	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X	X	.	X	X	.	X	.	.	.	X	.	.	.	.	.	.
MFN-3048B	.	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	X	X	X	X	.	.	.	.	.	.	X	.	.	.	.	.	.
MFN-4432	.	X	.	X	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	X	.	.	.	.	.	.
MFN-4433	.	.	.	X	.	X	.	.	.	.	X	.	.	.	.	.	.	X	.	X	X	.	X	.	.	.	X	.	.	.	X	.	.
MFN-4434	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	X	X	.	X	.	.	X	.	.	.	X	.	.	.	X	.	.
MFN-4435	.	.	.	X	.	X	.	.	.	.	X	.	X	.	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	X	.	.
MFN-4436	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	X	.	.	.	X	.	.	.	.	.	.
MFN-4437A	.	.	.	X	X	X	X	X	.	.	X	.	.	.	.	.	X	.	.	X	X	.	X	.	.	.	.	.	.	.	X	.	.
MFN-4437B	.	.	.	X	.	X	.	.	.	.	X	.	X	.	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	X	.	.
MFN-4438	.	.	.	X	.	X	.	.	.	.	X	.	X	.	.	.	.	X	.	X	.	.	X	.	X	.	X	.	.	.	X	.	.
DSDP SITE 289																																	
MFN-3053	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-3054	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.
MFN-3054B	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.
MFN-3056	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.
MFN-3055	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	X	.	.	X	.	.	.	.	.	.	.	X	.	.
MFN-3057	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X	X	.	X	.	.	.	.	.	?	.	.	.	.	X	.	.
MFN-3058	.	.	.	X	X	X	.	.	.	.	.	.	X	.	.	.	.	X	.	X	.	.	X	.	.	.	.	.	.	.	X	.	.
MFN-3059	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X	X	.	X	.	.	X	.	.	.	.	.	.	.	X	.	.
MFN-4439	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.	X	.	.	.	X	.	.	.	.	.	.
MFN-4440	.	.	.	X	.	X	.	.	.	.	X	.	?	.	X	.	X	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.
MENDI AREA																																	
MFN-3941A	X	.	.	X	.	.	.	.	X	.	.	.	X	X	.	.	.	X	X	X	.	.	.	.	.	.	X	.	.	.	X	.	.
MFN-3942	.	X	.	X	.	.	.	.	X	.	.	.	X	.	.	X	X	X	X	X	X	.	X	.	.	.	X	.	.	.	X	.	.
MFN-3941B	X	X	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X	X	?	X	X	.	X	X	.	.	X	.	.	.	X	?	.
MFN-3943	.	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.	X	.	.	X	X	.	X	.	.	.	X	.	.	.	X	.	.
MFN-3944	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	X	.	.	X	X	.	X	.	.	.	X	.	X	.	X	?	.
MFN-3945	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	X	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.
WABAG AREA																																	
MFN-3071	.	.	.	X	X	X	.	.	.	.	.	.	X	X	.	.	.	X	X	X	.	.	.	.	.	.	X	.	.	.	X	.	.
MFN-3072	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	X	X	.	.	.	.	.	X	X	.	.	.	.	.
LAI RIVER AREA																																	
MFN-3063	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	X	.	X	X	.	.	.	.	.	X	.	.	.	X	.	.
MFN-3064	.	.	.	.	.	X	.	.	.	X	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	.	X	.	.
MFN-3079	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	X	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.
DELAMBRE #1																																	
MFN-2241	X	.	.	X	.	.	.	.	.	.	.	.	?	.	.	.	.	.	X	X	.	.	.	.	.	.	X	.	.	.	X	.	.
MFN-2242	X	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	X	.	.	.	X	.	X
MFN-2243	.	.	.	X	X	X	.	.	X	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.
MFN-2244	X	.	.	X	.	.	.	X	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	X	.	.
MFN-2245	X	.	.	X	.	.	.	.	.	.	.	?	X	.	.	X	.	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.
