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A REVIEW OF THE TRIASSIC PALAEOENVIRONMENTS IN THE CANNING BASIN, WESTERN AUSTRALIA.

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CONTENTS

SUMMARY

The depositional environments of Triassic rocks in the Canning Basin, north Western Australia, are described. Interpretations are based on lithological and palaeontological criteria. The sequence records a transgressive and regressive cycle, best exposed in the Fitzroy Graben, and younger deltaic, fluviatile, and lacustrine sediments penetrated by petroleum exploration wells in the offshore Bedout Sub-basin. Rock colouration and the palaeontological succession indicate that the climate became more arid later in the Triassic, probably owing to removal of the mitigating effects of the Blina Sea from the basin and a change to a more continental regime.

INTRODUCTION

Although Triassic rocks in the Canning Basin (Figure 1) have been described (Veevers & Wells, 1961; McKenzie, 1961; Yeates et al., 1975) and divided into four named onshore formations and their unnamed offshore equivalents, no synthesis of the palaeoenvironment of these rocks has been presented. Interpretations in the literature of the depositional environment of the Canning Basin Triassic rocks are generally unsatisfactory; some are based only on the contained fauna, flora, or on limited lithological studies of small areas. This study integrates all known properties of the rocks, palaeontological, lithological, and geochemical, into a coherent picture of the depositional environments of the Canning Basin during Triassic time. The rocks are treated as a genetically related sequence and are considered to represent a broad environmental episode.

Data in the literature, mapping by the Bureau of Mineral Resources (Yeates et al., 1975), cores and cuttings, interpretation of subsidized logs of petroleum exploration wells and subsidized seismic sections are used in the synthesis.

DESCRIPTIVE STRATIGRAPHY OF TRIASSIC UNITS

Four formations are presently defined in the onshore Canning Basin. These units are the Millyit Sandstone, Blina Shale, and Erskine and Culvida Sandstones. A section of similar lithology to the Blina Shale, referred to informally as the 4A Beds, was drilled by BMR Wallal 4A (Henderson et al., 1953) in the southwestern Canning Basin (Figure 1). Two offshore wells penetrated the Triassic: Keraudren 1 passed through a thick Upper and Middle Triassic section but did not reach Lower Triassic rocks and Bedout 1 penetrated a substantially thinner, but older section, than Keraudren 1. These sections will be referred to informally as the Keraudren Beds and Bedout Beds respectively. Structural provinces referred to in the test are plotted in Figure 1, but do not necessarily describe active Triassic tectonic provinces.

Millyit Sandstone: The Millyit Sandstone was defined by Elliot (*in* McWhae et al., 1958) and the type locality was designated at the head of Spring Creek, Millyit Range (Figure 1). The unit is restricted to the southeastern Fitzroy Graben and according to Yeates et al. (1975) is generally less

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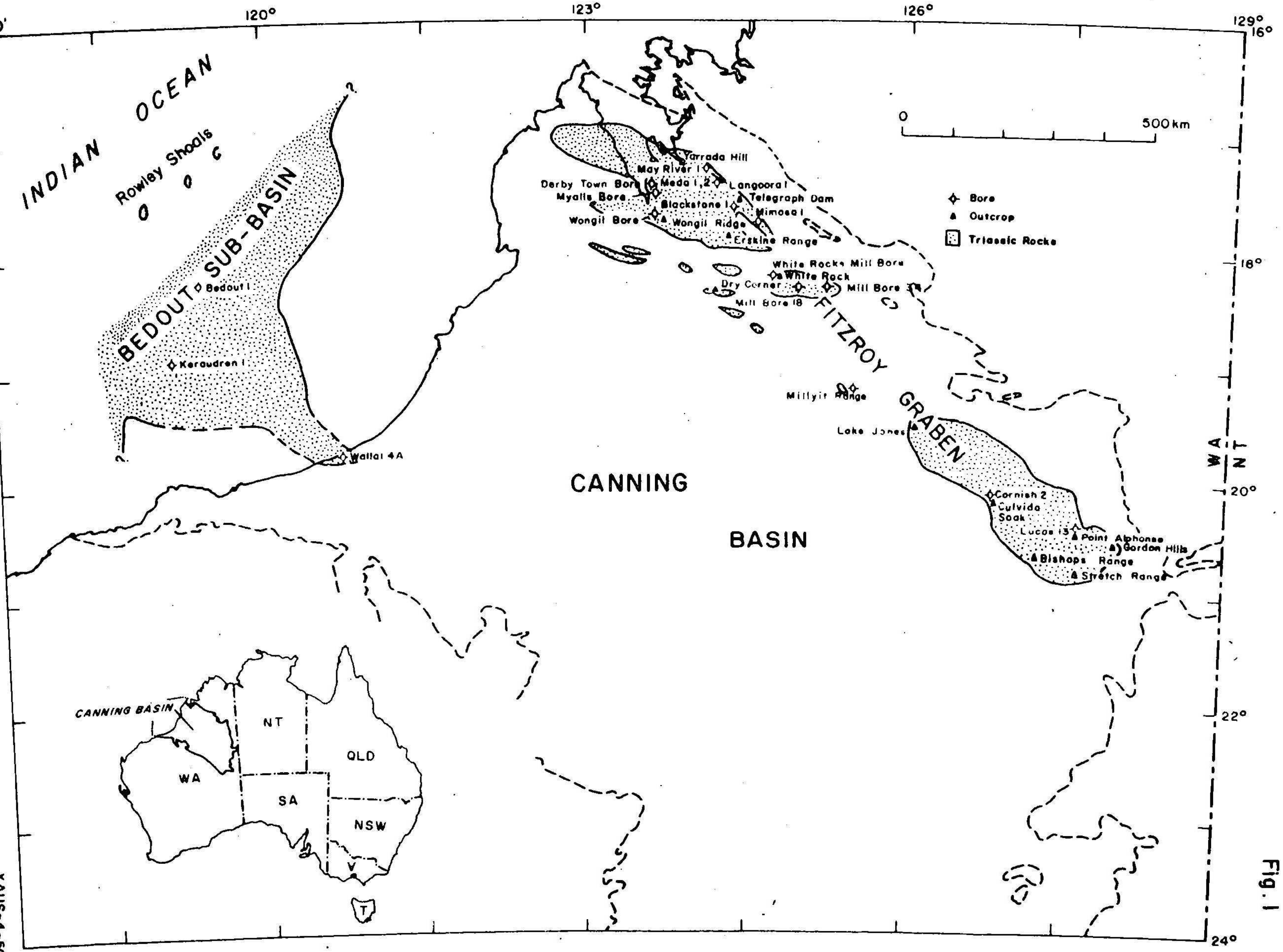

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Fig. 1

than 100 m thick. Yeates et al. (1975) placed the base of the Millyit Sandstone at 85 m in BMR Lucas 13 but on lithological grounds the base of the Blina Shale in this well is here picked at 97.5 m. Thus the top of the Millyit Sandstone is placed at the topmost appearance of thick sandstone at 97.5 m, and the thickest measured section of the unit is thus only 80.5 m (97.5 - 178 m). The Millyit Sandstone overlies Upper Permian rocks with a 1-2^{o} unconformity at Millyit Range (Elliot, in McWhae et al., 1958) and is disconformable on Permian rocks to the southeast (Yeates et al., 1975). The upper contact is conformable with the Blina Shale and the unit interfingered to the northwest of Millyit Range with the lower Blina Shale although erosion has removed evidence of this.

