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CORRELATION OF TERTIARY ROCKS OF THE AUSTRALASIAN REGION

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by

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ABSTRACT

A comprehensive correlation chart of the Tertiary rocks of Australia, New Zealand, and Papua - New Guinea is presented including maximum known thicknesses of the formations. The most complete sequences occur in New Zealand. In Australia, rocks of Paleocene to Pliocene age occur in the Gippsland Basin of Victoria and the Otway and Murray Basins of Victoria and South Australia.

Significant planktonic foraminifera from the Paleocene Globorotalia chapmani and G. pseudomenardii to the entry of Orbulina suturalis and O. universa in the Miocene are shown on a range chart.

Tertiary rocks of eastern Australia are predominantly of non-marine or volcanic origin. Few are more accurately dated than of early or late Tertiary age. Non-marine sediments in South Australia and Victoria have been dated on palynological evidence.

A tabulation of the formations containing land mammals is given.

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INTRODUCTION

Recent discoveries of natural gas and oil in Esso Gippsland Shelf Wells 1, 2 and 4 drilled offshore in the Gippsland Basin, the most easterly of the three basins in Bass Strait (Weeks and Hopkins 1966a, b), have not only revived interest in Australian Tertiary sediments as favourable for petroleum exploration in Southern Australia but also emphasized the need for bringing into modern perspective the status of Tertiary rock correlation in Australia. While there has been a formidable volume of literature published in recent years on the controversial question of mid-Tertiary correlation, greater emphasis has been placed in Australia itself on resolving problems of correlating rocks of early Tertiary age. It is from such sediments that the present Gippsland shelf discoveries have been made. The steady accumulation of data for correlating the marine sedimentary rocks of Australia and New Zealand over most of the Tertiary sequence, and particularly in the Eocene and Oligocene, has been accompanied by a rapid advance in our understanding of the stratigraphic position of non-marine sediments of the region and their floras and vertebrate faunas.

Outside the specialist and somewhat local field, there appears to be fairly generally a lack of awareness of the advance in knowledge of Australian Tertiaries contributed by a number of workers since 1952. As an example, in the most recently published volumes H(1) and H(2) of the Treatise on Invertebrate Paleontology the type species of the brachiopod genus Aldingia (p. H 834) is stated to come from "Miocene (Janjukian)", although the type species was described (Tate, 1880, p. 161) correctly from Eocene limestones at Blanche Point now named Tortachilla Limestone in the sequence at Aldinga and Maslin Bays. (Reynolds, 1953).

The requirements of petroleum exploration and hydrogeological investigations are, however, only partly fulfilled by palaeontological correlation, since the interests of such surveys are principally with rock units. To meet the increasing need of a comprehensive rock unit tabulation and of collating a mass of palaeontological data from various sources a table is presented in Figure 3 correlating the Tertiary rock formations of Australia, New Zealand and Papua - New Guinea. Their maximum known thicknesses are included. The table shows considerable modification of the charts presented by Glaessner (1959), Bur. Miner. Resour. (1962), Eames et al. (1962) and Ludbrook (1963). Marine and non-marine rocks are distinguished by differences in lettering, marine sediments being shown in capitals, other rocks in lower case.

ACKNOWLEDGEMENTS

Preparation of a Tertiary rock unit chart was initiated by the writer to form a background for the Symposium on Tertiary Correlation held in Hobart at the August, 1965, Meeting of the Australian and New Zealand Association for the Advancement of Science. It is the collaborative effort of officers of the Geological Surveys of New Zealand, Victoria, and South Australia. The New Zealand section of the chart was compiled by N. de B. Hornibrook using foraminiferal data prepared in collaboration with D.G. Jenkins; the Victorian section was prepared by officers of the Geological Survey of Victoria, acting in collaboration with D.J. Taylor and using some unpublished information; the South Australian section was prepared by the writer with W.K. Harris and J.M. Lindsay of the Geological Survey of South Australia; the remainder of the chart was prepared from published information and from determinations of the ages of non-marine sediments by W.K. Harris, and of vertebrate faunas by the late R.A. Stirton and R. Tedford formerly of the University of California.

A paper by J.E. Thompson (1965) was kindly made available by the Bureau of Mineral Resources, Geology and Geophysics for data relating to the Territory of Papua and New Guinea.

