DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPT. BK. NO. 90/15

THE CORRELATION AND DEPOSITIONAL ENVIRONMENT OF TERTIARY STRATA BASED ON MACROFLORAS IN THE SOUTHERN LAKE EYRE BASIN, SOUTH AUSTRALIA

by

D.R. GREENWOOD and R.A. CALLEN

REGIONAL GEOLOGY BRANCH

and

N.F. ALLEY

BIOSTRATIGRAPHY BRANCH

SEPTEMBER, 1990

DME 252/72

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Rept Bk No 90/15
DME No. 252/72
E00056

THE CORRELATION AND DEPOSITIONAL ENVIRONMENT OF TERTIARY STRATA BASED ON MACROFLORAS IN THE SOUTHERN LAKE EYRE BASIN, SOUTH AUSTRALIA

ABSTRACT

Plant macrofossils from silicified Cainozoic fluvial sediments in the CURDIMURKA 1:250,000 geological sheet area occur in two discrete suites. One suite of these fossils has been found only in outcrops of silicified Eyre Formation sediments in the Poole Creek Palaeochannel. This suite and the macroflora of the Middle Eocene Eyre Formation at Nelly Creek appear correlative. These plant fossils were also identified at Mt Alford and in the Willalinchina Sandstone of the Stuart Creek area, indicating the presence of widespread silicified Middle Eocene sediments in the Lake Eyre South area.

The other suite of plant fossils is found in channels within sediments correlative with the ?Miocene Etadunna Formation. However, some taxa were found in both Eocene Eyre Formation and silicified ?Miocene Etadunna Formation sediments, indicating that some taxa had long stratigraphic ranges.

Palaeo-environmental analysis of the Eyre Formation fossil suites suggests that the Lake Eyre region in the Middle Eocene supported gallery rainforests and sclerophyllous vegetation in the interfluvial areas under a seasonally dry, possibly monsoon-type climate.

ACKNOWLEDGMENTS

The authors would like to thank the following people for their assistance and advice during this project: A.J. Parker and G.W. Krieg (SADME) for their enthusiasm and support for the project; D.C. Christophel (Botany Dept., Adelaide University) for providing unpublished data on the Nelly Creek macroflora; D. Barrett (Botany Dept., Adel. Univ.), B. Gare (Geology Dept., Adel. Univ.), P. Rogers, M.C. Benbow, and B. Forbes (SADME) for their assistance in the field and B. Gare for her careful attention to the line drawings of the silcrete fossil leaves. R. Barrett (Geology Dept., Adel. Univ.) and B. Gare developed and printed many of the photographs used to prepare the plates. We would also like to thank the Hunter family (formerly of Stuart Creek Station) and Reg Dodd (Finniss Springs Station) for their hospitality and assistance. Some specimens of fossil leaves from Stuart Creek were donated by Rick Davies of the Olympic Dam Environmental Office (W.M.C.) for which we are grateful. RAC would like to thank Dr R.T. Lange (Botany Dept., Adelaide Univ.) for his enthusiastic support and interest in the silcrete floras.

1. STRATIGRAPHY OF TERTIARY BASINS BETWEEN LAKE TORRENS AND LAKE EYRE NORTH.

This report focuses on the southern portion of the northwestern half of the Lake Eyre Basin (Figs. 1–2) and in particular on the Poole Creek Palaeochannel (Figs. 3–5) which flowed north from the Willouran Ranges and drained into it. The northwestern half of the Lake Eyre Basin, or Tirari SubBasin lies north of the Willouran Ranges and is largely buried beneath the dunefields, playas and alluvial spreads of the Tirari and Simpson Deserts. The main part of the basin contains up to 100 m of carbonaceous sands and silts of Late Paleocene to Eocene age (Eyre Formation), overlain by 30-50 m of dolomite and green clay of ? Late Oligocene to possibly Late Miocene age (Etadunna Formation).

The Etadunna Formation is exposed mainly along the southern margin of the basin between Lake Eyre North and South, and the Eyre Formation mainly between the Oodnadatta Track and Lake Eyre South. The oldest sediments are Middle Paleocene (Alley, 1983), but in Poole Creek palaeochannel, correlation with the sequences at Nelly Creek indicates the oldest sediments here are Middle Eocene.

The Poole Creek Palaeochannel (Fig. 3) contains significant macrofloras, in channels within both the Etadunna and Eyre Formations. This report concentrates on these floras, in an attempt to determine whether the lithostratigraphic correlations are born out by biostratigraphic data and to determine palaeoclimatic conditions.

To the west and northwest of Lake Torrens is the Billa Kalina Basin (Fig. 2), lying between the Willouran Ranges and the southerly extension of the Stuart Range southwest of the Lake Eyre Basin. The Billa Kalina Basin contains eroded remnants of a thin sequence (5–10 m) of sandstones (Watchie Sandstone and Willalinchina Sandstone) and fine clastics/carbonates (Mirikata Formation) deposited during the Eocene, ?Oligocene and Miocene.

The sediments of most relevance to this report lie beneath the beach ridges, in the Stuart Creek valley and its headwaters (Figs. 1–2). These sediments (Willalinchina Sandstone) consist of silicified sandy palaeochannels containing abundant plant fossils. The Willalinchina Sandstone is correlated with the Eyre Formation, and in particular with outcrops containing both plant macrofloras and Middle Eocene pollen at a site called Nelly Creek near the edge of Lake Eyre.

2. CAINOZOIC "SILCRETE FLORAS" IN SOUTH AUSTRALIA.

2.1 Introduction

Extensive outcrops of surficially silicified Cainozoic sandstones (silcretes) cover a large part of the arid area of South Australia. The silicified sediments are of particular interest for two reasons: firstly, they are very extensive and thus constitute an important component of the landscape and surficial geology, and secondly, they contain abundant well-preserved plant macro-fossils.

The age and stratigraphy of the fossils were not known until the work of Ambrose *et al.* (1979).

In the study area geological mapping by R.P. Coats (Webb *et al.*, 1963 on Callanna) delineated a broad Cainozoic sedimentary sequence, and a few fossil plants were found during a helicopter survey by Department of Mines & Energy personnel during 1980 (V. Vitols & G. Pitt samples). This, together with further mapping of CURDIMURKA (Krieg *et al.*, in prep.) and discovery of the Stuart Creek macrofloras to the southwest on Trecompana (Lange, 1978; Ambrose *et al.*, 1979), eventually led to the discovery of significant macrofloras at Poole Creek.

The importance of the Poole Creek area was enhanced by discovery of probable fossil 'gum nuts' (possibly Eucalyptus, subfamily Leptospermoideae of Myrtaceae. See northernmost locality, Fig. 3) and, most significantly, unsilicified carbonaceous sands containing well preserved palynofloras and macroflora discovered at Nelly Creek.

Detailed mapping and levelling of the Poole Creek palaeochannel was carried out on 1:40,000 scale colour aerial photography and on 1:10,000 enlargements by RAC (geology) and J. Harrison (surveying) with other geological contributions from P. Rogers and G.W. Krieg mainly during 1980–83. This work outlined three episodes of channelling and deposition during the Cainozoic, the earlier two being similar to the Eyre Formation and Etadunna Formation respectively. The term 'Poole Creek palaeochannel' is applied to these outcrops. The third channel phase is of Plio/Pleistocene age and is not discussed here.

Two fossil-plant-bearing channels of similar lithology but at different topographic levels were recognised in the central part of the Poole Creek palaeochannel (Fig. 5). Relationships between the topographically lower channel system and the Etadunna Formation were not clear, leaving open the possibility that the sequence might contain both early Tertiary (Eyre Formation of Wopfner *et al.*, 1974) and Miocene (Etadunna Formation of Stirton *et al.*, 1968) plant fossils. Attempts at direct lithostratigraphic correlation were frustrated by lack of outcrop between the Morris Creek/Crowsnest Bore area and Nelly Creek.

A preliminary examination of silcrete plant fossils from different areas revealed that some leaf-types were common to different areas of outcrop of the 'silcretes'. The mummified leaves in a facies of the Eyre Formation at Nelly Creek indicated that correlation of the silcrete floras with this palynologically dated unit may be possible.

Thus, the purpose of this study was to:

(1) Define and document the leaf-types present in the 'silcrete floras'.

(2) Ascertain the stratigraphy of the macrofloras and/or the influence of facies differences on the character of the macrofloras.

(3) Determine whether a correlation would be made between these floras and those at Nelly Creek.

(4) Determine the palaeoenvironment.

2.2 Sites of the principal floras.

The main areas of floras considered in this study are in the Poole Creek and Morris Creek catchments (Figs 1,2). Poole Creek is flanked to the east by low mesas which merge to become a plateau (Figs 2,3).

Silcrete present on these mesas and plateaux and in associated scree (often in the bed of creeks flowing westerly towards Poole Creek), contain leaf and fruit fossils a large collection of which was made by the Department of Mines and Energy in particular by RAC, since 1978.

This material forms the main source of fossils used in this study but since these collections were slightly biased towards fruits and seeds, further collections were made by DRG to obtain more representative samples of leaf-types (Fig. 4). The ?Miocene part of the palaeochannel yielded only sporadic poorly preserved material.

3. GEOLOGY OF THE POOLE CREEK PALAEOCHANNEL

3.1 Stratigraphy and Sedimentology.

The "silcrete floras" occur within two contrasting sedimentary facies. The older facies assemblage is correlative with Eyre Formation and consists largely of cross-bedded medium-grained fluvial sands (Plate 7, A & D). The Eyre Formation of Poole Creek was deposited in a series of sinuous channels up to 20 m deep and 30 m across. This develops onto a braided channel complex to the north, merging to sheet sand. These were mainly high energy sand-bed streams containing crescentic bars, often a metre or more high, but some abandoned meanders filled with fine grained sediment of quiet water facies, are also present.

The younger facies, thought to be equivalent to the Etadunna Formation, consists of white, interbedded lacustrine dolomite and olive to blue-green magnesium-rich clays, with coarse to fine fluvial sandy channel and overbank clay facies in the basin margins (Plate 7, B).

The Etadunna Formation is essentially a lacustrine infill of channels cut into the Eocene sediments. During the early stages of deposition, low energy streams were present, as indicated by the steep foresets and smaller sedimentary structures. Most detritus consists of local intraformational material. The dolomites and magnesium clays indicate an evaporative environment. The strong through-flowing streams of the Eocene were no longer dominant.

The sequence of events is recorded in the reconstructed diagrammatic sections A-D on Figure 4.

The Etadunna Formation rests unconformably on Eyre Formation, and the age of both depends on palynological investigations of bores in the Lake Eyre and Callabonna Basins (Wopfner *et al.*, 1974; Sluiter & Alley, in preparation, for the Eyre Formation; Harris, personal communication and Martin, in press, for the Etadunna Formation).

Poole Creek and its tributaries contain remnants of the eastern margin of a structurally controlled and complex palaeochannel. It contains a series of channel facies of varying ages deposited during several phases, each of which was graded to a different base level. This discussion is restricted to the central and northern sections of the palaeochannel, where the leaf fossils occur.

In the central part of the palaeochannel (Figures 2,3,4) the intertonguing between the fossiliferous younger channels and the more typical Etadunna Formation clay - dolomite facies can be demonstrated (Fig 4). This part of the palaeochannel also shows that channels containing the Etadunna Formation have cut through and removed most of the Eocene sediments, and demonstrates that siliceous duricrusts postdated both sequences.

To the north, Eyre Formation dominates and is topographically lower than the Etadunna Formation. No channel facies of Etadunna Formation have been identified in these outcrops; only the fine clastics of the lacustrine facies are present, and north of Lake Eyre South, dolomite dominates. Erosion of the Eyre Formation has occurred north of the Pleistocene shoreline of present day Lake Eyre, though remnants of partly silicified Eyre Formation channels occur in, and to the east of, Nelly Creek (Figure 2). The silicified sediments grade down into unweathered Eyre Formation containing lenses of carbonaceous clay, leaf macrofloras and well preserved palynofloras (see below). These sediments are correlated with the Eyre Formation of the Poole Creek palaeochannel on the basis of similar lithology and sedimentary structures.

The Eyre Formation channel deposits contain characteristically polished multicoloured pebbles in basal lags, and have large bar complexes with generally concave foresets. The pebbles are composed of fossil wood, agate, and varieties of quartz and chalcedony of various colours. Grain size varies from very coarse sand to boulders, averaging granule size. The unit is cemented by silcrete above the water table.