Blina Shale: The formation was originally proposed by Guppy, Cuthbert, & Linder (1950) for the top part of the Permian in the area near the Nerrima Dome (Figure 1). Guppy et al. (1950) used the name Belina Shale and attributed the name to unpublished reports by Kraus (1941) and Reeves (1951). The name was corrected to Blina Shale by Brunnschweiler (1954) and the Wongal Shale (Wonjil Shale of Brunnschweiler, 1954) of Fairbridge (1953) was placed in synonomy with the Blina Shale. As no type section of the Blina Shale has been proposed (cf Smith, 1961) the section measured by McKenzie (1961) at Erskine Hill (Figure 1) is accepted as the type section, following Playford et al. (1975).

The Blina Shale outcrops in the Fitzroy Graben, Lennard Shelf and Balgo Shelf (Veevers & Wells, 1961; Yeates et al., 1975) and has been penetrated by water bores (Guppy et al., 1958) and petroleum exploration wells (Figure 1). The thickness of the unit varies from 311 m in Blackstone 1 well to 129 m in the Stretch Range (Yeates et al., 1975). Sandstone mapped as Blina Shale in the southeastern area (Yeates et al., 1975; White & Yeates, 1976) are more properly assigned to either the Millyit or Erskine Sandstones.

The Blina Shale unconformably overlies Upper Permian rocks in the northwestern Fitzroy Graben (Playford et al., 1975) and passes downward into the Millyit Sandstone to the southeast.

Erskine Sandstone: Wade (1938) gave the name Erskine Series to outcrops at the top of the Permian sequence in the West Kimberley District. Brunnschweiler (1954) revised the name to Erskine Sandstone and recognized the unit as the younger of the two Triassic formations in the Erskine Range (Figure 1) where he designated the type section. The Erskine Sandstone outcrops on the Lennard Shelf, Balgo Shelf, and the Fitzroy Graben. The thickest section is 255 m in Derby Town Bore (Veevers & Wells, 1961) and 40 m was measured by Yeates et al. (1975) in an eroded section at Point Alphonse (Figure 1).

The Erskine Sandstone conformably overlies the Blina Shale in the Fitzroy Graben and oversteps the Blina Shale to rest unconformably on Upper Permian rocks on the northwestern Lennard Shelf (Brunnschweiler, 1954). However, McKenzie (1961) recognized the lower contact at Erskine Hill as a disconformity. In the southeastern Fitzroy Graben, the Erskine Sandstone passes gradationally downwards into the Blina Shale at a Point Alphonse, but the contact may be locally disconformable (Yeates et al., 1975). The upper surface of the unit is generally eroded and sometimes overlain by Jurassic sandstones or surficial sands.

<u>Culvida Sandstone</u>: The unit was defined by Casey & Wells (1960) and first published by Veevers & Wells (1961). The formation is restricted to a small area around Culvida Soak (Figure 1) where the type locality was designated by Casey & Wells (1964). The thickest section known is 207 m drilled by BMR Cornish 2, where is passes conformably into Blina Shale (cf. Yeates et al., 1975, who correlated the lower unit with Erskine Sandstone). Yeates et al. (1975) consider the Culvida Sandstone to be conformable on Erskine Sandstone at Culvida Soak.

<u>Bedout Beds</u>: Only known from Bedout 1 in the Bedout Sub-basin (Figure 1), the Bedout Beds unconformably overlie Upper Permian volcanics and are overlain unconformably by Jurassic rocks (B.O.C., 1971). The unit is 110 m thick.

<u>Keraudren Beds</u>: The Beds have only been partly penetrated by Keraudren 1 in the Bedout Sub-basin where they are more than 1384 m thick. The upper contact is unconformable under Jurassic rocks and the lower boundary is unknown, but expected to lie on Upper Permian rocks. The relationships of the Keraudren Beds and Bedout Beds are unknown but the Keraudren Beds probably grade down conformably into the Bedout Beds.

<u>4A Beds</u>: Only known from BMR Wallal 4A, the unit is 25 m thick, disconformably overlies Upper Permian rocks and is unconformably below Jurassic sandstones. The areal extent of the unit is unknown but probably extends westwards into the Bedout Sub-basin.

AGE AND CORRELATION OF THE TRIASSIC UNITS

<u>Millyit Sandstone</u>: Similarities in lithology and stratigraphic position disconformably above Permian sediments led Elliot (<u>in</u> McWhae et al., 1958) to assign a Jurassic age to the Millyit Sandstone, but fossil leaves and wood found subsequently indicated a Permian or Lower Triassic age. Plants identified include <u>Vertebraria</u>, <u>Glossopteris</u>, and <u>Dicroidium</u> (White & Yeates, 1976).

<u>Blina Shale</u>: The varied fauna and flora of the Blina Shale includes similar conchostracans and fish to those found in the Triassic of New South Wales (Brunnschweiler, 1957). Temnospondyl amphibians described by Cosgriff (1965; 1974) indicate a Lower Triassic age.

White & Yeates (1976) recorded a transitional Permo-Triassic macroflora from the Blina Shale at Point Alphonse, with <u>Glossopteris</u> and lycopods. From a microfossil assemblage from the upper Blina Shale at Erskine Hill, Balme (1969b) inferred that the Blina Shale is entirely Scythian "but does not encompass the whole of the Lower-Triassic". Microflora from the lower part of the unit in Mimosa 1 are Stage Tr1b (cf. Evans, 1966) on the presence of <u>Nevesisporites fossulatus</u>, <u>Osmundacidites senectus</u>, <u>Densoisporites playfordi</u>, and <u>Guthoerlisporites cancellosus</u>. This assemblage (Dolby, 1973) contains forms assignable to the <u>Kraeuselisporites seaptatus</u> Assemblage Zone of Dolby & Balme (1976) which these authors referred to as Griesbachian to Dinerian.