The writer expresses her indebtedness to all who collaborated in the compilation and in particular to N. de B. Hornibrook and D.J. Taylor and her colleagues W.K. Harris and J.M. Lindsay for their most generous assistance.

TERTIARY SEDIMENTARY ROCKS

The most complete Tertiary sequences occur in New Zealand, where, with the exception of coal measures and volcanic rocks, all Tertiary sediments are of marine origin, deposited in widely varying thicknesses in geosynclinal troughs or marginal areas (Finlay and Marwick, 1948; Hornibrook, 1958). In contrast, deposition in Australia for the most part took place under stable conditions in shallow sedimentary basins or embayments of the continental margin. (Figure 1).

A geological sketch of the structure, history, and sedimentation of the basins in Bass Strait is given by Weeks and Hopkins (1966a). More detailed descriptions of the structure and stratigraphy of the Gippsland Basin are given in Boutakoff (1951, 1964), Hocking and Taylor (1964) and Carter (1964). The Otway Basin is the subject of present joint studies by the Geological Surveys of Victoria and South Australia. Its western extension encompasses the Gambier Embayment which as the "Gambier Sunklands" was formerly described in South Australia as part of the Murray Basin. From the extensive literature on various aspects of sedimentation in the Basin selected references which may be consulted for descriptions of the rock units shown on the chart are Thomas and Baragwanath (1950), Bowler (1963), Raggatt and Crespin (1955), Carter (1958a), Bock & Glenie (1965), Gill (1957), Baker (1950, 1953), Glenie and Reed (1961).

The Tertiary stratigraphy of the Murray Basin in South Australia was described by Ludbrook (1961). General accounts of the Tertiary geology of the various states in Australia are contained in McWhae et al. (1958), Glaessner and Parkin (1958), Hill and Denmead (1960), Spry and Banks (1962).

Only in southern Victoria including the Gippsland, Bass, and Otway Basins are sedimentary sequences comparable with those of New Zealand developed.

Tertiary deposition is generally more continuous in the more easterly Basins and becomes less continuous westerly towards the shield areas.

No Lower Paleocene rocks have been recognised as such in Australia. McGowran (1964, 1965) has shown that the earliest Tertiary marine transgressions began in the Middle and Upper Paleocene in the Otway Basin of Victoria and in the Upper Paleocene of the Perth and Carnarvon Basins of Western Australia. Using palynological data, Harris (1965a, 1965b,. and unpublished data incorporated on the correlation chart) has extended considerably the knowledge of Paleocene non-marine sediments which are more widely distributed in most Australian states than formerly believed.

Except for one record (McWhae et al., 1958, p. 120; McGowran, 1964, p. 85) of Lower Eocene foraminifera in the Carnarvon Basin, there appears to have been a widespread depositional hiatus in the Lower Eocene, followed by a major transgression late in the Middle Eocene or early in the Upper Eocene, with conspicuous carbonate sedimentation in the Eucla and Carnarvon Basins. Paralic and freshwater sediments correlated on palynological evidence with the Middle to Upper Eocene marls, limestones and glauconitic sands and clays, are widely distributed in basins and on shelf areas in South Australia.

The extent and duration of Oligocene sedimentation is imperfectly known. Some discontinuity or irregularity in sedimentation after the Upper Eocene and before recognized Lower Miocene is evident but the length of the hiatus was variable, with an apparent increase in its duration towards the west. A further major transgression followed in the early Miocene with consequent widespread carbonate sedimentation during the mid-Tertiary. This was succeeded by a further discontinuity of short or moderate duration in Victoria and in the Murray and St. Vincent Basins of South Australia, but lasting until the Pleistocene in the Eucla Basin and in most of Western Australia. Marine influence was extensive in Victoria and South Australia during the Pliocene; the resulting sediments however, rarely exceed a few feet in thickness outside the limits of the Murray and St. Vincent Basins.

FAUNAL BASIS FOR CORRELATION

Significant planktonic foraminifera providing criteria for Tertiary correlation are shown on Figure 2. McGowran (1965 p. 23-4) has used Globorotalia chapmani Parr as evidence for correlating the Pebble Point Formation with the Globorotalia pusilla pusilla - G. angulata Zone of Trinidad and the Tethyan region.