The Etadunna Formation channels in the central area have a basal lag of milky quartz pebbles only, with generally straight higher angle foresets on cross-beds (Plate 7), and contain white dolomite clasts typical of the Etadunna Formation. They are cemented by both grey carbonate and silcrete. The silcrete tends to be more cherty in appearance and more strongly coloured than that of the Eyre Formation. The cross-beds of the Etadunna Formation tend to be smaller than those of the Eyre Formation, and bars are not so well developed (Plate 7, A & B).

Plant macrofossils can be found throughout the Eyre Formation, but most commonly in fine flaggy brown sandstones and near the base or margins of the bar and channel facies. The top of the

Eyre Formation is characterised by a "reed mould" horizon (Krieg *et al.*, in prep).

In the Etadunna Formation, plant fossils are found only in silicified sandstone about 30 cm above the base of the channel facies.

3.2 Silcretes and Sediments

Silicification (including anatase) with pedogenic structures took place in the surficial environment mainly after deposition of the Etadunna Formation, and probably during the late Tertiary to early Quaternary (Callen, 1983). However, the presence of silcrete pebbles in all the channels testifies to an earlier silicification phase. The fact that these include highly polished as well as rough-surfaced clasts suggests erosion of earlier silcrete caps.

Silicification occurs as quartz overgrowths on detrital grains or as microquartz and chalcedony-opal cement. The coarser varieties are more common in the coarser sands, and opal in the clay and silt. Nodular structures are associated with surficial horizons, and overgrowths with plants in probable vadose conditions (Callen, 1983; Krieg *et al.*, in preparation). The nodular form may be deposited much later than the vadose types. Silicification probably took place during deposition, but the massive crusts did not develop fully until sedimentation slowed or ceased at times of widespread non-deposition associated with disconformities.

Silica and titanium was derived by acid leaching of siliceous rocks in stream headwaters (c.f. Milnes & Twidale, 1983; Taylor & Ruxton, 1987), and precipitated in more distal evaporative environments, or where organic matter such as chelates favoured replacement. Both replacement and cementation of plant material and sediments took place.

4. THE MACROFLORAS

4.1 Previous Palaeobotanical Studies

Perhaps the earliest reference to leaves from central Australian silcretes was by Tate, who commented in the report of the 'Horn Scientific Expedition' on leaf impressions on "flaggy quartzites" from the "Desert Sandstones" west of Lake Torrens and Lake Eyre (Tate & Watt, 1896). Tate, however, made only cursory assessment of these floras, referring a few specimens to species described from the Eocene flora at Vegetable Creek in northern New South Wales (Ettingshausen, 1888).

The first comprehensive study of the floras was by Chapman (1937), who examined and described material given to him or to the Geology Museum of Adelaide University, including the material collected on the Horn Expedition, and provided the first illustrations of fossil leaves. He referred much of the material to modern genera, including *Tristania* and *Eucalyptus*, *Hedycarya* (Monimiaceae or Atherospermataceae), *Lomatia* (Proteaceae), and *Nothofagus*. This work, however, is of little value to the present study because much of the material has ambiguous collection details or none at all, and there is no stratigraphic information.

It was with the recognition of the need for more rigorous taxonomic descriptions, and assessment of the modern affinities of fossil taxa, that Offler (1965, 1969, 1984: Lange & Offler, 1963) examined conifer shoots from a number of floras from near Mount Eba Station and to the north of Woomera (Fig. 2). Slabs of silcrete with impressions of coniferous shoots were coated with rubber latex to produce high quality three-dimensional moulds. A set of morphological characters which could be used to classify conifer shoots into artificial foliage categories was produced, which could be used to narrow down the number of potential comparisons required to make a match with a modern genus (Offler & Lange, 1963; Offler, 1984).

Offler (1969) referred the conifer shoots to modern conifer genera, including: *Araucaria* and *Agathis* (Araucariaceae), *Papuacedrus (Cupressaceae)*, *Dacrycarpus* (as Section *Dacrycarpus* of *Podocarpus*) and *Dacrydium* sensu lato (Podocarpaceae). On the basis of morphological comparisons the conifer floras from sites west of Lake Torrens were believed to be most closely related to extant species restricted to montane rainforests in New Caledonia and New Guinea (Offler, 1969; Lange, in Wells & Callen, 1986). The stratigraphic relationships of the host sediments of these silcrete floras, however, is often uncertain.

The most recent, and perhaps botanically most interesting study of the floras has concerned the discovery of fruits of *Eucalyptus s.l.* and capsular fruits ('gum nuts') of other members of the Myrtaceae (Lange, 1978). A diverse suite of 'gum nuts' from a number of localities, principally in the Willalinchina Hut area of Stuart Creek and to the south near Andamooka has been reported (Lange, 1978, 1980; Ambrose *et al.*, 1979; Wells & Callen, 1986). These fossils occur as moulds and when filled with latex produce detailed three-dimensional casts of the original fruit (Lange, 1978, 1982).

The `gum nuts' are important in understanding the phylogenetic history of a major Australian plant genus, and also provide information on the development of the eucalypt-dominated vegetation of Australia. The presence of Myrtaceae in the central Australian Early Tertiary macrofloras, but their apparent absence from macrofloras of similar ages from southeastern Australia, was used as evidence to suggest the appearance of a sclerophyllous vegetation in central Australia much earlier than in southeastern Australia (Lange, 1978, 1980, 1982). Foliar remains of Myrtaceae are common in some Eocene macrofloras from southeastern Australia (Christophel & Greenwood, 1987) but these leaves mostly represent genera typical of rainforest vegetation, the berry-fruited Myrtaceae (eg. *Syzygium/Myrtaciphylum;* Christophel & Lys, 1986).

A requirement of present taxonomic and phylogenetic studies of the genus *Eucalyptus sensu lato* is an understanding of its evolutionary history through the Tertiary, including the biogeography of the component groups within *Eucalyptus s.l.* (Chippendale, 1988). The `gum nuts' contain a diversity of forms and thus suggest that considerable evolution had already occurred within the genus at the time of deposition (Lange, 1978, 1984). The age and further resolution of the modern affinities of these 'gum nuts' are therefore important in unravelling the evolutionary history of *Eucalyptus.*

4.2 Description and Delimitation of Fossil Form-taxa.

No attempt is made here to assign the silcrete plant material to particular fossil or modern taxa. Each of the specimens studied has been assigned to a "form-taxon" within a classification based on the morphology of the leaves (Appendix 7.1). Each form-taxon represents a morphological entity which can be used for the purposes of biostratigraphic correlation, although it is possible that some leaf form-taxa may contain fossil leaves from more than one biological species. However, where possible the suggested affinity of particular form-taxa to either modern taxa or previously described fossil taxa is indicated. In general, descriptive terminology follows Hickey (1979); others are defined in Appendix 7.1.

Individual leaf or fruit specimens have not been numbered and so the specimen numbers refer to a unique rock sample by its Rock Sample (RS) number. In most cases arrows have been drawn on the rocks to indicate the location of the specimens referred to in this report. A master list of all the rocks examined in this study is given in Appendix 7.2.

Leaf-type. 'Coarse-reticulate' (Plate 1 A, B)

Leaves simple with entire margins, generally narrow elliptic, rarely linear. Leaf apex acute where present, leaf base acuminate with a short petiole. Secondary venation brochidodromous, with reticulate tertiary venation. Secondary and tertiary venation very prominent on all specimens.

Location. Stuart Creek, Morris Creek, Poole Creek, Nelly Creek, Mount Alford.

Stratigraphic position and age. Willalinchina Sandstone (Eocene), Eyre Formation (Eocene).

Remarks. This leaf type is the most common type in the Eyre Formation of the Poole Creek palaeochannel. It is also known from the Nelly Creek mummified flora (Christophel, pers. comm.) and from Stuart Creek but is unknown from any of the ?Miocene sites. The presence of individual leaves with a more linear shape and more highly developed looped secondary veins suggests that this taxon may represent two biological entities, although both forms intergrade and are present at most locations.

Leaf-type. 'imbricate conifer' shoot (Plate 1C)

Generally unbranched shoots of awl-shaped, short, imbricate needles. Needles partly spreading or loosely appressed, in rows and all of one size and type. Spread of needles 3-6mm.

Location. Poole Creek, Stuart Creek, Nelly Creek.

Stratigraphic position and age. Eyre Formation, Willalinchina Sandstone (Eocene).

Remarks. Most likely a conifer shoot. Not common in the northern section of the Poole Creek palaeochannel, but more common in the southern Eyre Formation sites and also at some sites in Stuart Creek. A very similar shoot has been found in the Nelly Creek macroflora, but has not as yet been examined (Christophel, pers. comm.).

Leaf-type. 'Serrate-coarse' (Plate 1 D)

Simple elliptic to narrowly ovate leaves with coarsely serrate margins. Lamina 5 to 8 cm long, 2 to 4 cm wide. Venation craspedodromous with well developed secondary veins extending to the teeth. Teeth apically directed and appearing glandular in some specimens. Midvein usually straight, rarely diverting in the upper half of the leaf. Tertiary venation usually not preserved, otherwise reticulate and prominent.

Location. Poole Creek, Stuart Creek, Mt Alford, Morris Creek.

Stratigraphic position and age. Eyre Formation, Willalinchina Sandstone (Eocene).

Remarks. Never a common leaf, but has been found in all three of the Eyre Formation areas. The affinities of this leaf-type are difficult to assess, but it is similar in some respects to some members of the Cunoniaceae and Meliaceae which are rainforest plants and the latter, more rarely monsoon vine forest trees.

Leaf-type. 'entire pinnatifid leaf' aff. Proteaceae (Plate 2 A)

Leaves deeply pinnatifid. Lobes linear and generally very narrow, spreading, with narrow sinuses and entire margins. Leaf base unknown, apex representing a continuation of the main lamina, ultimate apices of lobes and leaf acute. Primary venation actinodromous with successive main veins of each lobe massive and originating alternately along the length of the main midvein. Secondary venation actinodromous with successive main veins of each lobe massive and originating alternately along the length of the main midvein. Secondary venation not preserved in most specimens, where present semi-craspedodromous.

Location. Poole Creek, Stuart Creek, Mt Alford, Morris Creek, Nelly Creek, Stuart Creek.

Stratigraphic position and age. Eyre Formation, Willalinchina Sandstone (Eocene).

Leaf type. 'serrate pinnatifid leaf' (?aff. Proteaceae) (Plate 2 B)

Pinnatifidly lobed leaf with serrate margins; lobes spreading and often broadest at the mid-length of the lobe. Teeth apically directed and prominent. Primary venation actinodromous with successive main veins of each lobe massive and originating alternately along the length of the main midvein. Tertiary venation semi-craspedodromous with a single secondary vein entering each tooth.

Location. Morris Creek, Stuart Creek, Nelly Creek.

Stratigraphic position and age. Eyre Formation, Willalinchina Sandstone (Eocene).

Remarks. Not a common leaf, although fragments are common in the Nelly Creek macroflora. The craspedodromous venation of some specimens and the arrangement of the lobes of this leaf-type suggest it may have affinities to the Proteaceae.

Leaf-type. 'Brachychiton' aff. Sterculiaceae. (Plate 2 C, D)

Leaves bilateral, palmatifid with five or seven (rarely three) lobes; the lamina of each lobe extend beyond the sinus for greater than 2/3 of the total length of the lobe mid-vein. Lobe apices acuminate, becoming almost cirrhose in some specimens; sinus between lobes rounded, acute; lamina of lobes broadest at or about the mid-length of the lobe, narrowing prior to fusion with the mid-length of the lobe, narrowing prior to fusion with adjacent lobes. Lobe margins entire or undulate (preservational artifact?). Middle lobe marginally larger than other lobes, varying from approximately 5 cm length and 1.4 cm width to greater than 17 cm length (incomplete) and 5 cm width. Basal pair of lobes less than 2/3 length of largest lobe, and may be imperfectly fused with adjacent lobes. Primary venation actinodromous, with the primary vein divergence basal; venation in each lobe perfect in upper 2/3 of lobe and eucamptodromous with the secondary veins diverging to become almost parallel to the margin.

Locations. Stuart Creek, Mount Alford, Poole Creek, Morris Creek.

Stratigraphic position and age. Eyre Formation, Willalinchina Sandstone (Eocene).