The basal Blina Shale in BMR Lucas 13 (Core 3) contained a Stage Tr1b microflora (Paten & Price, 1975) with abundant <u>Protohaploxypinus</u> spp and <u>Falcisporites</u> spp. This core then is assignable to the <u>Lunatisporites pellucidus</u> Zone of Helby (1973) which is closely comparable to the <u>K. saeptatus</u> Assemblage Zone (Dolby & Balme, 1976). <u>Aratrisporites</u> is rare in the K. saeptatus Assemblage Zone (Dolby & Balme, 1976) and occurs only in the upper Blina Shale. Very rare Aratrisporites are found in Cores 1 and 2 of BMR Lucas 13 in the upper Blina Shale were assigned to Stage Tr2 (Paten & Price, 1975).

A Stage Tr2 assemblage was also recovered from Core 3 at the top of the Blina Shale (Erskine Sandstone of Yeates et al., 1975) in BMR Cornish 2 well (Paten & Price, in Yeates et al., 1975), with abundant Densoisporites spp, very few Aratrisporites spp or bisaccate pollen and no acritarchs (Paten & Price, 1975). Except for the absence of acritarchs the assemblage suggests a correlation with the Kraeuselisporites saeptatus Assemblage Zone of Dolby & Balme (1976).

The Blina Shale in the east then ranges through basal Tr1b to Tr2 stages and is characterized by the Kraeuselisporites saeptatus Assemblage-Zone.

4A Beds: Balme (1963a) assigned a Lower Triassic age to the 4A Beds on the basis of pollen spores from core 6 of BMR Wallal 4A. This he referred to his Leuckisporites assemblage, also found in the Kockatea Shale of the Perth Basin, where ammonites and microspores have been dated at Scythian (Balme, 1969b). The presence of Leuckisporites of kraeuseli and abundant acritarchs suggests equivalence with core 1 in BMR Lucas 13 well.

The lower Bedout Beds in Bedout 1 (Wall, 1971) contain forms assigned to Stage Tr2 of Helby (1973). The presence of Nevesisporites limulatus suggests some of the section is assignable to Stage Tr2b (Helby, 1973).

Bedout Beds: Diverse Aratrisporites (4 species) suggests that the Bedout Beds are younger than the K. saeptatus Assemblage Zone. Dolby & Balme (1976, p. 116) state that the K. saeptatus zone is distinguishable at least in the lower part of the Blina Shale in the Canning Basin (presumably based on Mimosa 1 well - Dolby, 1973) but the upper limits are undefined. Microflora from Derby Town Bore and Myalls Bore are assigned by them to the younger Tigrisporites playfordii Assemblage Zone, suggesting that the upper Blina Shale is younger towards the west than in the east. The section in Bedout 1, farther west, contains abundant Aratrisporites; according to Dolby & Balme (1976) this genus first becomes abundant in the Tigrisporites playfordii Assemblage Zone. Also present in the Bedout Beds are Falcisporites australis and Nevesisporites limulatus, the latter of which is confined to the T. playfordii Assemblage Zone in the Carnarvon Basin. Hence the upper Blina Shale and the correlative Bedout Beds young westwards. Dolby & Balme (1976) regard the Tigrisporites playfordii Assemblage Zone as ranging from Smithian to early Anisian. The upper Blina Shale and the acritarch-rich lower Bedout Beds may then correlate with a global eustatic rise which culminated in the Smithian (MacTavish & Dickins, 1974) and the most easterly deposits of the Blina Shale (BMR Lucas 13 well) represent the maximum extent of transgression.

Erskine Sandstone: The Erskine Sandstone contains a Dicroidium macroflora (White, in Veevers & Wells, 1961; White & Yeates, 1976) which appears before the end of the Scythian (Helby, 1973). The transition from older Scythian floras is best shown by the change from Taeniaesporites (=Lunatisporites) microflora to the Pteruchipollenites (=Falcisporites) microflora (Balme & Helby, 1973) which corresponds to the change from Stage Tr2 to Stage Tr3 (cf. Evans, 1966). From the Erskine Sandstone of Derby Town and Myalls Bores, Balme (1969) records Aratrisporites, Falcisporites, and disaccate pollen which Dolby & Balme (1976) place in their Tigrisporites playfordii Assemblage Zone. The age range is thus Smithian to early Anisian.

Culvida Sandstone: The Culvida Sandstone contains Dicroidium sp similar to that found in the Ipswich Series of Queensland (White, 1961). In BMR Cornish 2, the Culvida Sandstone has been assigned to Stage Tr3 (Paten & Price, 1975). This late Scythian to Anisian microflora contains abundant Aratrisporites spp, Osmundacidites spp, common megaspores and extremely rare Falcisporites. As the Culvida Sandstone overlies the Blina Shale conformably in BMR Cornish 2 and contains abundant Aratrisporites it is probable that it is assignable to Dolby & Balme's Tigrisporites playfordii Assemblage Zone and, as such, is correlated with the Erskine Sandstone.

Keraudren Beds: Keraudren 1 well bottomed in sediments dated by miospores as early Ladinian to Anisian (Ingram, 1974). The interval 2810-3565 m contains spores in common with Ladinian Mungaroo Beds of the Carnarvon Basin (Ingram, 1974), including Rimaesporites aquilonalis and Samaropolleninites speciosus. Rimaesporites aquilonas makes its first appearance in the Staurosaccites quadrifidus Assemblage Zone of Dolby &

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Balme (1976) and Samaropollenites speciosus is the name species of the next zone. Thus the age of this interval ranges through upper Anisian to Carnian (Dolby & Balme, 1976).

The upper interval (2462-2625 m) in Keraudren 1 contains long-ranging Triassic forms but the presence of Taeniaesporites australis and Aratrisporites sp. cf A. strigosus indicates an age no younger than early Upper Traissic (Ingram, 1974). It is probable that this interval is entirely Carnian but the possibility that it ranges higher cannot be discounted as Aratrisporites persists into younger assemblages as a minor component in the Carnarvon Basin (Dolby & Balme, 1976).