The Rivernook Member of the Dilwyn Clay, at about the middle of the Wangerrip Group, is correlated with the upper part of the Globorotalia pseudomenardii subzone of the G. velascoensis zone on the evidence of an abundant planktonic fauna which includes Globorotalia aequa Cushman and Renz, G. pseudomenardii Bolli and Globigerina osnaensis Le Roy as well as Chiloguembelina trinitaensis (Cushman & Renz) which is restricted to the G. velascoensis subzone, and Globigerina pseudoiota Hornibrook which was described from the Waipawan stage of New Zealand (Hornibrook, 1958, p. 34).

The Paleocene sequence of the Carnarvon Basin of Western Australia and the King's Park Shale of the Perth Basin are regarded as Upper Paleocene. (McGowran 1964; 1965, p. 21).

Between the Paleocene and the Upper Eocene Faunal Unit 1 of Carter (1958b, 1959) and below the zone of _Hantkenina alabamensis compressa_ Parr there occur in South Australia assemblages containing _Globoquadrina primitiva_ Finlay and _Truncorotaloides collactea_ (Finlay). This is the Mayurra microfaunule of Ludbrook 1963, in which _T. collactea_ was recorded as _Globorotalia_ cf. _tribulosa_ Loeblich and Tappan. Excluding doubtful occurrences, _G. primitiva_ has an observed range of Paleocene to Middle Eocene, with one rare occurrence in the New Zealand Kaiatan Upper Eocene. _T. collactea_ has a range of Lower to Middle Eocene, very rare in the Kaiatan Upper Eocene (Hornibrook, 1961, p. 149; Jenkins, 1965). Both are common in the New Zealand Bortonian. Until the Mayurra faunule can be studied in greater detail it can be tentatively correlated with the Bortonian (Middle Eocene). It may possibly be as young as early Upper Eocene.

From the entry of _Hantkenina alabamensis compressa_ associated with _Globigerapsis index_ (Finlay) in the Upper Eocene to the entry of _Orbulina universa_ d'Orbigny in the Miocene the sequence of eleven Faunal Units established by Carter (1958, 1959) is for the most part applicable with some modification in southern Australia (Ludbrook, 1963; Wade, 1964). Of these, Units 3, 4 and 5, of which Unit 4 at least is of Oligocene age, need redefinition and are the subject of present study by J.M. Lindsay of the Geological Survey of South Australia. Significant foraminifera in the interval are _Chiloguembelina cubensis_ (Palmer), _Guembelitria_ sp., *Globigerina angiporoides* Hornibrook, *G. linaperta* Finlay, *G. ampliapertura* Bolli and *Cassigerinella chipolensis* (Cushman and Ponton).

The sequence of Miocene events beginning with the entry of *Globoquadrina dehiscens* (Chapman, Parr, and Collins) in the New Zealand Waitakian and Australian Longfordian (Unit 6) and leading to the evolutionary sequence culminating in the *Orbulina* datum is summarized on Figure 2. Above the entry of *Orbulina suturalis* Bronnimann in Faunal Unit 10 and of *O. universa* in Faunal Unit 11 there are at present no realistic data for correlating Australian Tertiary faunas by means of planktonic foraminifera.

CORRELATION OF BENTHONIC FORAMINIFERA

The time ranges of benthonic foraminifera appear to be fraught with irregularities when attempts are made to use them for external correlation. Wade (1964) has summarized the literature pertaining to the influence of temperature on the distribution of planktonic foraminifera, and it seems certain that climatic and environmental factors were responsible for the absence or rarity of tropical or semi-tropical populations in southern Australia Tertiary marine sediments.

Of the orbitoids and nummulitids, only Lepidocyclina and Cycloclypeus are present in southern Australia, but these permit correlation of the Batesfordian with the New Zealand Altonian, in which Globigerinoides bisphericus Todd also occurs. Victoriella conoidea (Rutten) which is claimed by Carter (1959, table 2, p. 7) to range from Faunal Unit 3 to Faunal Unit 5, occurs in the Waitakian-Otaian of New Zealand (Hornibrook, 1958), signifying either its later appearance in New Zealand or the necessity of correlating the upper part of the Janjukian with the lower part of the Waitakian. Hofkerina semiornata (Howchin), occurring rarely in the Waitakian to Otaian (Hornibrook, 1961, p. 169), enters at a similar level but has a longer range in Southern Australia. Tubulogenerina mooraboolensis Cushman, with a range of Longfordian to Batesfordian in southern Australia, occurs only in the Otaian of New Zealand while Heterolepa ("Cibicides") victoriensis (Chapman, Parr and Collins), an important index fossil of Faunal Unit 11 (Bairnsdalian), was reported from the Altonian by Geiger (1962). This would imply that H. victoriensis was in New Zealand before Orbulina suturalis which preceded its entry in Australia.