MFN-2246	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2249	X	X	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X	X	.	X	.	.	.	.	.	.	X	.	X	.	.	.	X
MFN-2250	.	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2251	.	X	.	.	.	X	.	.	.	.	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2252	.	.	.	X	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2253	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	X	.	X	X	.	.	.	.	.	X	.	.	.	X	.	.

Checklist 11 (continued)

	LITHRAPHIDITES CARNIOLENSIS	LITHRAPHIDITES PRAEQUADRATUS	LITHRAPHIDITES QUADRATUS	LOXOLITHUS ARMILLA	MANIVITELLA GRONOSA	MANIVITELLA PEMMATOIDEA	MARKALIUS ASTROPORUS	MICRORHABDULUS BELGICUS	MICRORHABDULUS DECORATUS	MICRORHABDULUS HELICOIDEUS	MICULA AFF. MURUS	MICULA CONCAVA	MICULA MURUS	MICULA PRAEMURUS	MICULA PRINSI	MICULA STAUROPHORA	NEOCHIASTOZYGUS ANTIQUUS	NEPHROLITHUS FREQUENS	PARHABDOLITHUS EMBERGERI	PERCHNIELSENELLA STRADNERI	PERVILITHUS GLAESSNERIUS	PLACOZYGUS FIBULIFORMUS	PLACOZYGUS SIGMOIDES	PREDISCOSPHAERA CRETACEA	PREDISCOSPHAERA GRANDIS	PREDISCOSPHAERA HONJOI	PREDISCOSPHAERA MAJUNGAE	PREDISCOSPHAERA SPINOSA	QUADRUM GOTHICUM	QUADRUM TRIFIDUM	REINHARDTITES AFF. LEVIS	REINHARDTITES ANTHOPHORUS	REINHARDTITES LEVIS
DSDP SITE 288																																	
MFN-3037A	.	.	.	.	.	X	.	.	X	.	X	X	X	X	.	X	.	.	X	.	X	X	.	X	.	.	.	X	.	.	.	X	.
MFN-3037B	.	X	.	.	.	X	.	.	X	.	X	.	X	X	.	X	.	.	X	.	.	X	X	X	.	.	.	X	.	.	.	X	.
MFN-3038	.	.	.	.	.	X	.	.	.	.	X	X	X	.	.	X	.	.	.	.	.	.	X	X	.	.	.	X	.	.	.	.	.
MFN-3039B	.	.	.	.	.	X	.	X	X	.	X	X	X	.	.	X	.	.	X	.	.	.	X	X	.	.	.	.	X	.	.	.	X
MFN-3040	.	.	.	.	X	.	.	.	.	.	X	X	X	.	?	X	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
MFN-3040B	.	.	.	.	.	X	.	.	X	.	X	X	X	.	.	X	.	.	X	.	.	.	X	X	.	.	X	.	.	.	.	X	.
MFN-3042	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	X	.	.	.	X	.	.	.	X	.	.	.	X	.	.	.	.	.
MFN-3043B	.	.	.	.	.	X	.	.	X	.	X	X	X	.	.	X	.	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	.
MFN-3045B	.	.	.	.	.	X	.	.	X	.	X	X	X	.	.	X	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.
MFN-3048A	.	.	.	.	.	X	.	.	X	.	X	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
MFN-3048B	.	.	.	.	.	X	.	.	X	.	X	X	.	.	.	X	.	.	.	.	.	.	X	X	.	.	.	X	X	.	.	.	X
MFN-4432	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	X	X	.	.	.	X	.	.	.	.	.
MFN-4433	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	X	X	X	.	.	.
MFN-4434	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	X	X	.	.	.
MFN-4435	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	X	X	.	.	.
MFN-4436	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	X	.	.	.
MFN-4437A	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	.	X
MFN-4437B	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	X	.	.	.	.	X	X	.	.	.
MFN-4438	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.	.	.	.	X	X	.	.	.