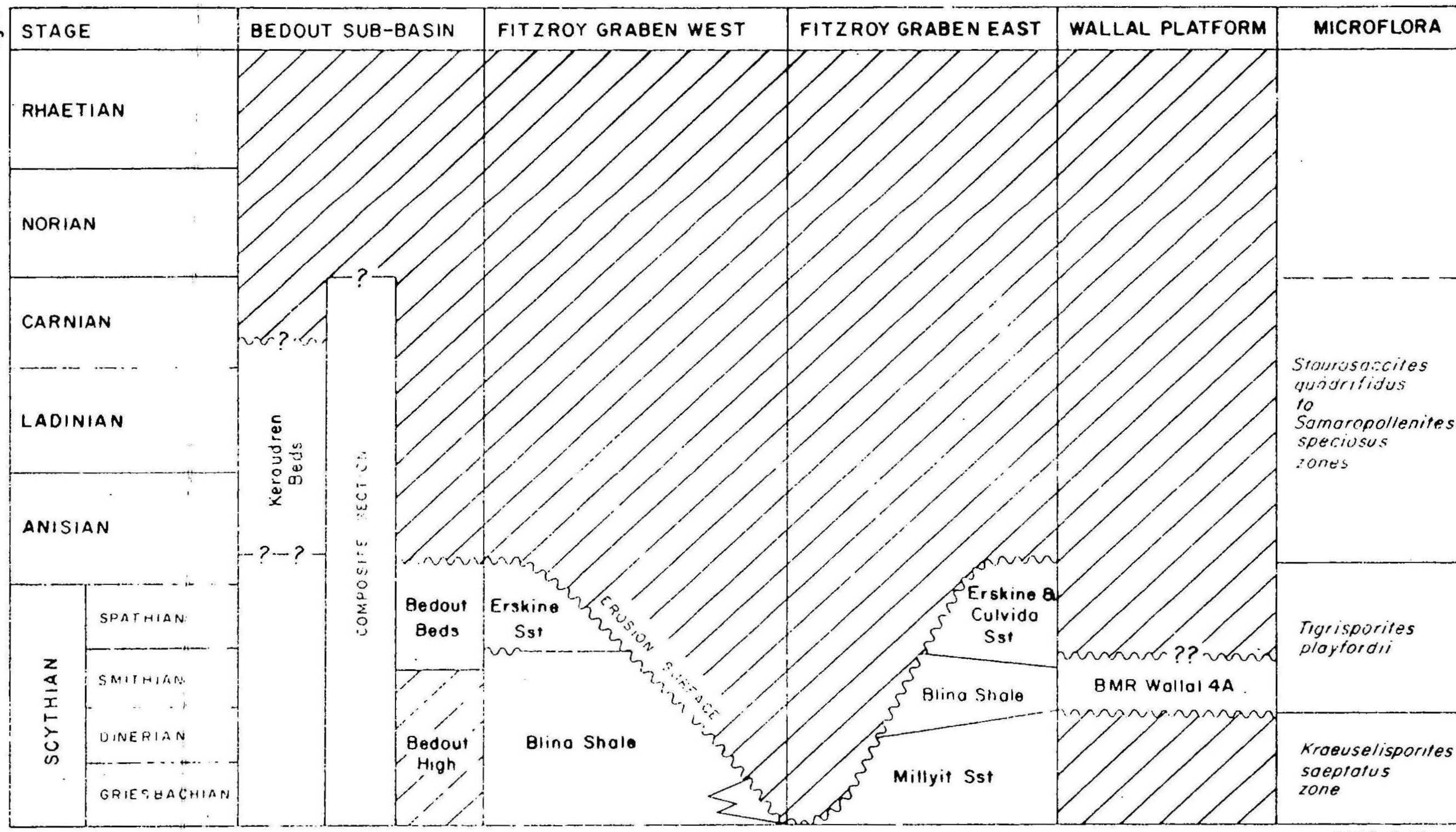
The lower part of the Keraudren Beds cannot be correlated satisfactorily with the upper part of the Bedout Beds on either lithology or palaeontology. Thus the possibility remains that sediments of the Keraudren Beds are somewhat younger than those of the Bedout Beds. Until a complete section is drilled it is impossible to resolve this problem. However, the sample gap is probably not long in duration as microfloras from two successive assemblage zones are present in the upper and lower deposits respectively.

In summary, the Triassic rocks of the Canning Basin range from Griesbachian through Carnian although rocks younger than Anisian are only present offshore (Figure 2). The base of the Blina Shale is transgressive; oldest in the western area (Griesbachian) and Smithian in the east. The sea withdrew from the present onshore region in the Smithian and the youngest Blina Shale is probably late Smithian. The correlative lower Bedout Beds may also be late Smithian or Spathian and pass upwards into Anisian rocks. In the Fitzroy Graben, the Erskine and Culvida Sandstones are chronostratigraphic with the upper Bedout Beds. A sampling gap may exist between the upper Bedout Beds and the oldest penetrated sediments of the Keraudren Beds which range from Anisian (probably upper) to Carnian.

FACIES AND ENVIRONMENTAL SIGNIFICANCE

Sedimentological observations can be summarized in the form of a relatively small number of depositional facies units. The term 'facies' will be considered to denote the sedimentary record of an environment or

Fig.2



Microfloral zones after Dolby & Balme, 1976

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group of related environments. The facies are defined on the basis of a combination of textural, compositional structural, and palaeontological characteristics (Selley, 1970). The small number of samples, extensive erosion, and the lack of adequate palaeontological information probably results in an incomplete list of facies types and a sketchy areal distribution.

Examination of all available measured sections and borehole data allows the construction of a representative lithological section (Figure 3). Log analyses have aided determination of sedimentary succession. BMR stratigraphic wells, for which cores are available, are used to illustrate the lateral lithological changes in the Millyit Sandstone, Blina Shale, and Culvida Sandstone. Detailed lithological changes are not always apparent in wells where only cuttings are available and the log coverage is often incomplete. The broad facies are interpreted depositional environments of the Millyit, Culvida, and Erskine Sandstones, Blina Shale, Bedout Beds, Keraudren Beds, and 4A Beds are presented below.

Names formations are broken down into facies groups and all lithological parameters are listed (Appendix 1) with the suggested environment of deposition and broad fossil content (e.g. spores and pollen, acritarchs etc).

FACIES I - Fluviatile: This facies is characterized by high-angle crossbedding, dominance of sandstone and frequent conglomerate, upward fining, and absence of marine fossils. A combination of these characters is compatible with deposition in a fluviatile regime (Allen, 1965), and where upward fining cycles are present, a meandering stream origin is suggested (Allen, 1965; 1970). Such cycles are present in the Millyit Sandstone (Yeates et al., 1976), Culvida Sandstone (Yeates et al., 1976), Bedout Beds (2938 - 2997 m from gamma-ray curve) and Keraudren Beds (2568 - 2801 m, 3630 - 2844 m (total depth) from gamma-ray curve). Finer clastics usually top the fining upwarding sequences and are interpreted as overbank deposits (Allen, 1965).