AUSTRALIAN STAGE NAMES AND THE EUROPEAN TIME SCALE

It is inevitable that New Zealand and Australian stage or faunal names will continue to be employed locally so long as, for example, contrasting views on the Oligocene-Miocene boundary and on the Orbulina datum exist among European workers. Recent reviews of the literature on these problems have been published by Bandy (1966) and Vella (1965).

While Australian stages from Janjukian to Kalimnan have been defined and revised (Carter, 1959, 1964), the pre-Janjukian stages are in need of clarification.

Wangerripian

For purposes of local utility, the stage name "Wangerripian" first used by O.P. Singleton in Notes on the Geology of the Otway Ranges, Victoria, circulated for A.N.Z.A.A.S. excursion, 1955, for the interval represented by the deposits of the Wangerrip Group (Baker, 1953) and referred to by McGowran (1965) is retained in the sense in which it has been applied to the holostratotype section. The Middle and Upper Paleocene faunas and microfloras have been described by F.A. Singleton (1943), McGowran (1965) and Harris (1965a).

Anglesean, Johannian, and Aldingan

The Anglesean was proposed by F.A. Singleton (1941, p. 24) for the time required for the deposition of Cyclammina-bearing sands of the cliff sections between Anglesea and Point Addis, with which he correlated tentatively (Table facing page 62) various early Tertiary, mostly paralic, sediments. The absence of faunal criteria for correlation (Raggatt and Crespin, 1955, pp. 111, 130; Carter 1959 p. 48) and its facies connotation led to its abandonment as a stage name. Palynological evidence has shown that sediments of the Anglesea facies range in age from Paleocene to Oligocene or younger.

The name Johannian was first used by O.P. Singleton in the notes cited above for "Upper Eocene - ? Oligocene sediments of the Torquay - Eastern View, Aire River, Johanna River and Moonlight Head - Port Campbell areas" containing Carter's Faunal Units 1, 2, 3. In this sense it was used by Carter (1959, Table 2) and Ludbrook (1963, Fig. 1). In the same sense the name Aldingan was used by Wade (1964, p. 278), Carter (1964, p. 47) and Reed (1965, p. 50). The Johannian stage requires redefinition to include the Johanna River Formation which underlies the Brown's Creek Clay containing Faunal Units 1, 2 and 3. It is here employed for the time interval required for the deposition of sands and silts of the Johanna River Formation above the Wangerrip Group and below the greensand at Brown's Creek containing Hantkenina alabamensis compressa. Contemporaneous with part at least of the interval are the sediments containing the Mayurra microfaunule with Globoquadrina primitiva and Truncorotaloides collactea referred to above.

The Aldingan Stage has been redefined (Ludbrook and Lindsay, 1966) as the time interval required for the deposition of the Tortachilla Limestone, the Blanche Point Marls, the Chinaman's Gully Beds, and the lower half of the holostratotype Port Willunga Beds. It contains Faunal Units 1, 2 and 3, and on present evidence, is Upper Eocene. Hantkenina alabamensis compressa occurs near the base, and the upper part of the sequence contains Halkyardia sp., Linderina sp. and characteristic Eocene benthonic forms, associated with Globigerina linaperta whose extinction marks the top of the stage. The uppermost part of the Aldingan appears to be equivalent to the Globigerina turritilina turritilina zone of Eames et al. (1962, p. 68). The Eocene - Oligocene boundary is at the top of this zone and occurs within the Port Willunga Beds. Jenkins (1963) has suggested that in New Zealand the boundary occurs within the Whaingaroan.

The name Giralian (F.A. Singleton, 1941 p. 36) was introduced, but has not generally been adopted, for limestone now named the Giralia Calcarenite of the Carnarvon Basin in Western Australia. Nummulites sp., Discocyclina (Discocyclina) sp., and D. (Aktinocyclina) sp. indicate both a middle to late Eocene age equivalent to part of the letter stages 'a' and 'b' of the East Indies and a faunal affinity with the Indo-Pacific region (Chapman and Crespin, 1935).