DSDP SITE 289																																	
MFN-3053	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
MFN-3054	.	.	.	.	.	.	.	.	X	.	X	X	X	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
MFN-3054B	.	.	.	.	.	.	.	.	.	.	X	X	X	X	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
MFN-3056	.	.	.	.	.	X	.	.	.	.	X	X	X	.	.	X	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.
MFN-3055	.	.	.	.	X	X	.	.	X	.	X	X	X	.	.	X	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	X
MFN-3057	.	.	.	.	.	X	.	.	.	.	X	X	X	.	.	X	.	.	X	.	.	.	.	X	.	.	.	X	.	.	.	.	X
MFN-3058	.	.	.	.	.	X	.	.	.	.	X	X	X	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
MFN-3059	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	X	X	.	.	X
MFN-4439	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	X
MFN-4440	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	X	X	.	.	X
MENDI AREA																																	
MFN-3941A	X	.	X	.	.	.	X	.	.	.	.	.	X	.	X	X	.	.	.	.	.	X	.	X	.	.	.	X	.	.	.	.	.
MFN-3942	X	X	X	.	.	X	X	.	.	X	X	X	X	X	.	X	.	.	.	.	.	X	.	X	.	.	.	X	.	.	.	X	.
MFN-3941B	X	X	X	.	.	X	.	X	X	.	.	X	.	.	.	X	.	.	.	.	.	X	.	X	X	X	X	X	.	.	.	X	.
MFN-3943	X	.	.	.	.	X	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	X	X	X	X	.
MFN-3944	X	.	.	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	X	X	X	X	X	X	.
MFN-3945	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	X	.
WABAG AREA																																	
MFN-3071	.	.	X	.	.	X	.	.	X	.	X	X	.	.	.	X	.	.	X	.	.	.	.	X	.	.	X	X	.	.	.	.	.
MFN-3072	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	X	X	X	X	.
LAI RIVER AREA																																	
MFN-3063	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	X	X	X	X
MFN-3064	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.
MFN-3079	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.
DELAMBRE #1																																	
MFN-2241	.	.	X	.	.	.	.	.	.	.	.	X	X	.	.	X	.	X	X	?	.	X	.	.	X	.	X	X	.	.	.	.	.
MFN-2242	.	.	X	.	.	.	X	.	.	.	X	X	.	.	.	X	.	.	X	.	.	X	.	.	X	.	.	X	.	.	.	.	.
MFN-2243	.	X	X	.	.	X	.	.	X	.	.	X	.	.	.	X	.	.	X	.	.	X	.	X	.	.	.	X	X	.	.	.	.
MFN-2244	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.
MFN-2245	.	X	.	.	.	.	X	.	X	.	X	X	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MFN-2246	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	.
MFN-2249	X	.	.	.	X	X	.	X	X	X	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MFN-2250	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X	.	X	X	?