FACIES II - Transgressive: This facies is also characterized by a general fining upwards sequence, although high-angle crossbedding is absent and glauconite and marine fossils (acritarchs and lingulids) are present. The

Fig. 3

PERIOD / FORMATION	LITHOLOGY	FOSSILS	SEDIMENTARY STRUCTURES	MINERALOGY	COLOUR	ENVIRONMENTS
JURASSIC						
KERAUDREN V			Laminated		Multicoloured	Lacustrine
KERAUDREN I			↑	Trace pyrite cement	Light grey, minor multi.	Meandering stream, overbank
KERAUDREN V		F	Laminated, thin bedded	Trace pyrite and calcite, dolomite	Multicoloured	Lacustrine
KERAUDREN IVb			↓	Pyrite, calcite cement, carbon	Grey, multi-coloured in part	Prograding distributary channels – prodelta
KERAUDREN III			Thin bedded, laminated, thickness increases with depth	Trace siliceous, calcitic cement, kaolinitic in part	Grey	Shallow marine or bay
KERAUDREN I			↑	Trace to common kaolinite, pyrite or calcite	Grey, white, black/brown clays	Meandering streams and overbank deposits
			SAMPLING GAP			
BEDOUT IVb			↓		Grey/green when fresh	Prograding distributaries
BEDOUT I, ERSKINE I, CULVIDA I			↑, clay pellet conglomerate	Kaolinitic	Greenish grey, black, red in part	Meandering stream and overbank
BLINA, IVa, BEDOUT, IVa, ERSKINE, IVb		F	Cross laminated, thick bedded, laminated, slump and flow, coquina	Pyrite	Green, grey, black	IVa shoaling sequence – shallow marine to tidal flat. IVb prograding channels, tidal flat channels
BEDOUT, III, BLINA, III		F	Laminated	Glauconitic, pyrite, calcite, chert	Green, grey/green and grey	Shallow marine
BLINA, II, 4A, II MILLYIT, I		F, S	Laminated, thin to massive, bedding, coquina ↑ poor to well bedded, trough cross bedded	Glauconitic, ?collophane, pyrite	Black, grey green white, grey, black	Transgressive marine Meandering streams and overbank

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Claystone
Siltstone
Sandstone
Conglomerate
Limestone
Coal
Wood
Plants
Megspores
Acritarchs

Conodonts
Foraminifera
Bryozoa
Lingulids
Conchostracans
S Shell
F Fish
Tetrapods
Gastropods
Diplocraterion

Bioturbation
Ripples
Scour
Mud cracks
Crossbeds
↑ Up fining
↓ Down fining
Unconformity
Spores/pollen

facies is recognized in the basal Blina Shale (e.g. Blackstone 1, Meda 1, Langoora 1, BMR Lucas 13) and the 4A Beds in BMR Wallal 4A. The content of sand decreases upwards and megaspores (in Blackstone 1 and Meda 1 (P.J. Jones pers. comm.)) become less pentiful. To the east, the Blina Shale oversteps the fluviatile Millyit Sandstone (e.g. BMR Lucas 13 - Yeates et al., 1976).

FACIES III - Marine: The marine facies is characterized by the common presence of marine fossils, preponderance of laminated green and grey siltstone, claystone, or shale, sandstone stringers, and glauconite. In Blackstone 1 this facies contains abundant foraminifera, conodonts, and lacks megaspores. The facies is recognized in the Blina Shale (Blackstone 1, Langoora 1, Meda 1), lowermost Bedout Beds (Bedout 1, 2997 - 3020 m) and Keraudren Beds (3124 - 3630 m in Keraudren 1). The marine facies grades down into the transgressive facies in all sections except at Bedout 1 where it directly overlies weathered Upper Permian basalt (B.O.C., 1971). Probably the Bedout High (Figure 1) was inundated late in the transgression and coarser clastic deposits were not available.

FACIES IV - Regressive: The major character of this facies is a coarsening upwards trend, coupled with a decrease of marine fossils and an increase in land plant component. The vertical sequence may terminate in two distinct sub-facies: regression may be accomplished by coastal aggradation (Walker & Harms, 1975; Andrews & Laird, 1976) where a shoaling sequence is overlain by coastal plain deposits, or by delta progradation (Coleman & Gagliano, 1965). Shoaling sequences (FACIES IVa) are apparent in both the upper part of the Blina Shale (e.g. at Erskine Hill (McKenzie, 1961)) and the lower Bedout Beds (Bedout 1 from 2911 to 2938 m).

The regressive sequence at the top of the Blina Shale is notable for the lack of massive sandstone bodies, thought to be due to deposition in a shallow environment with a low tidal range and little wave agitation. In such an environment winnowing of mud from the sediment would not result in the build-up of sandbars or beaches (Walker, 1972). Alternatively, sand supply may have been low, suggesting a subdued hinterland. However, the presence of much sand and conglomerate in the immediately preceding and overlying fluviatile sequences suggests that lack of winnowing was the major factor in the absence of sand bodies in the upper Blina Shale.

At Erskine Hill, the basal massive crossbedded sandstone (McKenzie, 1961) suggests a prograding distributary of a deltaic system which was advancing over the upper Blina Shale. However, the lithological association is similar to that of estuarine sands, as described by Land (1973), except for the lack of marine shelly fossils. Prograding distributary sands are also interpreted in the Keraudren Beds (2960 - 3124 m in Keraudren 1 on gamma-ray curve pattern) and the upper Bedout Beds (2911 - 2938 m in Bedout 1). These progradational sand bodies are included in FACIES IVb, and always overlay FACIES III with basal scour. In the Fitzroy Graben IVb always gives way to FACIES I, but at Keraudren 1 it is overlain by a possible lacustrinal facies (FACIES V).

FACIES V - ?Lacustrine: This facies is recognized only at Keraudren 1 (2801 - 2960 m and 2460 - 2568 m), and is characterized by thin-bedded and laminated claystone, minor sandstone, and may contain calcilutite (2825 - 2864 m in Keraudren 1). No marine fossils are present, but spores and pollen (Ingram, 1974) and coal may be present. The claystones are multicoloured, suggesting deposition under alternating humid to arid climate (Falke, 1971); humid conditions are also suggested by the presence of coal, and drier conditions by dolomite.