Remarks. Can be very common in small localized patches, particularly at Willalinchina Hut in the Stuart Creek area. Leaves generally occur in the intermediate size range - about 16cm length of middle lobe with the five-lobed form more common. The three-lobed form is known from only a few specimens, with one being the smallest example - 5cm length of middle lobe.

The 'Brachychiton' leaf-type superficially resembles leaves from *Brachychiton* (Sterculiaceae), which has been recorded from a number of southern Australian Eocene mummified leaf floras, including the Golden Grove deposit near Adelaide (Christophel & Greenwood, 1987, 1988). The leaf architecture of the leaves differs, however, from extant *Brachychiton* and the Golden Grove leaves in important ways. The silcrete palmatifid leaves have a clear narrowing of the lobes at the sinus between each lobe, with the broadest part of each lobe at the approximate midpoint of the lobe. the venation of each lobe is eucamptodromous, with the secondary veins arching apically and running almost parallel to the margin for a short distance. The leaves of extant *Brachychiton* have lobes which are typically broadest at the sinus between each lobe, tapering to the apex. Also, the venation of the lobes of *Brachychiton* is often craspedodromous, with the secondaries dichotomising about 1/2 to 2/3 the distance from the midvein to the margin. However, individual leaves from the rainforest species, *Brachychiton acerifolius*, may similarly narrow at the sinus.

Palmatifid leaves with architectural features similar to the 'Brachychiton' leaf-type, but not referred to *Brachychiton*, have been recorded from the Paleocene-Eocene Vegetable Creek locality in New South Wales (Ettingshausen, 1888), and from the Eocene Maslin Bay locality in South Australia (Blackburn, 1981). The Maslin Bay leaf-taxon, *Parafatsia subpeltata* Blackburn, and the Vegetable Creek taxa, *Aralia oxleyi Ett*. and *A. prisca Ett*., were attributed to the Araliaceae, although Blackburn noted that the Vegetable Creek taxa should be transferred from *Aralia* to another genus within that

Family (Blackburn, 1981; Ettingshausen, 1888). The 'Brachychiton' leaf-type also resembles the leaves of *Aralia oxleyi* and *A. prisca* figured by Ettingshausen (1888), which, like the silcrete specimens, have entire margins in contrast to the toothed margin of *Parafatsia subpeltata*. Members of the Araliaceae are often lobed in the manner observed for the 'Brachychiton' leaf-type, and the narrowing of the lobes at the sinus is characteristic of the palmatifid leaf-type for the Family. Although *P. subpeltata* has toothed margins (Blackburn, 1981), the absence of teeth is more typical of the Family (Toelken, 1983), as observed for the silcrete specimens.

Superficial comparison of the 'Brachychiton' leaves and these fossil Araliaceae may suggest a match. However, modern members of the Araliaceae typically have 9 -12 lobes, although individual trees may have single leaves with as few as two lobes. Also, whereas *Brachychiton* almost always has 1, 3, 5, or 7 lobes, leaves from members of the Araliaceae show no predilection for particular numbers of lobes. All of the silcrete specimens in this study, including a large number seen in situ on large boulders in the field, have had 3, 5. and rarely 7 lobes. It is more likely, therefore, that the leaves represent *Brachychiton*, or some extinct relative from the Sterculiaceae, than a member of the Araliaceae.

Leaf-type, 'Banksieaeformis' I. aff. Proteaceae (Plate 3 A)

Leaves bilateral, pinnately lobed, lobes acute and apically directed. Apical side of lobe usually concave, rarely straight; basal side convex, sinuses acute. Leaf base and apex unknown. Leaf length greater than 8.5cm, width 1.2 to 1.6cm. Lobes typically with four veins, rarely five, with a pronounced vein leading to the apex of the lobe end and ramifying prominently. Leaf rachis massive.

Location. Stuart Creek.

Stratigraphic position and age. Willalinchina Sandstone (Eocene).

Remarks. The arrangement and shape of the lobes, and the gross venation of this leaf-taxon strongly resembles some modern species of *Banksia* and *Dryandra* (Proteaceae). According to Hill & Christophel (1988), fossil leaves with this morphology but lacking epidermal detail should be placed in the organ-genus *Banksieaeformis*. They also consider that such leaves represent now extinct species within the tribe Banksieae of the Proteaceae (which includes modern *Banksia* and *Dryandra*). This leaf-taxon bears a strong resemblance to the organically preserved *Banksieaephyllum cuneatum* Blackburn from the Eocene Maslin Bay flora (Blackburn, 1981), differing only in the much smaller size of the individual lobes of the silcreted specimen. Unfortunately, the base and apex of the silcrete leaf-type is not known, thus preventing further comparison between these two taxa.

Leaf-type. 'Banksieaeformis' II. aff. Proteaceae (Plate 3 B)

Leaves bilateral, pinnately lobed, lobes generally narrowly acuminate apex and apically directed. Apical side of lobes straight to slightly concave, rarely strongly concave; basal side straight but curving to produce a broad attachment to the rachis. Leaf base unknown, apex consisting of a terminally directed modified lobe (single specimen). Lobes opposite in some specimens, but becoming alternate further along the rachis in other specimens; some specimens fully alternate. Leaf length (incomplete) to 16 cm, width to 8 cm (estimated), but may be as small as 2 cm width. Individual lobes 0.8 to 2.7 cm wide at the rachis. Lobes typically with 2 prominent veins, rarely 1 or 3 to 4 on the one specimen, with a single vein leading to the lobe apex. Tertiary veins in a loose reticulate net. Leaf rachis massive.

Location. Stuart Creek, Morris Creek, Mount Alford.

Stratigraphic position and age. Eyre Formation, Willalinchina Sandstone (Eocene).

Remarks. As noted for the previous leaf-type, 'Banksieaeformis' II possesses the gross morphology typical of some modern members of the tribe Banksieae of the Proteaceae. This leaf-type has been previously described by Chapman who used a name proposed by Tate; *Banksia praegrandis* Tate (Chapman, 1937). This name must be changed in the light of the revision of Tertiary Banksieae by Hill & Christophel (1988), and if appropriate, the taxon transferred to the organ genus *Banksieaeformis*. The acuminate apices of the lobes of this leaf-typed and the general tendency for each pair of lobes to be opposite is unusual for the Banksieae, and is more typical of the arrangement seen in the fronds of some members of the Cycadales. The broad base of the individual lobes and the reticulate tertiary venation of the lobes however, suggest that this leaf-type is not a cycad-frond. The lobes in several specimens are not paired and show a tendency to become progressively alternate, as seen in modern leaves of Banksieae (*Banksia* and *Dryandra*).

Leaf-type 'Ficophyllum'. (Plate 3 C)

Leaf simple, linear to narrowly lanceoloate or narrowly elliptic, apex tapering to acuminate, base acuminate, margin entire. Primary venation brochidodromous, secondary veins densely arranged at a shallow angle and extending to the margin where the upward loops fuse very close to the margin to form an intramarginal vein. Leaf appears quite coriaceous.

Location. Stuart Creek, Poole Creek, Mount Alford.

Stratigraphic position and age. Eyre Formation, Willalinchina Sandstone (Eocene).

Remark. This leaf-type is uncommon. A similar leaf-type has been recently collected from the Eocene flora at Golden Grove where it has been found as an impression of a leafy twig bearing an organic stain in the lighter matrix there (D.J. Barrett, Univ. Adel., pers. comm., 12/10/88). This leaf-type bears a close resemblance to leaves of both the modern genus *Nerium* (Apocynaceae), a common garden ornamental (Oleander) originally from the South Pacific, and some species of *Ficus* (Moraceae).

Leaf-type. ?'Sapindaceae' (Plate 3 D)

Simple, narrowly elliptic to linear leaves with entire margins. Leaf base and apex acuminate. Leaf petiolate and 7-12 cm length, 2-4 cm width. Primary venation craspedodromous with well defined and fine but irregular secondary veins prominently bifurcating at 1/2 to 2/3 of the distance from the midvein. Tertiary veins loosely reticulate and very fine.

Location. Poole Creek, Morris Creek, Mount Alford.

Stratigraphic position and age. Eyre Formation (Eocene).

Remarks. Uncommon but generally present as intact well preserved leaves of moderate size (ca. 10 cm length). The venation pattern and general shape of the leaf is consistent with some members of the Sapindaceae and also Proteaceae. It is labelled ?Sapindaceae as it resembles leaves of *Dodonaea* (Sapindaceae).

Fruit type. 'Daisy' ?flower. (Plate 6 A)

Irregular disc with central inner circle, outer diameter 2 - 1.5 cm, inner diameter 0.2 - 0.4 cm. Main body (outer ring) consisting of overlapping radiating segments, each segment approximately 1 mm wide, tapering towards the central part of the disc, inner tip of segments forming a slight swelling in some specimens. Central ring generally obscured, where visible displaying a raised hexagonal honey-comb lattice with very small pits inside each hexagon.

Location. Nelly Creek, Poole Creek, Stuart Creek.

Stratigraphic position and age. Eyre Formation, Willalinchina Sandstone (Eocene).

Remarks. Although the exact nature of this structure is unknown, it appears to be either a floral structure (eg. a compound inflorescence such as a 'daisy head'; Asteraceae), or a fruiting structure. It is described here as it is very distinctive, and is known from several sites, both at the Poole Creek palaeochannel, and at Stuart Creek and from a single specimen of mummified material from Nelly Creek (Christophel, pers. comm.). Identical structures are recorded from upper Pidinga Formation (Eocene) in the Eucla Basin (M. Benbow, pers. comm.).

Fruit-type. 'coarsely papillate' seeds. (Plate 6 B)

Strongly papillate elliptic to subcircular disc up to 2 cm diameter. Papillae coarse, 1 - 3 mm high, linked by branching ridges to produce a rugose texture.

Location. Poole Creek.

Stratigraphic position and age. Etadunna Formation (Miocene).

Remarks. A rare seed type which strongly resembles the endocarp of *Elaeocarpus* (Elaeocarpaceae). Similar seeds are common in many Cainozoic macrofloras (both Eocene and Miocene). Modern species from the Elaeocarpaceae are generally rainforest trees but a few occur in drier forest communities.

Leaf-type. 'Tristaniophyllum' aff. Myrtaceae (Plate 4 A)

Often very large simple elliptic to ovate leaves with entire margins, lamina usually incomplete with widths up to 6 cm, but typically 2 - 3cm. Venation brochidodromous but appearing craspedodromous in some specimens through poor preservation of the very fine intramarginal vein very close to the margin formed by fusion of the back loops of the secondary veins. Secondary veins always closely parallel and diverging from the midvein at shallow angles (80^o - 70^o), rarely dichotomising and generally very fine.

Location. Poole Creek, Morris Creek, Nelly Creek, Stuart Creek.

Stratigraphic position and age. Eyre Formation (Eocene).

Remarks. Although Chapman (1936) figured a number of leaf specimens with intramarginal veins which he ascribed to several species of *Tristania* on the basis of their shape and size, Lange (in

Wells and Callen, 1983) considered the determinations invalid since they were based on superficial examination. However, it is possible to recognise within the silcrete floras a distinct leaf-type probably containing leaves of several biological species, which bear a resemblance to leaves of the extant species, *Lophostemon confertus* (syn. *Tristania conferta*). This leaf-type is characterised by the shallower angle of junction of the secondary veins with the midvein, than seen in the 'Eucalyptophyllum' leaf-type, their closer and more orderly arrangement, and the broader nature of the lamina. The blade tends to be more elliptic than seen in either of the other two Myrtaceae leaf-types, and this leaf-type is further differentiated by both its very large size and the massive nature of its' primary vein.

Leaf-type. 'Myrtaciphyllum' aff. Myrtaceae (Plate 4 C,D)

Leaves simple with entire margins, ovate to elliptic, L:W 3.3., lamina up to 6.5 cm long and 2.0 cm wide. Leaf apex tapering to acute?, leaf base acuminate. Venation brochidodromous with the back loops fused to form a well developed intramarginal vein close to the margin, secondary veins generally parallel and originating at an angle of about 50 - 40^{o} to the midvein, intersecondaries at an irregular and branching. Leaf surface pitted on some specimens (?oil glands).

Location. Poole Creek, Morris Creek, Mount Alford, Nelly Creek, Stuart Creek.

Stratigraphic position and age. Eyre Formation (Eocene).