MFN-2251	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X	X	X	X	X
MFN-2252	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X	X	X	X	X
MFN-2253	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	X	X	X	X	X

Checklist 11 (continued)

	REINHARDTITES MIRABILIS	RETACAPSA SCHIZOBRACHIATA	RHAGODISCUS ANGUSTUS	RHAGODISCUS ASPER	RHAGODISCUS RENIFORMIS	RHAGODISCUS SPLENDENS	SCAPHOLITUS FOSSILIS	STEPHANOLITHION LAFFITTEI	TETRAPODORHABDUS DECORUS	TRANOLITHUS GABALUS	TRANOLITHUS ORIONATUS	VEKSHINELLA ELLIPTICA	VEKSHINELLA IMBRICATA	WATZNAUERIA BARNESAE	WATZNAUERIA BIPORTA	ZYGODISCUS BICRESCENTICUS	ZYGODISCUS DEFLANDREI	ZYGODISCUS LACUNATUS	
DSDP SITE 288																			
MFN-3037A	.	.	X	.	X	X	.	.	X	.	.	.	.	X	.	.	.	.	MFN-3037A
MFN-3037B	.	.	X	.	X	X	.	.	X	.	.	.	.	X	.	.	.	.	MFN-3037B
MFN-3038	.	.	X	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-3038
MFN-3039B	.	.	X	.	X	X	.	.	X	.	.	.	.	X	.	.	.	.	MFN-3039B
MFN-3040	.	X	.	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	MFN-3040
MFN-3040B	.	.	X	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-3040B
MFN-3042	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-3042
MFN-3043B	X	.	.	.	X	X	.	.	X	.	.	.	.	X	.	.	.	.	MFN-3043B
MFN-3045B	.	.	X	.	X	X	.	.	X	.	.	.	.	X	.	.	.	.	MFN-3045B
MFN-3048A	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	MFN-3048A
MFN-3048B	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-3048B
MFN-4432	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-4432
MFN-4433	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-4433
MFN-4434	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-4434
MFN-4435	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-4435
MFN-4436	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	MFN-4436
MFN-4437A	.	.	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.	MFN-4437A
MFN-4437B	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-4437B
MFN-4438	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-4438
DSDP SITE 289																			
MFN-3053	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-3053
MFN-3054	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-3054
MFN-3054B	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-3054B
MFN-3056	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-3056
MFN-3055	.	.	.	.	.	.	.	.	?	.	.	.	.	X	.	.	.	.	MFN-3055
MFN-3057	.	.	.	.	.	.	.	.	?	.	.	.	.	X	.	.	.	.	MFN-3057
MFN-3058	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	MFN-3058
MFN-3059	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-3059
MFN-4439	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	MFN-4439
MFN-4440	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	MFN-4440
MENDI AREA																			
MFN-3941A	.	.	.	.	.	.	X	.	X	.	.	.	.	X	.	.	.	.	MFN-3941A
MFN-3942	.	.	X	.	X	.	.	.	X	.	.	.	.	X	.	.	.	.	MFN-3942
MFN-3941B	.	.	.	.	X	.	X	X	X	.	.	.	X	X	.	.	.	X	MFN-3941B
MFN-3943	.	.	.	.	.	.	.	.	X	.	.	.	.	X	X	.	.	.	MFN-3943
MFN-3944	.	.	X	.	X	.	.	X	.	.	.	.	.	X	X	.	X	.	MFN-3944
MFN-3945	.	.	.	.	.	.	.	X	X	.	.	.	.	X	.	.	.	.	MFN-3945
WABAG AREA																			
MFN-3071	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	MFN-3071
MFN-3072	.	.	.	.	X	.	.	.	X	.	?	.	.	X	.	.	.	.	MFN-3072
LAI RIVER AREA																			
MFN-3063	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	MFN-3063
MFN-3064	.	.	.	.	.	.	.	.	.	.	?	.	.	X	.	.	.	.	MFN-3064
MFN-3079	.	.	.	.	.	.	.	.	.	.	?	.	.	X	.	.	.	.	MFN-3079
DELAMBRE #1																			
MFN-2241	.	.	.	.	.	.	X	.	X	.	.	X	.	X	.	.	.	.	MFN-2241
MFN-2242	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	MFN-2242
MFN-2243	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	MFN-2243
MFN-2244	.	.	.	.	X	.	.	.	X	.	.	.	.	X	X	.	.	.	MFN-2244
MFN-2245	.	.	.	.	X	.	.	.	X	.	?	.	.	X	X	.	.	.	MFN-2245
MFN-2246	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	MFN-2246
MFN-2249	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	X	X	.	MFN-2249
MFN-2250	.	.	.	.	.	.	.	.	.	.	?	.	.	.	.	.	.	.	MFN-2250
MFN-2251	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	MFN-2251
MFN-2252	.	.	.	.	.	.	.	.	.	.	?	.	.	X	.	.	.	.	MFN-2252
MFN-2253	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	X	.	.	MFN-2253

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