Picard & High (1972) state that deposits bounded by fluviatile units, as at Keraudren 1, or unconformities, and the presence of a nonmarine fauna in sediments that could variously be ascribed to marine or lacustrinal origin, are suggestive of lacustrine deposition. A similar stratigraphic position between continental deposits was also stated by Greiner (1974) to be characteristic of lacustrine deposits. The common presence of iron sulphides, siliceous and calcitic cement (Hematite, 1974) is further suggestive of lacustrine sediments (Picard & High, 1972).

ROCK COLOURATION - ENVIRONMENTAL SIGNIFICANCE

The literature on the colour of rocks is extensive, particularly that of redbeds (see Glennie, 1970) and the relationships between colouration and sedimentation still a contentious issue. The change in rock colouration, from grey and green to red, is a feature judged by many authors to be characteristic of the transition from marine to continental conditions (Kuijpers, 1975).

McBride (1974) in a study of the Difunta Group, Mexico, concluded that the hue of rock body may be significant in aiding the interpretation of the environment of deposition. Colour primarily reflects the oxidation state (McBride, 1974). Applying the broad results of McBride's study can help in the delineation of the sedimentary environment and palaeoclimates of the Triassic rocks in the Canning Basin. As extensive weathering has modified the colour of outcrop and shallow subcrop, only unweathered subsurface rocks will be considered.

In the Millyit Sandstone, the fluviatile facies is dominantly white or grey (Yeates et al., 1975) which suggests the sediments were not exposed sufficiently long for reddening to occur during or soon after deposition. In the Difunta Group, McBride (1974) concluded that the time needed for drab-coloured sediments to redden was in the order of only a few thousand years. One possible explanation is that rapid deposition did not allow enough time for oxidation of ferric minerals to hematite. The presence of minor inter-bedded black claystone in the crossbedded sandstone facies suggests reducing conditions. A second, and perhaps more likely explanation, requires that the earliest Triassic annual climate cycle did not possess a true dry season when the water-table was lowered and oxidation took place. Consequently a climate with even precipitation is inferred. Van Houten (1973) related the oxidation state of overbank shale (i.e. colour) to the climatic conditions under which the strata were deposited: The drier the climate the greater abundance of oxidized strata (redbeds). Thus the lack of redbeds in the Millyit Sandstone suggests deposition under a humid climate. Other explanations for the lack of redbeds is unweathered Millyit Sandstone are the rapid transgression of the Blina Sea over the formation before oxidation commenced, or the nearby sea influenced the weather to produce a humid climate. Of the explanations proposed the second is most favoured with perhaps the third also playing a role in the diagenetic history.

The lower transgressive facies (FACIES II) of the Blina Shale is predominantly light grey, off-white, to green. The grey siltstones and minor sandstones probably represent the original colour of these shallow marine rocks and the presence of pyrite reflects deposition under reducing conditions. Green colours are dominant in FACIES III of the Blina Shale and also occur in the regressive FACIES IVa. According to McBride (1974), the colour of green rocks is directly attributable to ferrous iron in chlorite and illite and indirectly to lack of other colouring agents; the rocks grade to grey with an increase in organic matter. The green colour of the unweathered Blina Shale implies deposition under reducing conditions, a conclusion supported by the presence of pyrite and glauconite.

The lower facies of the Erskine Sandstone (FACIES IVb) contains red, yellow, white, and grey siltstone, grey to red sandstone, and minor dark grey claystone. The dark grey sediments were probably deposited under reducing conditions and contain appreciable amounts of organic matter. The redbeds are probably so coloured because of hematite staining. Red and yellow colours also occur in the lower Culvida Sandstone (Yeates et al., 1975) in BMR Cornish 2 (Core 1). The advent of reddish hues in unweathered sediments probably indicates contemporaneous or pene-contemporaneous oxidation of ferrous iron to red hematite during deposition. McBride (1974) interpreted similar reddening in the Difunta Group to processes of oxidation during dry seasons when the water-table was lowered sufficiently to permit oxidation of ferrous iron and decomposition of organic matter. Yellow beds, according to McBride, usually contain organic material responsible for preventing strong oxidation. Siltstones in the Culvida Sandstone contain plant material at Culvida Soak (Casey & Wells, 1964), and carbonaceous siltstone occurs in BMR Cornish 2. The distribution of reddish or yellow sediments in this unit indicates periods of subaerial weathering.

The upper Erskine Sandstone (FACIES I) is dark reddish brown, yellow, grey, and white when unweathered, whereas the upper Culvida Sandstone is white and yellow and contains minor white or mauve siltstone. The red colour of the upper Erskine suggests subaerial weathering during deposition and this may indicate seasonal lowering of the water-table or exposure in a soil.

The overall picture presented by the Erskine and Culvida Sandstones indicates a shift from the previous 'wetter' climate of the Blina Shale to one with less, or seasonal rain and possibly high summer temperatures. The change in climate in the onshore Canning Basin can be attributed to the removal of the mitigating effect of the Blina Sea, and consequent greater continentality.

In the Bedout Sub-basin the lower Bedout Beds (FACIES III) are white to dark greenish grey and were probably deposited in similar conditions to the Blina Shale. The lower facies is overlain by greenish siltstone and sandstone containing minor coal (FACIES I). The upper facies (FACIES IVb) is olive grey and multi-coloured at the top and becoming grey and greenish grey with depth. The olive and multi-coloured sediments may result from weathering at the intra-Triassic unconformity: the grey and greenish grey sediments represent the true primary colour. The sediments are contemporaneous with the lower Erskine and Culvida Sandstones and uppermost Blina Shale of the Fitzroy area, and represent deposition in an area of higher rainfall than the more continental eastern deposits, probably owing to the proximity of a large water body in the Bedout Sub-basin and a declining marine influence in the Fitzroy Graben during latest Scythian time.

The lower facies (FACIES I) of the 'Keraudren Beds' is dominantly grey and contains minor coal, and it is not until above 2960 m in Keraudren 1 that multi-coloured sediments, associated with dolomitic calcilutite, appear in the late Middle Triassic. Again the presence of a humid climate is indicated in the lower facies with lessening rainfall evident in later deposits. The presence of dolomitic calcilutite (2801 - 2960 m) further suggests elevated temperatures.

BIOFACIES

An extensive literature search for the environmental tolerances of each element (autecology of Ager, 1963) of the flora and fauna preserved within the Triassic rocks of the Canning Basin (Appendix 2) was undertaken. The combined biota (synecology of Ager, 1963) of each lithofacies is considered on its overall ecological implications and is termed 'biofacies' (see Table 1). Each biofacies is considered in light of the significant contained fossils - that is, those of which the ecological limits are reasonably well known - and is used to reconstruct a picture of the Triassic environmental succession.