Remarks. The general morphology of this leaf-type is unlike *Eucalyptus*, but very similar to the venation, shape, and size of leaves seen in modern species of *Syzygium*, *Acmena*, and *Eugenia* (Myrtaceae). These genera cannot be separated on the basis of leaf architecture alone (Christophel and Lys, 1986). The secondary veins of the leaves of extant *Syzygium* generally occur at a much shallower angle from the midvein than in *Eucalyptus* or *Melaleuca.* In addition, the general shape of *Eucalyptus* leaves is much narrower than broad ie. L:W >6, compared to a L:W of approximately 3–4 for many extent species of *Syzygium*.

Other leaf-types with Myrtaceae-type venation (with parallel secondary veins and a prominent intramarginal vein) also occur in the silcretes. This leaf-type can be distinguished from the other by its tendency to an ovate shape, the leaf size (particularly the width, approx. 2cm), and the closely parallel secondaries.

Leaf-type. 'Eucalyptophyllum' aff. Myrtaceae (Plate 4 B)

Simple lanceolate, linear or narrowly elliptic leaves with entire margins. Length 5 to 10 cm, width 0.8 to 1.5 cm, generally much narrower than long. Venation brochidodromous with the back loops fused into a prominent intra-marginal vein. Secondary veins at an acute angle with the midvein (about 30°), loosely arranged in a ladder-like manner and occasionally dichotomising and reconnecting. The surface appears pitted in some specimens, suggesting oil glands.

Location. Poole Creek, Morris Creek, Stuart Creek, Mt Alford, Nelly Creek.

Stratigraphic position and age. Eyre Formation, Willalinchina Sandstone (Eocene); Etadunna Formation (Miocene).

Remarks. This leaf-type is very common in the 'silcrete floras' and probably includes leaves from a number of species and possibly more than one genus. The narrowly lanceolate (rarely falcate) shape, and the steep angle at which the secondary veins diverge from the midvein distinguish this leaf-type from the other two Myrtaceae leaf-types. Many species of modern *Eucalyptus s.l.* and some species of *Melaleuca* have leaves with the same size, shape and venation detail as this leaf-type. However, in the absence of epidermal detail it is not possible to determine the affinities of this leaf-type.

Fruit-type. 'Gymnostoma' cones. aff. Casuarinaceae (Plate 5 A,B)

Infructescene (or 'cone'). Broadly ellipsoid impression 9 to 15 mm wide and 15 to 20 mm long, often with a narrow cylindrical impression extending from one end representing the peduncle. Regularly arranged paired valves in alternating rows aligned along the long axis. Valves aprox. 2 mm wide and 2 to 3 mm long, often prominently striated, no more than three pairs of valves in any row (impression is of half of structure). When cast, ellipsoid with successive rings of four moderately to strongly exserted paired bracteoles.

Location. Stuart Creek, Poole Creek, Morris Creek, Mt Alford, Nelly Creek.

Stratigraphic position and age. Eyre Formation, Willalinchina Sandstone (Eocene), and Etadunna Formation (Miocene).

Remarks. These 'fruits' resemble the so-called cones of modern sheoaks, bulloaks and blackoaks; all formerly placed within the genus *Casuarina* sensu lato. *Casuarina* sensu lato has been recently revised and segregated into four genera on the basis of both foliar and cone morphology (Johnson, 1980, 1982). The arrangement, size, number, and degree of exsertion of the cone valves of this fruit-type is consistent with modern members of *Gymnostoma*, and quite distinct from the *Casuarina-Allocasuarina* group. The often strong exsertion of the cone valves (bracteoles) is typical of *Gymnostoma*. Foliage of *Gymnostoma* has been found in the Nelly Creek mummified flora (Christophel, pers. comm., 1988).

Eocene macrofloras from southern Australia appear to contain only foliage and cones of *Gymnostoma*, whereas Oligo-Miocene macrofloras from southern Australia contain cones and foliage of both *Casuarina-Allocasuarina* and *Gymnostoma* with *Gymnostoma* being subordinate (Christophel, 1981; Scriven & Christophel, 1988). However, Scriven & Christophel (op cit.) have reported a Miocene macroflora from central Queensland, at Moranbah, containing foliage and cones of *Gymnostoma*. More recently this flora has been redated and placed as Eocene based on a K/Ar date from associated basalt flows (Christophel, per. comm., Dec. 1988).

Fruit-type. 'Casuarina' cones. aff. Casuarinaceae (Plate 5 C,D)

Infructesence ('cone'). Cylindrical to ellipsoid impression no more than 10mm long and about 5 to 8 mm wide, usually with a short narrow cylindrical impression extending from one end representing the peduncle. Generally poorly preserved. Numerous protuberances arranged in three to five regular vertical rows separated by a fine raised line, typically 5 rows, but may number 10.

Location. Poole Creek, near BMR drill hole Poole Creek 3.

Stratigraphic position and age. Etadunna Formation (?Miocene).

Remarks. These 'cones' have been tentatively assigned to the *Casuarina-Allocasuarina* group on the basis of the size and general shape of the structure, the size and arrangement of the protuberances (valves?) into rows, and the number of these 'valves'. An alternative interpretation is that these structures represent conifer cones. However, the size, and arrangement of the 'valves' is not consistent with most conifer cones. The cones of *Casuarina-Allocasuarina* differ those of *Gymnostoma* by the smaller size of the individual valves, the overall reduced size of the cones, and the greater number of valves in each whorl. *Gymnostoma* typically has 4 parts per whorl.

Leaf-type. 'Banksieaeformis' III. (Plate 6 C)

Description. Leaves bilateral, pinnately lobed; lobes generally rounded at the apex, straight sided and extending at right angles from the rachis. Leaf width 5 - 8 mm, individual lobes 2 - 5 mm wide at base.

Location. Southern part of Poole Creek locality.

Stratigraphic position and age. Etadunna Formation (?Miocene).

Remarks. This leaf-type superficially resembles the fronds of some modern ferns (eg. *Gleichenia, Dicranopteris*), but is generally much larger and more robust. Thus, it may represent a variant of 'Banksieaeformis' I, although this leaf-type is consistently such smaller and never shows any venation. Also, some specimens appear to have been deposited in a slightly sinuous arrangement suggesting that the leaves were quite pliable at the time of deposition. The leaves of modern members of the Banksieae are generally robust and sclerophyllous, making it unlikely that individual leaves would have been deposited in a twisted arrangement. Thus, fern fronds are viewed as more likely candidates.

Leaf-type. 'parallel veins' / 'reed fragment' (Plate 6 D)

Rectangular to trapezoid leaf (?) fragments with numerous parallel dichotomising veins. No mid-vein present. Veins do not appear to anastomose (cross-link) and seem all of equal size. Width from 5 mm to 10 mm, margin generally straight, occasionally wavy, never toothed or serrate. End pieces always irregular, crossing veins and interpreted as broken edges.

Location. Poole Creek.

Stratigraphic position and age. Etadunna Formation (?Miocene).

Remarks. Possibly represents fragments of reed stem and leaves. Generally appears not robust and often with wavy veins that are of similar size over the whole width of each fragment and do not anastomose. No pieces were seen which could be interpreted as pinnules of a pinnate frond.

5. BIOSTRATIGRAPHY OF THE CAINOZOIC MACROFLORAS.

The Nelly Creek mummified flora is the key macroflora for correlation with the silcrete floras, as their associated sediments also contain abundant and diverse palynofloras. The Nelly Creek flora occurs as thick layers of mummified leaves in Eyre Formation sediments, in the creek bed about a kilometre upstream from Lake Eyre South (Figure 2 & Plate 7 D). Lithological comparisons suggest that Eyre Formation in Nelly Creek is correlative with silicified facies to the south. Partially silicified sediments are also found within the bed of Nelly Creek, some containing poorly preserved leaves.

5.1 Palynology.

Palynofloras from the Eyre Formation in Nelly Creek are correlated with the *Nothofagidites falcatus* Zone (Alley, 1989; Sluiter & Alley, in prep.) and are thus of Middle Eocene age. This zone is the time equivalent of the Lower *Nothofagidites aspersus* Zone (Stover & Partridge, 1973, 1982) and the *Proteacidites pachypolus* Zone (Harris, 1971). This means that the plant fossils are time equivalents of other macrofossils in the North Maslin Sand at Maslin Bay and Golden Grove (Alley, 1987; Christophel & Greenwood, 1987).

Correlation with the *N. falcatus* Zone is made on the basis of the presence of the nominate taxon in association with other *Nothofagidites 'brassii'* form taxa, *Sapotaceoidaepollenites rotundus* Harris 1972, *Proteacidites stipplatus* Partridge 1973, *P. pachypolus* Cookson & Pike 1954, *P. asperopolus* Stover & Evans 1973, *P. confragosus* Harris 1972, *P. reticulatus* Cookson 1950, *Santalumidites cainozoicus* Cookson & Pike 1954, *Rhopipites angurium*, (Partridge) Pocknall & Mildenhall 1984, *Tricoloporites scabratus* Harris 1965 and *Myrtaceidites verrucosus* Cookson 1950.

The pollen assemblages are correlated with the Lower *N. aspersus* Zone and the *P. pachypolus* Zone of southern Australia on the basis of the presence of *Nothofagidites falcatus* (Cookson) Stover & Evans 1974 and the lack of *Triorites magnificus* Cookson 1950 (Alley, 1989).

The above evidence indicates that the leaf-bearing beds in Nelly Creek belong to the youngest part of the Eyre Formation. Sediments of similar age are encountered between 65.6 m and 84.25 m in nearby B.M.R. Peachawarrina 2 borehole in the Lake Eyre Basin and in a number of wells in the Frome Embayment including Pacminex 7A (115.21-118.26 m), Sedimentary Uranium B240/C3 (104.4-119.4 m), Chevron QDH 16 (109.73-141.73m), Chevron QDH 18 (120.4-121.92 m) and Minad LC/1A (192.02-204.22 m)(Sluiter & Alley, in prep.).

Although the palynofloras are diverse there is considerable variation in frequency of a number of taxa from sample to sample, as would be expected of pollen spectra produced by riparian plant assemblages. In general, however, pollen similar to extant *Casuarina sensu lato* (i.e. including both *Casuarina* and *Gymnostoma*), mainly the form taxon *Haloragacidites harrisii*, dominate the assemblages. In view of the frequent occurrence of *Gymnostoma* foliage in the macroflora (Christophel, pers. comm.), this pollen probably also represents *Gymnostoma*. Pollen of rainforest types such as *Nothofagidites* spp. and coniferous plants (apart from *Lygitepollenites florinii*) form only a minor part of the palynofloras at Nelly Creek. In most southern Australian Mid-Eocene palynofloras, these pollen types dominate.

Nothofagus pollen is commonly over-represented in fossil and modern palynofloras, this being a reflection of the high pollen productivity of the genus. The low frequency of *Nothofagidites* ssp. pollen in the Middle Eocene palynofloras at Nelly Creek may imply that *Nothofagus* formed only a very minor part of the local vegetation or, more likely, the pollen was transported considerable distances from uplands such as the Flinders and Willouran ranges. In general the low frequency of pollen from rainforest plants in association with high Casuarinaceae (?*Gymnostoma*) and diverse and reasonably well represented proteaceous pollen suggests that rainforest may have been restricted to moister valley bottoms and more sclerophyllous vegetation dominating the hinterland.

5.2 Leaf form-taxa as biomarkers.

Examination of modern analogues of fossil leaf beds have demonstrated that most of the leaves preserved represent the local flora, that is the riparian plant communities (Spicer, 1980; Burnham, 1989; Christophel & Greenwood, 1989). Sediments of similar age and derived from similar sedimentary facies will contain similar suites of leaf taxa (=leaf types). Analysis of the silcrete floras demonstrates that amongst the 19 `taxa' identified, several consistently occur together, whereas, some do not.

Six fossil types are the most useful for correlating the Eocene and ?Miocene macrofloras. Three of these are represented by leaves, and the remainder by 'fruit' or floral structures. Significantly, two of these taxa are found in the Nelly Creek flora. The occurrence of the 19 taxa recognised for all samples from all of the sites is given in Appendix 7.2, however, an account of each site with all samples summed is shown in Table 4.1. Three taxa are recorded from the majority of sites: 'Gymnostoma' cone (Plate 5 A,B), 'coarse reticulate' leaf (Plate 1 A,B), and 'daisy' (Plate 6 A). Similarly, the fern-like 'Banksieaeformis' III leaf type (Plate 6 C) and 'Casuarina' cones (Plate 5 C,D) are restricted to only three sites, and are absent from any of the sites where the 'coarse reticulate' leaf, or 'daisy' taxa occur. A third leaf type, represented by leaf fragments with prominent parallel veins (Plate 6 D), is also restricted to the sites where 'Banksieaeformis' III and 'Casuarina' cones occur, but did not occur at the other sites. This material appears to represent reed stems and leaves.