Janjukian

The Janjukian has been subjected to more confusion than any other Australian Tertiary stage. This stage is recognized as the time interval required for the deposition of the Jan Juc Formation as restricted by Raggatt and Crespin (1955). It contains Faunal Units 4 and 5 (Carter, 1959). In earlier literature Janjukian has been employed in the broader sense of F.A. Singleton (1941) for the time interval required for the deposition of the Torquay Group which includes both the Jan Juc Formation and the overlying Puebla Formation of Raggatt and Crespin. However, the Upper Eocene age and correlations of Raggatt and Crespin are not supported, the microfauna containing Hantkenina which they record from the Jan Juc Formation has not been confirmed by other workers and would be anachronistic in Janjukian sediments elsewhere.

Discontinuity in outcrop in the coastal sections between Torquay and the Aire Coast has contributed to past misunderstandings of the relative position of Janjukian and Aldingan sediments in Victoria. The Port Willunga Beds of the St. Vincent Basin in South Australia contain within the formation the conformable transition from Aldingan to Janjukian. The lower part of the Janjukian containing Faunal Unit 4, in which _Cassigerinella_ _chipolensis_ (Cushman & Ponton) first appears may be equated with the _Globigerina_ _oligocaenica_ zone of Eames et al. (1962).

The microfaunal sequence in the Jan Juc Formation is undescribed and until the planktonic succession in the type area is known, the problem of the Oligocene - Miocene boundary in the Australian Tertiary as elsewhere will remain unresolved. The Oligocene age ascribed to the whole of the Janjukian by Australian workers is disputed by Eames _et_ _al_. (1962). These authors (p. 21) state that Carter's Faunal Unit 5 is Lower Aquitanian because it contains _Globorotalia_ _opima_ _opima_ Bolli on quoted evidence of Carter 1958 and Glaessner, 1959 p. 62. Carter, however, does not record _G_. _opima_ _opima_, and Glaessner's reference to its restriction to "equivalents of Carter's unit 5" may refer to its occurrence in the Clifton Formation reported by Wade (1964). Jenkins (1960) shows the species as ranging in the Lakes Entrance Oil Shaft from his Zone 1 to the lower part of

Zone 3, approximating to the interval containing Carter's unit 6 or possibly uppermost 5. Cicha, Chmelik and Stranik (1965) determined a zone containing G. opima opima in the Middle Oligocene of Moravia, and Banner and Blow (1965) have stated that the G. opima opima zone must be redefined because of its overlap with the Globigerina ampliapertura zone.

Post-Janjukian stages

The Miocene Longfordian, Batesfordian, Balcombian, and Bairnsdalian stages have been redefined by Carter (1959, 1964). They contain his Faunal Units 6 to 11 to which Jenkins's (1960) Zones 1 to 8 and Banner and Blow's (1965) Zones N5 to N12 approximate. Correlation of these stages with European scale cannot be resolved until agreement is reached on the disputed question of the Orbulina datum level. While the correlation shown in the first column of Figure 2 is preferred after the work of Cita and Elter (1960), and Cita and Silva (1960), an alternative correlation based on the entry of Orbulina in the Burdigalian is given in column 6.

As stated by Glaessner (1959) in presenting evidence of a post-Aquitanian age for the Lepidocyclina-Cycloclypeus fauna of Faunal Unit 9, the Batesfordian is the only stage for which biostratigraphic comparisons may be made between southern Australian and Indo-Pacific faunas. Further evidence to support a late Burdigalian age for the Batesfordian has since been advanced by Carter (1964) using nepionic variation in populations of Lepidocyclina howchini Chapman and Crespin and Cycloclypeus victoriensis Crespin. The upper part of the Nullarbor Limestone containing Flosculinella bontangensis (Rutten) also contains Valvulineria trinucleata Carter in association with Marginopora vertebralis Blainville and Ammonia beccarii (Linné). Valvulineria trinucleata is a rare species known only from the clay immediately overlying the Batesford Limestone (Carter, 1964, p. 103) and from the Munno Para Clay (Lindsay and Shepherd, 1966), i.e. from uppermost Unit 9 or lowermost Unit 10.