Biofacies associated with Facies I are characterized by the complete absence of marine fossils.

In the basal Triassic Millyit Sandstone the flora included ferns, equisetaleans, cycads, glossopterids, conifers, and peltasperms, with rare *Dicroidium*. In the comparable facies (FACIES I) of the Erskine Sandstone, *Dicroidium* and its allies are the dominant plant type and ginkgoaleans make their first appearance. Fossils are rare in this facies, probably because of oxidizing conditions inherent in a continental environment. Glossopterids are rare. Conifers and corystosperms are also prominent in Facies I of the Keraudren Beds and Bedout Beds. Representatives of the pleuromeid complex (*Aratrisporites*) are also present in the latter two units but the occurrence of *Aratrisporites* in the Bedout Beds is questionable due to possibilities of caving. Overbank deposits in the Culvida Sandstone show that the plant communities during the early Middle Triassic were dominated by *Dicroidium* and contained hydrophytic plants (e.g. *Equisetum*) which probably grew in billabongs or ponds, and conifers, ginkgoes, and cycads, probably of upland habitat.

Early Middle Triassic Facies I rocks in the Bedout Sub-basin (Keraudren 1 well, 3630 - 3844 m) contain no marine fossils, fine upwards, and are in part carbonaceous or kaolinitic. The sediments represent meandering stream deposits and the predominant green colour suggests a humid climatic regime in the sub-basin. Fluviatile deposition (Facies I) occurs above 2810 m with fining upwards cycles, minor coal, and multi-coloured claystone indicating continental deposition, but no fossils are recorded.

Facies II is represented by the basal Blina Shale and the 4A Beds, but little is known of the palaeontology of the latter unit. However, both units contain acritarchs which are characterized by forms which indicate shallow marine, near-shore environments (Sarjeant, 1974). These acritarchs occur in great numbers: such 'swarms' are interpreted by Dolby & Balme (1976) as indicative of immature ecosystems, as is to be expected in transgressive conditions. The occurrence together in the Blina Shale of lingulids and conchostracans, both indicative of brackish water (Ferguson, 1962; Tasch, 1975), further underlines the transitional nature of the Facies.

The poorly diversified microfloral assemblage (*Kraeueselisporites saeptatus* zone of Dolby & Balme, 1976) represents plants that grew in a specialized coastal environment (Balme, 1969a) which Dolby & Balme (1976, p. 131) suggest developed in response to the early Triassic transgression onto an older peneplaned surface. The broad tidal flats formed were colonized by halophytic lycopod and coastal gymnosperm groups (represented by Lunatisporites and other taeniate bisaccate pollens), hydrophytic plants, such as Equisetum (Batten, 1974) and ferns indicating moist conditions.

The marine Facies III is characterized by the presence of forms with wide ecological tolerances. The arenaceous foraminifer Ammodiscus is recorded from cold-water deposits (Crespin, 1958) but presumably had a wider tolerance. The acritarchs are of the same genera present in FACIES II and lingulids and conchostracans also occur. The presence of conchostracans in the Blina Shale suggests that influx of fresh water into the shallow sea had not ceased with the drowning of the Millyit rivers. Seasonal flooding of rivers and flushing of freshwater biota (reptiles, amphibians, fish, and plants) into the marine environment (see Cockbain, 1974) could explain the anomalous admixture of marine and freshwater organisms (Table 1). Hyposalinity is further suggested by the rarity of stenohaline invertebrates and the presence of lingulids possibly because of nearby rivers which discharged into the gulf. Connections with the open sea are shown by the presence of marine fish, microplankton, conodonts, and ammonoids. The dominant microplankton are forms which indicate inshore, partly enclosed environments (Sarjeant, 1974) in an immature ecosystem (Dolby & Balme, 1976), and the presence of the arenaceous foraminifer Ammodiscus suggests a marginal marine environment. The abundance of U-shaped burrows of Diplocraterion is probably indicative of subtidal environments (Sellwood, 1970).

Of the two identifiable conodont genera present (see Nicoll & Gorter, in prep.), Neohindeodella is euryhaline (Kozur, 1976), and Neogondolella was extremely sensitive to raised salinities but could tolerate slightly brackish water (Kozur, 1976). This is compatible with the presence of lingulids and conchostracans, especially if the latter were washed into the marine environment by flooding.

The microflora, although poorly sampled in this facies, is broadly comparable to the Tigrisporites playfordii Assemblage zone in the Carnarvon Basin, which Dolby & Balme (1976) believe, because of the high number of acritarchs, reflects the maximum Smithian transgression. Of the plant

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types represented in the microflora the majority are ferns and conifers, although Equisetum remains are also present. The conifers are of the type designated 'coastal flora' by Balme (1969a). However it is possible that some of these conifer pollen and fern spores may represent upland communities rather than reflect the begetation in the immediate vicinity to the marine environment (see Chaloner & Muir, 1968, p. 137).

In the Bedout Sub-basin, the Bedout High was partly transgressed as shown by the shallow marine sediments (Facies III) at the base of the Bedout Beds in Bedout 1. The local vegetation on the emergent parts of the Bedout High included conifers, some of Araucarian type, ferns, and Dicroidium as suggested by palynology. The shore-face probably was inhabited by coastal lycopods and equisetaleans, although there are no equisetalean spores reported in the microflora. Between 3124 and 3630 m in Keraudren 1 the interpretation of Facies III (Marine) is consistent both with the sediments and the presence of acritarchs (Hematite, 1974).

Facies IVa, the regressive facies, is present in the upper Blina Shale, and also contains the T. playfordii Assemblage but lacks the abundant acritarch element. This microflora marks the first appearance of Aratrisporites in abundance in the Canning Basin, and indicates the introduction of the pleuromeid complex. The first appearance of Aratrisporites, considered by some to be the microspore of the megaspore Cylostrobus (Potonie, 1970), although not confined to that genus (Retallack, pers. comm. 1977) and borne by the coastal lycopod Pleuromeia (Retallack, 1975) occurs in this facies. Pleuromeia first occurs in the Erskine Sandstone at Yarrada Hill (Brunnschweiler, 1957, Retallack, 1975). Balme (1963) interpreted Pleuromeia as a plant adapted to more desert-like conditions than earlier lycopods and, as the fauna and sedimentary facies indicate a retreat of the sea during the introduction of the pleuromeid complex, it is possible the pleuromeids colonized less humid environments. However, Retallack (1975) recently proposed that Pleuromeia grew in monotypic stands along the waters edge and in shallow water, much like the modern coastal mangrove. Probably, as suggested by Balme & Helby (1973), the pleuromeid complex represents an opportunistic plant group that rapidly colonized the new ecological niche resulting from the retreat of the sea. Kauffman (1969) similarly has noted that environmental crisis associated with regression is often accompanied by rapid changes in environmental parameters and accelerated evolution at the species level.