Other leaf types represented convenience groupings of morphologically similar fossil types and might be mixtures of several related or unrelated taxa. For example, leaves from the silcrete floras which possess the Myrtaceae venation pattern can be differentiated into three leaf types, based on the angle of the secondary veins, their organisation, and the overall shape of the leaves. However, each of these categories may include leaves from several genera as leaves from the Myrtaceae are difficult to place into seperate genera based on gross features of the venation alone (Christophel and Lys, 1986). Thus, morphologically similar leaves superficially like *Eucalyptus* (ie. 'Eucalyptophyllum'), may be present in both Eocene and Miocene sediments, yet represent different species or genera. Such taxa are unsuitable for biostratigraphic correlation, and thus, the presence of the three Myrtaceae leaf types (Plate 4) was noted for each site, but not used in the biostratigraphic analysis.

5.3 Macrofloral Correlation and Age.

The macrofloras of the Poole Creek Palaeochannel can be separated into two groups based on the discrete occurrence of diagnostic taxa at particular sites (Table 4.1). Lithological comparisons demonstrate these separate macrofloras occur in Etadunna and Eyre Formation sediments respectively. The macrofloras of sites with putative Eyre Formation sediments were moderately diverse, with a number of taxa present, with some taxa unique to individual sites or a very small number located at quite distant sites. Generally the macrofloras of the Eyre Formation contained the taxa: `Daisy', `coarse reticulate' leaf, `coarse serrate' and `entire pinnatifid' leaf-types. Other taxa were also useful for correlation and are discussed below.

The silicified Etadunna Formation sediments of Poole Creek Palaeochannel contain generally much less diverse macrofloras than the Eyre Formation in this area, although one more diverse suite occurs at a site near the Oodnadatta Track. Taxa diagnostic of the Eyre Formation sediments are absent from the Etadunna Formation sites (Table 4.1). Two leaf-types are common to all of the Etadunna Formation sites - a fern-like leaf assigned to `Banksieaeformis' III, and a parallel-veined leaf fragment (`reed'). Cones attributed to *Casuarina sensu strictu* (`Casuarina') are found in association with these taxa at most sites. These taxa are not found at any sites containing the taxa diagnostic of Eyre Formation sediments in Poole Creek (Table 4.1), and so are considered diagnostic of the Etadunna Formation.

The Etadunna Formation sediments do contain taxa in common with the Eyre Formation sediments of Poole Creek, but in association with taxa unique to the Etadunna Formation macrofloras. As has been argued earlier, the taxa in common to the two macrofloras represent leaf-forms recognised at a very broad level, and most likely represent unrelated but superficially similar form-taxa. Myrtaceae leaves, placed in the `Eucalyptophyllum' leaf-type are rarely present; `Casuarina' cones are also found at two of the sites with `Gymnostoma' cones. `Gymnostoma', in one instance occurs on a single rock face with both `Casuarina' cones and a putative *Banksia* cone (Greenwood, in prep.).

Preliminary analysis of the Nelly Creek macroflora has isolated a large collection of whole leaves and some reproductive structures (D.C. Christophel, pers. comm., 1989), some of which match fossil taxa in the silcrete floras. A selection of leaf types from the Nelly Creek macroflora, including some in common with the silcrete floras, are shown in Plate 8 and Figure 6. Small entire-margined leaves (<5cm) appear to dominate the flora, although rare much larger leaves are occasionally found. A feature of the Nelly Creek leaf-beds is that particular samples contain quite different suites of leaf-types, although some leaf-types are common to all samples. This may reflect differences in the taxonomic content of discrete layers within these leaf-beds. Similar results have been found in other Eocene leaf-beds (eg. Golden Grove: Barrett, 1987; Barrett and Christophel, 1988) and modern stream beds (Burnham, 1989).

A number of distinctive taxa are common to both the Eyre Formation Poole Creek and Nelly Creek macrofloras, and form the basis for correlation between these areas. Of particular interest are the `coarse reticulate' leaf (Plate 1A), `entire pinnatifid' leaf (Plate 2A), the `serrate pinnatifid' leaf (Plate 2B), and the so-called `daisy' ?fruit/flower (Plate 6A). Fragments of both of the `pinnatifid' leaf types are generally common in Nelly Creek samples, while the `daisy' is only known from a single specimen. Small intact leaves and fragments of larger examples of the `coarse reticulate' leaf-type are also common, although the Nelly Creek material indicates that two separate taxa may be combined within this taxon.

Leaves of Myrtaceae are common in some samples of the Nelly Creek macroflora, with broad-lamina specimens, usually as fragments, occasionally dominating. These are similar to many of the leaves from the Poole Creek flora attributed to the `Tristaniophyllum' group. Rarer examples of Myrtaceae leaves from Nelly Creek are attributable to the `Myrtaciphyllum' group. In addition a number of imbricate-foliaged twigs are similar to the `imbricate conifer' leaf-type of the Poole Creek silcrete floras. Occasional leaf-bearing twigs of *Gymnostoma* are also found (Christophel, pers. comm., 1988).

Some of the rarer leaf-types, such as `Banksieaeformis' II (aff. *B. praegrandis* Tate), `Brachychiton' and `Ficophyllum', allow correlation of the Stuart Creek Willalinchina Sandstone and Eyre Formation sediments at Mt Alford with the Eyre Formation sediments in the Poole Creek palaeochannel (Table 4.1). `Brachychiton' leaves (eg. Plate 2 C,D) are common in some of the localities, especially at Stuart Creek, whereas only two localities at Morris Creek also contain

`Brachychiton'. `Banksieaeformis' II leaves (Plate 3B) are locally common at Stuart Creek, and sparsely so at Morris Creek and Mt Alford.

Some of the leaf types recorded from the Poole Creek floras resemble fossil taxa recorded from Mid-Eocene macrofloras from souther Australia, and thus the silcrete floras of Poole Creek may be of similar age. The *Banksieaeformis* leaf-form (or *Banksieaephyllum* if organically preserved) with strongly developed lobes is characteristic of examples of this organ genus from Eocene macrofloras. Both `Banksieaeformis' I & II (Plate 3 A,B) from the Poole Creek floras are of this form. *Banksieaeformis* leaves from Miocene macrofloras from southern Australia are distinctly not lobed, possessing simple outlines and dentate margins (Hill and Christophel, 1987). In addition, `Banksieaeformis' I (Plate 3A) closely resembles the organically preserved species, *Banksieaephyllum cuneatum* Blackburn (1981) from the Mid-Eocene Maslin Bay macroflora. The taxon, `daisy', is present in carbonate sediments of the Eocene Bring Member of the Pidinga Formation of the Eucla Basin (M.C. Benbow, pers. comm., 1988). Leaves of *Brachychiton* are also common in some Mid-Eocene macrofloras (Christophel & Greenwood, 1989).

The Etadunna Formation sites in the Poole Creek palaeochannel contain both `Gymnostoma' and Casuarina' cones (Plate 5). *Gymnostoma* is present in Eocene macrofloras from southern Australia and has been recorded from Oligo-Miocene lignite macrofloras in the Latrobe Valley, Victoria, with *Casuarina* (Blackburn, 1985). Christophel has suggested that *Gymnostoma* may have been an important and characteristic component of Eocene vegetation in southern Australia, whereas *Casuarina* first appears in the fossil record in the Oligo-Miocene, apparently ecologically displacing *Gymnostoma* in southern Australia by the Miocene (Christophel, 1980, 1989; Christophel & Greenwood, 1989). The presence of `Casuarina' in the Etaduna Formation silicified sediments supports a post Eocene age, and with `Gymnostoma' present, probably and Oligo-Miocene age for these sediments, as *Casuarina* s.s is not known from Eocene macrofloras.

6. PALAEOENVIRONMENTAL RECONSTRUCTION OF THE CAINOZOIC FLORAS

6.1 Methods of palaeoenvironmental analysis.

Reconstructions of southern Australian Cainozoic climates based on non-marine sediments have generally relied on fossil pollen as proxy records of climate (eg. Kemp, 1978; Martin, 1986) and less commonly macrofossils (Christophel, 1981; Christophel and Greenwood, 1989). Generally speaking, the climatic parameters of the source vegetation of the palynoflora (or macroflora) are estimated through the extrapolation of the ecological preferences of modern relatives of the component taxa. This approach has been termed "floristic analysis" (Axelrod and Bailey, 1969; Martin, 1986.

Floristic analysis has been criticised because it is possible for errors to be introduced through the identification of an incorrect closest modern relative (particularly with paylnomorphs because of convergent evolution of grain structure in unrelated plant families), and equally so, the possibility that plant taxa may have changed their thermal requirements over the Tertiary (Martin, 1986; Christophel and Greenwood, 1988). To overcome these criticisms, most analyses rely on the principle that the highest probability palaeoclimatic analogue is that indicated by the majority of taxa in a flora. This modified approach is, however, of little use if the majority of the flora is either unknown, or have no close modern relatives.

A second technique, "foliar physiognomic analysis" (Christophel & Greenwood, 1988, 1989) avoids these criticisms by removing the assumptions of unchanged ecological preferences over time and accurate identification. Most modern vegetation types generally share a common set of leaf characteristics (foliar physiognomy) which reflect morphological and physiological adaptation to the prevailing climate. Observed correlations between this common foliar physiognomy for modern vegetation types and climate, can be extrapolated to fossil leaf floras (Martin, 1986; Christophel and Greenwood, 1987, 1988). The underlying assumption is that the foliar characteristics of a fossil flora accurately reflect the foliar characteristics of the palaeovegetation, and thus reflect the prevailing climate. A further assumption is that the leaves present in a fossil bed accurately reflect the local vegetation, and not solely a specialised waterside flora.

Because of the potential sources of error in palaeoenvironmental analysis it is advisable to apply a mixed approach in order to provide several independent sources of information. Corroborative predictions by these (and other) techniques serve to reinforce confidence in the resulting reconstruction (eg. Christophel and Greenwood, 1987). In all such cases, however, the reconstructions constitute hypotheses, which may be altered by the addition of new information.

6.2 Floristic analysis.

The floristic analysis of the silcrete floras must be considered tentative as only a very few of the fossil taxa have yet been assigned modern botanical affinities. Nevertheless, some of the taxa provide important insights into the character of the Eocene palaeoenvironment, particularly through comparison with the floristic composition of better known Eocene macrofloras from southeastern Australia. The main floristic elements of use in this study are: the lobed leaves `Brachychiton', the Myrtaceae leaves, `Gymnostoma' cones, the `Banksieaeformis' *spp*., and the general taxonomic character of the flora (the presence or absence of dominant plant genera or families, and their identity).

The overall diversity of the Eyre Formation silcrete floras (*viz*. the number of different types of plants) is low when compared to many modern vegetation types, even taking an optimistic view of the number of leaf types as yet unidentified. This study recognises 19 taxa overall, of which 4 are restricted to Etadunna Formation. In addition to the 16 taxa found in Eyre Formation silcrete floras, a possible further 10 can be recognised in casual examination. This would give a similar diversity to that seen in other individual Eocene leaf beds from southern Australia, but is much lower than recorded for overall floras from a single locality. For example, in the Anglesea Mid-Eocene macroflora in Victoria (Christophel *et al.*, 1987) individual clay lenses only contain 30 or so leaf-taxa, other lenses producing an overall macroflora containing of about 100 taxa. Similar characteristics are found in the Mid-Eocene Golden Grove macroflora (Barrett, 1987; Barrett and Christophel, 1989, in press).

Some localities of the Eyre Formation silcrete floras are dominated by particular taxa, and often reflect different foliar physiognomic characteristics (see below). The most common leaf type in some of these localities is the `Eucalyptophyllum' (eg. Willalinchina Hut in Stuart Creek). In some parts of the Eyre Formation in the Poole Creek palaeochannel, two leaf types are common: the `coarse reticulate leaf' and the `coarse serrate' leaf. `Gymnostoma' cones are common at most of the Poole Creek sites, suggesting that trees of this taxon were common in the local vegetation of this area. `Banksieaeformis' leaves are only found at the Morris Creek sites within the Poole Creek palaeochannel, but are usually present at Stuart Creek sites. Also, the other two types of Myrtaceae leaves occur sporadically.