The uppermost part of the Nullarbor Limestone contains benthonic foraminifera indicating a level below the zone of Orbulina suturalis, which first appears within the Balcombian containing Faunal Unit 10. Using the ranges of restricted benthonic foraminifera considered by Eames et al. (l.c. p. 14) to aid correlation between the Indo-Pacific letter stages and the standard European succession, the top of the Nullarbor Limestone is post-Aquitanian. It contains Marginopora vertebralis tabulated as being not older than

Vindobonian, in association with Flosculinella bontangensis, regarded as Burdigalian. A stratigraphic position astride the Helvetian - Burdigalian boundary corresponding to the G. bollii zone of the type Langhian was similarly deduced from the correlation of planktonic foraminifera by Wade (1964) for the lowermost part of the zone containing Faunal Unit 10.

Above the zone of Orbulina suturalis there are at present few realistic foraminiferal criteria for external correlation of Australian Tertiary rocks.

Present correlation continues to be dependent upon the molluscan faunas. Globigerina nepenthes Todd is present in New Zealand (Geiger, 1962) and its utility has been discussed by McTavish (1966). Late Tertiary correlation is similarly incomplete for Papua - New Guinea. McTavish has recognized equivalents of faunas of the British Solomons on those recorded by Kicinski and Belford (1956), and Belford (1960 and 1962), but no zonation has been achieved.

NON-MARINE ROCKS

The present tabulation in Figure 3 shows considerable differences from previous charts in the stratigraphic position of non-marine sediments. The wider distribution of the Paleocene (Harris, 1965a, b; Harris & Cookson, 1965), the differentiation of Paleocene and Eocene and the recognition of the relatively long time interval represented in such sequences as the Latrobe Valley Coal Measures and the Murnpeowie Formation have resulted principally from recent unpublished studies of W.K. Harris.

Freshwater sediments are well distributed in New South Wales but studies of their microfloras have not been attempted in any detail. The Vegetable Creek deposit is believed to be of Eocene age, while the deep leads, once a source of gold, in New England, the Central Highlands and the Southern Highlands appear to be mid-Tertiary. Some are covered by Upper Miocene basalts for which datings of 13.8 ± 0.3 and 13.5 ± 0.4 m.y. have been obtained (Dulhunty and McDougall, 1966). Differentiation of non-marine Tertiary sediments in Queensland is not complete although distinction can be made (Allen et al., 1960) between those of the Lower and those of the Upper Cainozoic. Fossiliferous chalcedonic lacustrine limestones occurring over wide areas of northern Australia have been described by Paten (1964) who suggests that they are of late Tertiary age.

Dating of freshwater and paralic sediments has been achieved by palynological studies of marine and non-marine deposits within Australia and within New Zealand. External correlation of Tertiary rocks by palynological processes has so far scarcely been attempted.

FORMATIONS CONTAINING LAND MAMMALS

The late Professor R.A. Stirton of the University of California and his associates have been responsible for initiating and developing the search for Tertiary vertebrate faunas and establishing their stratigraphic sequence. (Stirton, Tedford, and Miller, 1961). Land mammals have been recovered from both continental and marine formations. The tabulation below with the faunal names in parenthesis was prepared by Professor Stirton and Dr. R.H. Tedford.

The Fossil Bluff Sandstone and the Etadunna Formation are shown as of Oligocene age. The Fossil Bluff Sandstone has usually been regarded as "Janjukian" in the broad sense referred to on page 15. However, Pritchard (1896) regarded the molluscan fauna of the Table Cape Group as the "direct equivalent of the so-called middle beds of the Spring Creek section in Victoria". These form part of the Puebla Formation at Torquay and are of Longfordian age.

The age of the Etadunna Formation is not known with certainty.

The Grange Burn "Coquina" is overlain by the "Newer Volcanics" for which a dating of 4.35 has been obtained (Turnbull et al., 1965).

Epoch	Tasmania	Victoria	South Australia	Northern Territory	Queensland	New Guinea
Pleistocene					Chinchilla (Chinchilla)	
Pliocene		Grange Burn "Coquina" (Hamilton) (Forsyth's Bank) Sandringham Sands (Beaumaris)	Mampuwordu Sands (Palankarina)			Otibanda (Awe)
Miocene			Wipajiri (Kutjamarpu)	Waite Fm. (Alcoota)	Carl Creek Lst. (Riversleigh)	
Oligocene	Fossil Bluff SSt. (Wynyard)		Etadunna Fm. (Ngapakaldi)			

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