The changes in taxonomic dominance (and changes in foliar physiognomy, see below) between sites suggest that at least two different plant communities were contributing to the silcrete macrofloras.

This interpretation may also reflect sampling bias as particularly for some sites, previous collecting has substantially over-collected some sites. In these sites more spectacular leaf-types, such as `Brachychiton' and `Banksieaeformis', have been preferentially removed.

The `Tristaniophyllum' leaf-type (the broad-lamina Myrtaceae) is similar to modern species of *Lophostemon* and allied genera (eg. *Tristania* s.s., *Tristaniopsis*) which are typical members of streamside and rainforest margin situations in the seasonally dry monsoon areas of northern Australia. The eucalypt-like leaves are, however, of little value as the over 500 modern species of *Eucayptus* occur in an enormous variety of plant communities from sub-alpine woodlands and the overstory of cool temperate rainforests to streams in semi-arid areas.

Modern species of *Casuarina* and *Gymnostoma* have different ecological preferences. *Casuarina* s.s is typically a tree in gallery forests along watercourses in seasonally dry moderate rainfall areas, although two modern species, *Casuarina cristata* and *C. decaisneana* occur in almost monospecific stands in arid areas, usually in areas where water collects, whereas species of the closely related genus, *Allocasuarina*, occur in edaphically dry woodlands and forests. Species of *Gymnostoma* are typically found in swamps or along watercourses in high rainfall areas of the tropics (southeastern Asia to Fiji) where disturbance is high and can be considered to be colonising species. In modern Borneo, however, a species of *Gymnostoma* is common in the seasonally dry `Karanga', a swamp forest which occurs on deep nutrient-poor podzolic sands (Brüning, 1983).

The *Banksieaeformis* leaf-type from Eocene sediments may represent extinct members of the Tribe Banksieae of the Proteaceae (Hill and Christophel, 1987; Christophel and Greenwood, 1989). The presence of true *Banksia* cones in Eocene sediments in Western Australia (McNamaraa et al., 1984), however, suggests that in some cases these leaves may also represent *Banksia* (Subtribe Banksiinae). In either case, the presence of members of the Tribe Banksieae suggests low soil fertility. Both *Banksia* and *Dryandra* (Subtribe Banksiinae) occur in moderate to high rainfall areas of low fertility soils, occasionally in swampy environments. *Musgravea* and *Austromuellera* (Subtribe Musgraveinae) occur only in the rainforests of NE Queensland, generally in montane rainforests (Simple Notophyll Vine Forest), but also rarely in lowland tropical rainforest (Complex Mesophyll Vine Forest; Christophel and Greenwood, in press). In each case, however, these forests are on nutrient-poor soils derived from granite.

The leaves of the rainforest Banksieae are morphologically very similar to *Banksieaeformis*, and may in many cases represent these taxa in Eocene macrofloras (Christophel and Greenwood, 1989).

The `Banksieaeformis' leaf-type may therefore indicate that the local area supported either a sclerophyllous vegetation under a dry climate, or, that the local soils were very nutrient deficient (or both).

6.3 Foliar physiognomic analysis.

Foliar physiognomic analysis is generally based on the proportion of species (leaves) present in a macroflora with entire margin leaves (that is, not toothed, lobed, or in some other manner with an interrupted margin) and the average size of the leaves of these species (Greenwood, 1987a). Within rainforest, the number of tree species with non-entire leaf margins increases with decreasing annual average temperature or rainfall. Similarly, the average leaf size decreases with decreasing annual average temperature and rainfall. To complicate matters, a similar effect is observed with decreasing soil fertility.

The main effect of decreasing rainfall is to reduce leaf width (and thus leaf leaf area), but much less so leaf length. Leaves from plants in seasonal environments also tend to be broader at the base or apex, whereas the leaves from plants in non-seasonal environments tend to be elliptic or linear. Reduced temperature tends to both reduce leaf size (both length and width equally) and increase the proportion of non-entire leaves. Low soil fertility has a more complex effect, causing overall leaf size to decrease and the proportion of non-entire leaf margins to increase, although quite large leaves may also be present. This is because some plant species are much better adapted to low soil fertility than others.

Most of the leaf specimens collected from the Poole Creek palaeochannel macrofloras are fragmentary, with either their upper or lower halves missing. The proportion of species with entire leaf margins must be used with considerable caution also, as perhaps a third of the flora is not assigned to a form-taxon. Nevertheless, 6 of the 12 leaf-types present are entire margined, thus being considerably higher than observed for other Eocene macrofloras (Christophel and Greenwood, 1988, 1989). Though difficult to assess, the overall size of leaves is similar, with the majority of leaves (many were estimated) being about 6-8 cm long. Occasional fragments of much larger leaves are seen in samples from some sites, such as at Morris and Stuart creeks. Some sites are dominated by quite small leaves (as are some samples of the Nelly Creek macroflora).

This evidence suggests that the local environment supported two plant communities with different foliar physiognomic characteristics. Two possible scenarios are: that the environment was distinctly seasonal, supporting an interfluvial vegetation adapted to seasonal dryness (the much smaller and narrower leaves), while permanent rivers supported a lusher rainforest-type gallery forest along their banks and floodplains (the larger leaves); or, that the area maintained a relatively high rainfall but that the vegetation of the interfluvial areas occupied highly infertile soils. A more plausible explanation combines elements of both scenarios. Certainly in the present monsoon areas of the Arnhem Land area of the Northern Territory rainforest occurs as gallery forest along permanent watercourses, while sclerophyllous vegetation dominated by eucalypts (and their relatives) or stunted `vine forest' occurs on the nutrient-poor soils of the interfluvial areas.

7. SUMMARY AND CONCLUSION

Fossil Macrofloras have assisted in distinguishing two rock units in the Poole Creek Palaeochannel. These floras occur in two superficially similar channel sand facies. The floras also provide important palaeoclimatic and botanical data.

The two channel facies can be recognised using the following criteria: (1) Eyre Formation - basal polished pebbles with agate and wood, thick cross-beds, with curved foreset beds in plan and section, presence of 'imbricate conifer', 'daisy', 'coarse reticulate', 'coarse serrate' and 'ential pinnatifid' leaves (2) Etadunna Formation - no polished fossil wood or agate pebbles, thinner more irregular cross-bed sets with usually straight foresets in section, presence of 'Banksieaformis III' ('fern'), 'parallel veined' leaf and small Casuarina cones.

The presence of three leaf-types and a fruit-type (`daisy') in both the silicified sediments and the macroflora of the unsilicified Eyre Formation at Nelly Creek supports the conclusion from lithological evidence that these sediments are correlatives (Figure 4). Thus the Poole Creek Eyre Formation sites are of Middle Eocene age.

The palaeovegetation of the Eocene Eyre Formation macrofloras is interpreted as being a mosaic of gallery rainforests along the water courses with sclerophyllous vegetation adapted to both low soil fertility and seasonally dry conditions in the interfluves. The presence of some taxa, such as `Gymnostoma', suggest that swamp conditions may have been seasonally present in some areas. A possible analogue is the present monsoon region of the northern part of the Northern Territory and also in the drier monsoonal eastern part of Borneo. However, the sediments although providing evidence of high rainfall and low soil fertility during the Eocene, do not exhibit the episodic depositional characteristics expected from such a seasonal climate.

Little can be said about the Etadunna Formation macroflora as it is not well preserved nor nearly so abundant. Its character does not conflict with the sedimentary evidence of greater seasonality, and longer intervals of aridity.

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9. APPENDICES

9.1 Glossary.

Actinodromous; leaf venation with three or more primary veins diverging radially from a single point at or above the base of the blade and running toward the margin, reaching it or not.

Brochidodromous; leaf venation with a single primary vein, the secondary veins not terminating at the margin but joined together in a series of upward arches or marginal loops on each side of the primary vein.

Craspedodromous; leaf venation with a single primary vein, all of the secondary veins and their branches terminating at the margin.

Cuticle (leaf); a waxy layer of interlocking polymer chains of hemicelluloses and other substances which coats the outer surface of all leaves as a water and gas impermable layer. Preserves the pattern and shape of the underlying cells of the leaf epidermis and is often preserved on carbonaceous plant fossils where it can be used to obtain considerable amounts of taxonomic information.

Epidermis (leaf); the outer most layer of cells in a leaf. The size and pattern of the epidermal cells, particularly the stomatal cells, is generally specific to particular plant groups and can be used taxonomically.

Eucamptodromous; leaf venation with a single primary vein, the secondary veins curved upward and gradually diminishing distally within the margin and interconnected by a series of cross-veins without forming conspicuous marginal loops.

Family (plant); the third main hierarchial level in plant classification. Each family is composed of one or more genera, each of which can contain one or more species, eg. the species *Eucalyptus camaldulensis* belongs to the family Myrtaceae, as does the species *Acmena smithii*.

Floristic Analysis; using the predicted modern affinities of fossil plant taxa to predict the palaeoenvironmental conditions of the fossil flora from the preferred environmental conditions of the modern relatives.

Foliar Physiognomy; using the correlatives between the prevailing leaf morphology (foliar physiognomy) and climate of modern vegetation to predict the palaeoenvironment of a fossil macroflora (leaves only) by the proportion of species or individuals with particular foliar attributes, usually the average size of leaves and the proportion of species or individuals with entire leaf margins.

Form-taxon; a group of morphologically similar individuals which constitute a taxonomic entity distinct from other such groups which may or may not share a common ancestor.

Intramarginal vein; an often prominent vein closely following the margin of a leaf formed through the fusion of the apically directed loops of secondary veins in a leaf with brochidodromous venation.

Palmatifid; leaves lobed like the fingers of a person's hand with a single major vein extending at least 1/2 the length of each lobe and originating at or near the base of the leaf.

Pinnatifid; leaves lobed like a pinnate palm frond (ie. with a single straight main rachis and lateral extensions either side) but with the blade of the leaf extending from the lobes and along the full length of the main rachis with single main veins branching off along it's length for each lobe.

Sclerophyllous (plants / vegetation); with leathery, tough, generally shiny, and often xeromorphic[1] leaves eg. most *Eucalyptus* spp., *Grevillea* spp., and *Banksia* spp. - the typical Australian plants *cf.* most rainforest trees.

[1](adapted to dry conditions with reduced surface area and other morphological adaptions to reduce water loss).

Secondary veins / secondaries; the usually prominent veins originated from the primary or midvein and diverging outwards to the margin of the leaf blade, often branching into smaller veins (tertiary veins) or looping upwards to link with each other.

9.2 Biostratigraphic Database of the Silcrete macrofloras. (also on Disk)

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fossil taxa:

A. 'Gymnostoma' cones
B. 'Casuarina' cones
C. 'Tristaniophyllum' (Myrtaceae)
D. ''Myrtaciphyllum' (Myrtaceae)
E. 'Eucalyptophyllum' (Myrtaceae)
F. imbricate conifer shoots (cfr. Dacrycarpus/Callitris)
G. serrate pinnatifid leaf
H. coarsely reticulate leaf
I. coarsely serrate leaf
J. entire pinnatifid leaf (aff. Proteaceae)
K. 'Brachychiton'
L. coarsely papillate seed
M. 'Banksieaeformis' I (aff. B. cuneatum)
N. 'Banksieaeformis' II (aff. B. praegrandis)
O. 'Banksieaeformis' III or 'fern leaf' (cf. Gleichenia)
P. 'daisy flower'
Q. 'Ficophyllum' type leaf
R. parallel leaf; palm or reed (Myrtaceae)
S. 'Sapindaceae'

sheet	no.	location									fossil taxa present												
& RS	No.	svy/photo/site			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
6438	485	2095	054	24															O			R	
6438	486	2095	054	24															O				
6438	487	2095	054	24															O				
6438	488	2095	054	24		B			E														
6438	560	2095	054	24		B																	
6438	581	2095	054	24															O			R	
6438	590	2095	054	24		B																	
6438	561	2095	054	25	A																	R	
6438	562	2095	054	25																		R	
6438	563	2095	054	25					E													R	
6438	564	2095	054	25					E										O			R	
6438	565	2095	054	25																		R	
6438	171	2095	054	8					E										O			R	
6438	174	2095	054	8															O			R	
6438	176	2095	054	8					E										O			R	
6438	178	2095	054	8					E										O				
6438	179	2095	054	8					E										O				
6438	180	2095	054	8					E										O			R	
6438	181	2095	054	8															O				
6438	184	2095	054	8					E													R	

6438	186	2095	054	8															O			R	
6438	187	2095	054	8					E														
6438	188	2095	054	8															O				
6438	201	2095	032	6					E														
6438	195	2095	032	6												L							
6438	524	2095	032	6												L							
6438	527	2095	032	6												L							

sheet	no.	location									fossil taxa present												
& RS	No.	svy/photo/site			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
6438	409	2095	032	13	A					F		H											
6438	233	2095	054	10	A																		
6438	234	2095	054	10								H											
6438	235	2095	054	10	A																		
6438	236	2095	054	10			C																
6438	237	2095	054	10										J									
6438	318	2095	054	10	A																		
6438	320	2095	054	10	A																		
6438	322	2095	054	10	A																		
6438	323	2095	054	10	A																		
6438	324	2095	054	10	A																		
6438	338	2095	054	10								H											
6438	339	2095	054	10	A							H											
6438	544	2095	054	10								H		J									
6438	545	2095	054	10				D				H			K								
6438	546	2095	054	10				D				H											
6438	547	2095	054	10					E														
6438	548	2095	054	10								H											S
6438	549	2095	054	10	A																		
6438	550	2095	054	10	A		C					H											
6438	551	2095	054	10	A																		S
6438	552	2095	054	10	A																		
6438	-	2095	054	13		B																R	
6438	239	2095	118	4	A					F			I										
6438	240	2095	118	4	A			D		F										P			
6438	319	2095	054	12				D				H											
6438	321	2095	054	12									I										
6438	553	2095	054	12				D	E														
6438	554	2095	054	12	A							H											
6438	555	2095	054	12				D				H											
6438	556	2095	054	12								H											
6438	557	2095	054	12	A							H											
6438	558	2095	054	12	A							H											
6438	559	2095	054	12								H											
6438	566	2095	117	1	A							H								P			
6438	567	2095	117	1	A							H											
6438	568	2095	117	1	A															P			

6438	569	2095	117	1	A							H	I							P			
6438	570	2095	117	1								H											
6438	571	2095	117	1	A																		
6438	572	2095	117	1					E														
6438	573	2095	117	1				D	E			H	I										
6438	574	2095	117	1																P			
6438	575	2095	117	1	A							H											
6438	576	2095	117	1	A																		
6438	578	2095	117	1	A							H											
6438	579	2095	117	1	A																		
6438	580	2095	117	1	A				E														

sheet & RS	no. No.	location svy/photo/site									fossil taxa present												
					A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
6438	410	2095	124	7					E														
6438	411	2095	124	7	A																		
6438	412	2095	124	7					E														
6438	413	2095	124	7										J									
6438	415	2095	124	7					E														
6438	416	2095	124	9				D				H	I										
6438	417	2095	124	9					E														
6438	418	2095	124	9					E														
6438	419	2095	124	9																			
6438	530	2095	124	9										J									S
6438	531	2095	124	9				D															
6438	532	2095	124	24				D													Q		
6438	533	2095	124	24					E														
6438	534	2095	124	24			C		E									N					S
6438	535	2095	124	24																			S
6438	538	2095	124	24			C		E				I										
6438	539	2095	124	24					E						K								
6438	540	2095	124	24																	Q		
6438	541	2095	124	24				D	E														
6438	542	2095	124	24									I										
6439	148	2097	080	4			C																
6439	150	2097	080	4														N					S
6439	191	2097	080	4					E				I										
6439	193	2097	080	4			C	D															S
6439	194	2097	080	4					E									N					
6439	195	2097	080	4			C																
6439	197	2097	080	4			C																
6439	200	2097	080	4			C		E														
6439	201	2097	080	4					E														
6439	202	2097	080	4			C		E														
6439	039	2097	080	5					E		G							N					
6439	042	2097	080	5	Eucalypt fruit																		
6439	043	2097	080	5	Smooth seed																		

6439	044	2097	080	5	?Gymnostoma																		
6439	087	2097	018	7					E	F													
6439	092	2097	018	7					E														
6439	156	2097	018	7						F													
6439	157	2097	018	7			C																
6439	203	2097	018	7								H											
6439	204	2097	018	7			C																
6439	205	2097	018	7									I										
6439	206	2097	018	7				D															
6439	207	2097	018	7																	Q		
6238	016	2092	016	7										J									
6238	017	2092	016	7																	Q		
6238	018	2092	016	7											K								
6238	020	2092	016	7											K								S
6238	116	2092			Seed																Q		
6238	098	2092	016	3	A																		

sheet	no.	location									fossil taxa present												
& RS	No.	svy/photo/site			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
6238	118	2092	014	22					E														
6238	122				A				E								M						
6238	124								E												Q		
6238	127										G												
6238	128				A																		
6238	120							D										N					

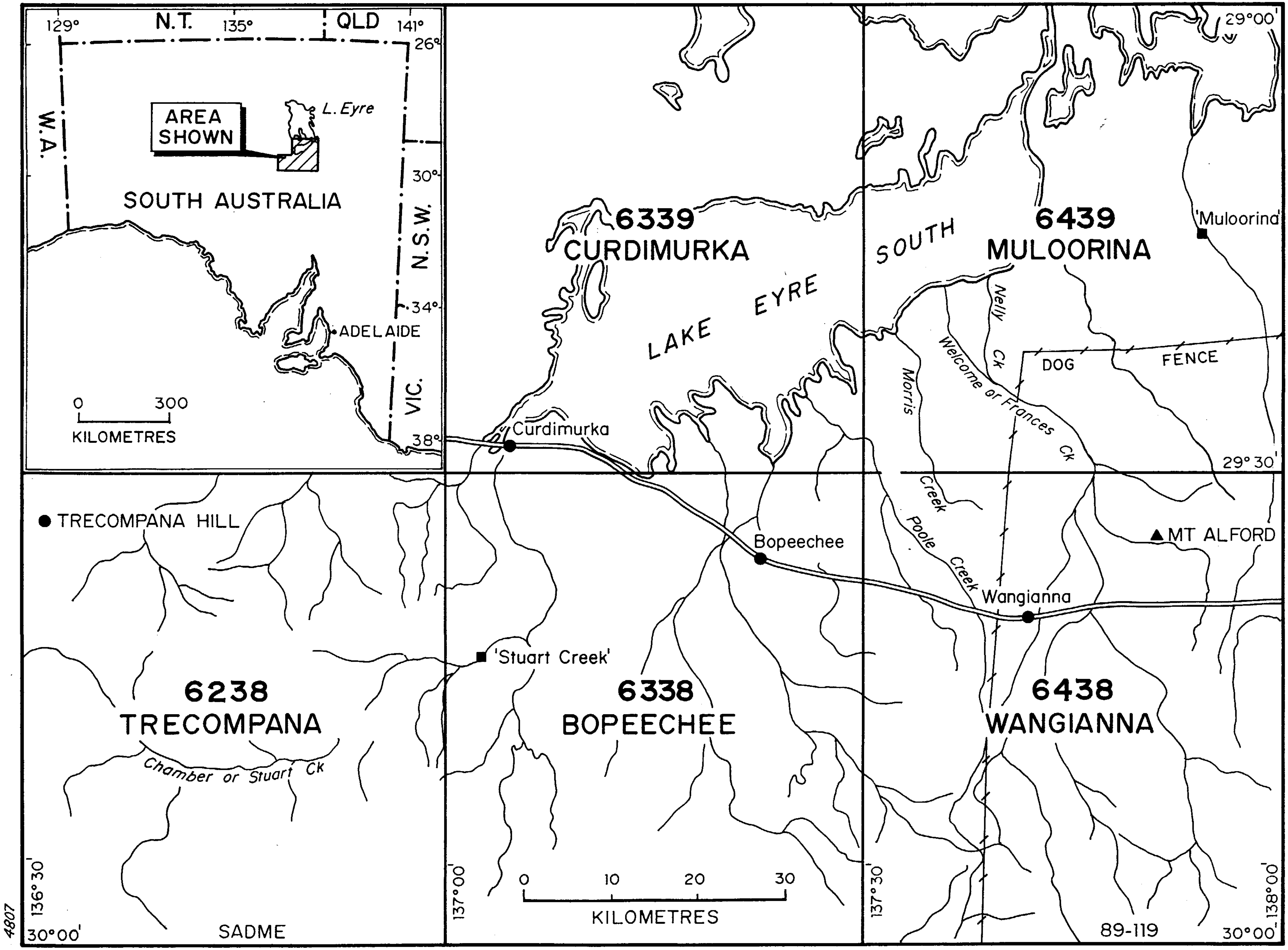

Figure 1. Location of the southern part of the Tirari Subbasin of the Lake Eyre Basin (CURDIMURKA) covered in this study.

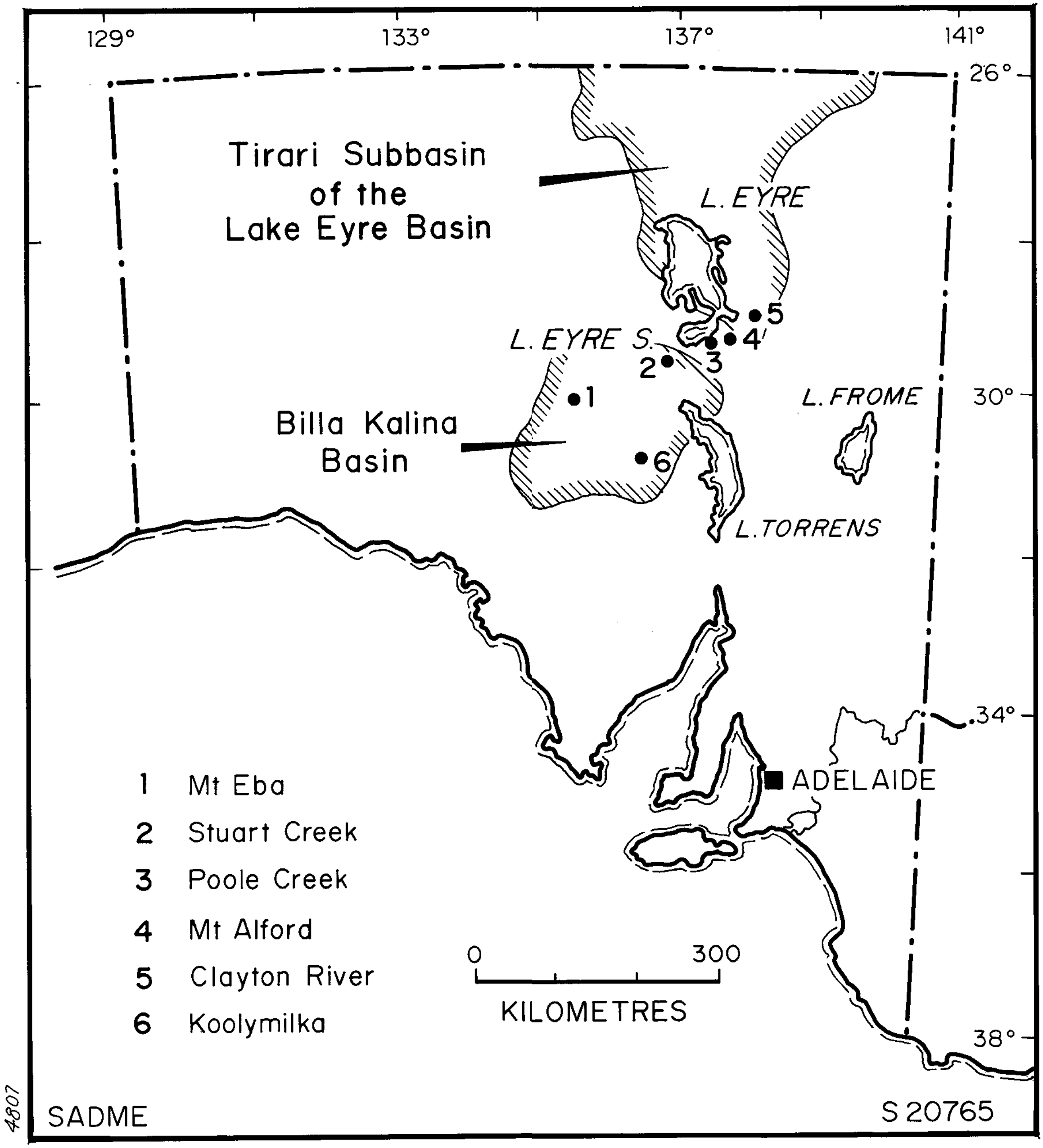

Figure 2. Map showing the location of Cainozoic macrofloras from South Australia, and geologic basin boundaries.

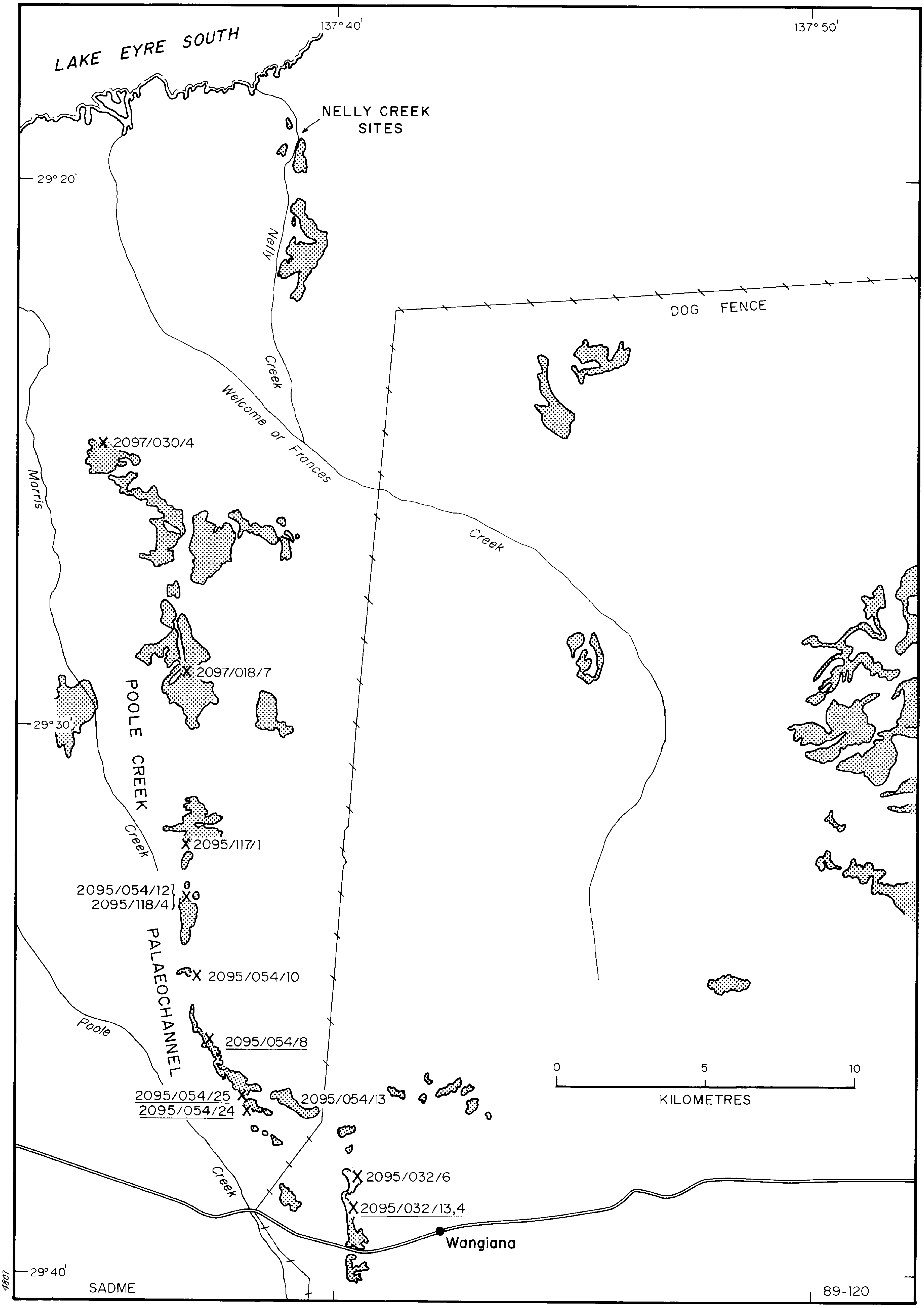

Figure 3. Location map showing outcrop of silicified Cainozoic sandstone (silcrete) and the fossil localities used in this study from the Poole Creek palaeochannel. (All are Eocene sites except those underlined, which are Miocene)

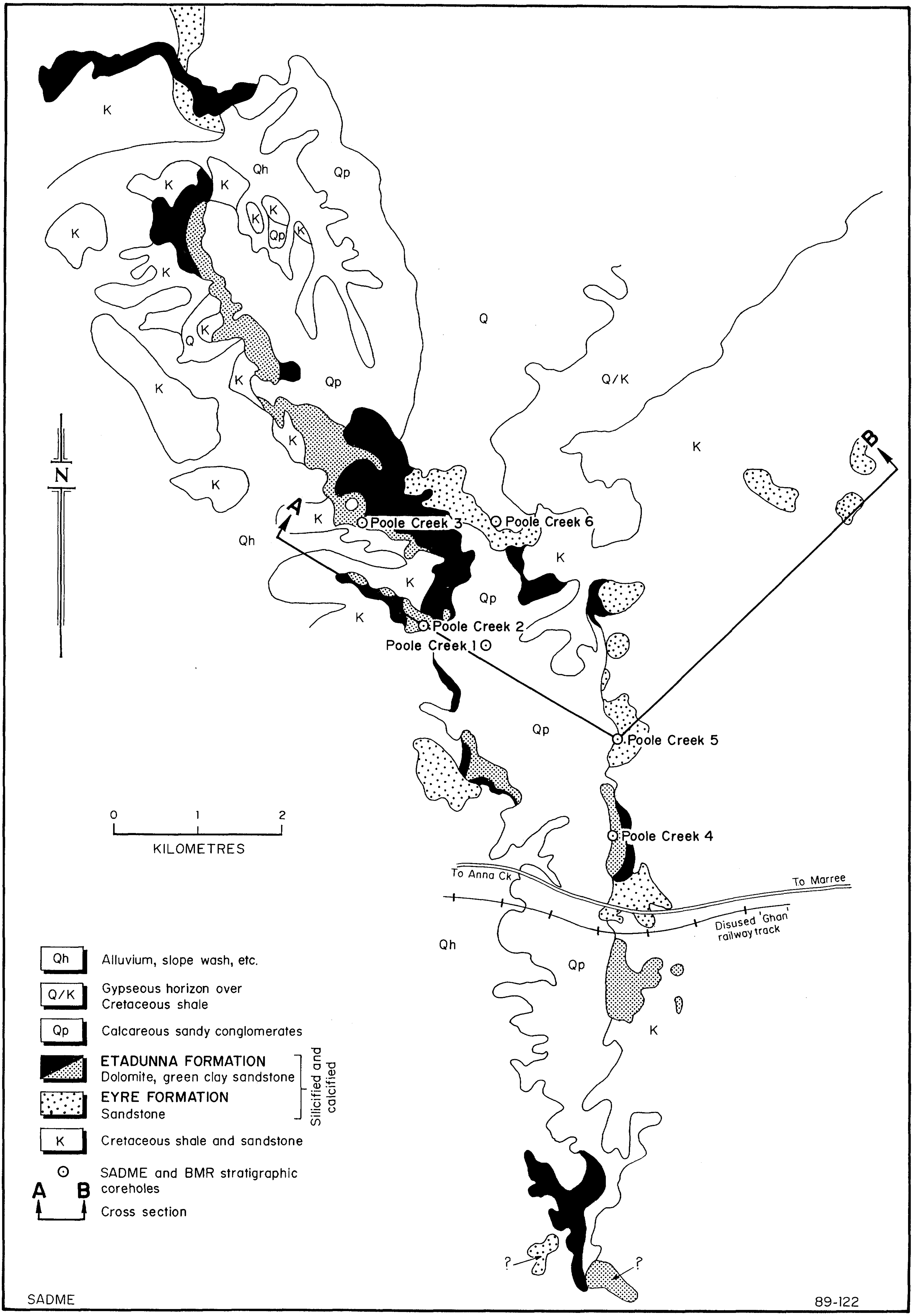

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Fig 4. Geology of Poole Creek area with location of Fig. 5 cross section.

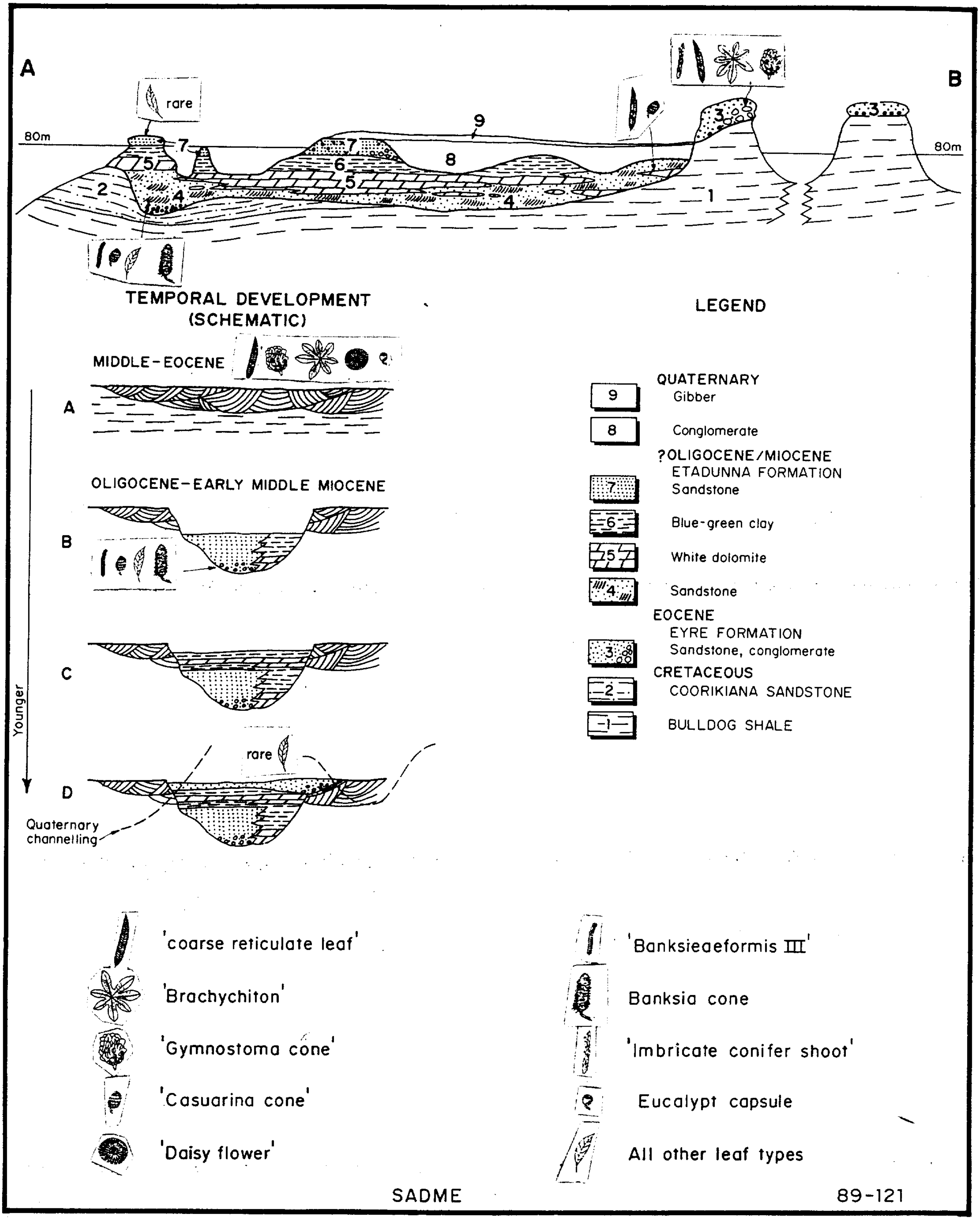

Figure 5. Poole Creek Palaeochannel _ Composite cross section prepared from levelling and drilling.