The Tigrisporites Playfordii Assemblage 1 Zone is more diversified than the preceding microflora. Certainly the macroflora represented in the upper Blina Shale (FACIES IVa) and lower Erskine Sandstone (FACIES IVb) reflects a greater plant diversity, especially in the several species of Dicroidium present. A similar situation in the Carnarvon Basin is suggested by Dolby & Balme (1976, p. 131) who state 'these modifications coincide, in broad terms, with the culmination of marine transgression in the Smithian and mark the recolonization of coastal areas by more diverse gymnosperm and cryptogam groups'. The Corystosperm Falcisporites is the dominant pollen type in the non-marine strata of the Canning Basin but is subordinate to Aratrisporites and other pteridophyte spores in the marine influenced sediments.

The upper Blina Shale (Facies IVa) contains a diverse faunal assemblage. Conchostracans are abundant, sometimes forming coquinas, and are associated with Lingula (McKenzie, 1961), bivalves (Casey & Wells, 1960) and Diplocraterion. This association of brackish, freshwater, and marine fossils indicates that marine and non-marine environments were intimately associated. This is shown by the presence of freshwater and marine fish, marine (Icthyosaurs) and non-marine (Capitosaurs) reptillians, marine (Erythrobatrachus) and fluviatile (Blinasaurus) amphibians in this facies. This interplay of marine and non-marine fauna is best explained in the context of semi-emergent tidal flats formed during regression of the sea, which were periodically inundated by flooding of streams draining into the sea during seasonal periods of high rainfall. Streams probably entered the sea year round but high discharge may have caused sheet flooding of the tidal flats and dilution of seawater, as suggested by the low diversity of stenohaline forms. In fact the only exclusively marine fossil reported is an ammonoid (Balme, 1969) from the Erskine Range. This fossil may have floated into the shore in the manner of dead Nautilus shells, buoyed up by gases given off from the decaying organic remains.

The concept of seasonal climate is also supported by the presence of the lung fish Ceratodus, probably with a climatic range of 11-31^{o}C (Saheffer, 1969).

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Distributaries on the tidal flats are represented by Facies IVb (e.g. lower Erskine Sandstone) and are distinguished by the lack of animal fossils and the presence of plant remains. Pterophytic plants included Equisetum and ?Schizoneura with coastal lycopods and conifers.

Facies IVb is also recognised in Keraudren 1 (2960 - 3124 m). Arenaceous foraminifera occur in several horizons (Hematite, 1974) and bryozoan fragments occur at 2960 m. Coarsening upwards cycles between 2955 and 3035 m are interpreted as progradational channels; the claystone above the upper channel contains bryozoans, interpreted as resulting from avulsion of the river causing a switch in the locus of sedimentation.

The lacustrinal facies (Facies V) is only recognised in Keraudren 1. The sequence above the progradational facies (1960 m) contains a dolomitic calcilutite unit in which conchostracans, fish, and gastropods were found. The microflora included ferns, corystosperms, and conifers. Aratrisporites is present, suggesting a coastal plain site for the lake or, alternatively, the pleuromeids may by this time have colonized inland lakes. However, as Aratrisporites has recently been isolated from other lycopod cores than Cylostrobus (Retallack, pers. comm. 1977), this record of A. sp may not necessarily indicate the presence of Pleuromeia. It is possible that lycopods occupied distributary channels in lake deltas as suggested by Retallack (1976). The hinterland was vegetated by Dicroidium (Falcisporites), conifers (Guthoerlisporites), ferns, and possibly cycads, as suggested by the contained microflora. The upper deposits in Keraudren 1 (2460-2568 m) are interpreted as possible lake deposits with a lack of marine fossils and fine grainsize. The shores of the lake probably supported lycopodian stands with a mixed Dicroidium-conifer vegetation occupying higher land.

PALAEOGEOGRAPHY AND GEOLOGICAL HISTORY

In this section the descriptive data and related interpretations of the preceding sections are synthesised in an attempt to reconstruct the geological history of the Canning Basin during the Triassic.

Four stratigraphic intervals were selected to illustrate the

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environmental changes with time through the Triassic, the palaeogeographic maps (Figure 4a-c) have been prepared.

The sea withdrew from the Canning Basin in Late Permian time and a brief period of erosion followed. At the commencement of the Triassic the sea again transgressed the basin. The extent of this transgression is unknown owing to erosion, but evidence of thick pre-Jurassic sediments from seismic data suggests that the Bedout Sub-basin and the Fitzroy Graben were flooded. The initial transgression (Figure 4a) is marked in the onshore basin by fine-grained sandstone and siltstone which often contain glauconite and a large number of acritarchs. In the northwestern Fitzroy Graben the shallow sea was flanked by low-lying land which supported a coastal plant community of lycopods, cycads, ferns, and conifers. In the southeastern area shallow marine sediments interfingered with fluviatile clastic sediments derived from the erosion of Palaeozoic rocks. The area around the fluviatile systems supported a Dicroidium vegetation with small waterside herbs, equisetaleans, and other hydrophytic plants occupying billabongs, ponds, and river-bank niches. Higher ground surrounding the shallow sea was the habitat of a glossopterid-conifer and cycad-ginkgoalean community, which also contained ferns and Dicroidium.

A shallow sea similarly occupied the Bedout Sub-basin, but probably did not inundate elevated areas such as the Bedout High (Figure 4a).

The major transgressive phase, culminating in the Smithian Substage, was probably contemporaneous with similar transgressions in the Carnarvon and Perth Basins (McTavish & Dickins, 1974). During this transgression the Bedout High was inundated (Bedout Beds - Facies III), the Wallal Platform was flooded (4A Beds), and the river systems of the eastern Fitzroy Graben drowned (Figure 4b).

In latest Scythian time the sea regressed from the Bedout High, Wallal Platform, and onshore Canning Basin. The transition from shallow marine to continental deposition (Facies IV) is represented by deposits of the upper Blina Shale, lower Erskine Sandstone, upper Bedout Beds and possibly the lower Culvida Sandstone. These transitional deposits are of great interest, for the plant communities were undergoing ecological change. The lower Scythian Taeniaesporites (=Lunatisporites) microflora (Balme, 1964)

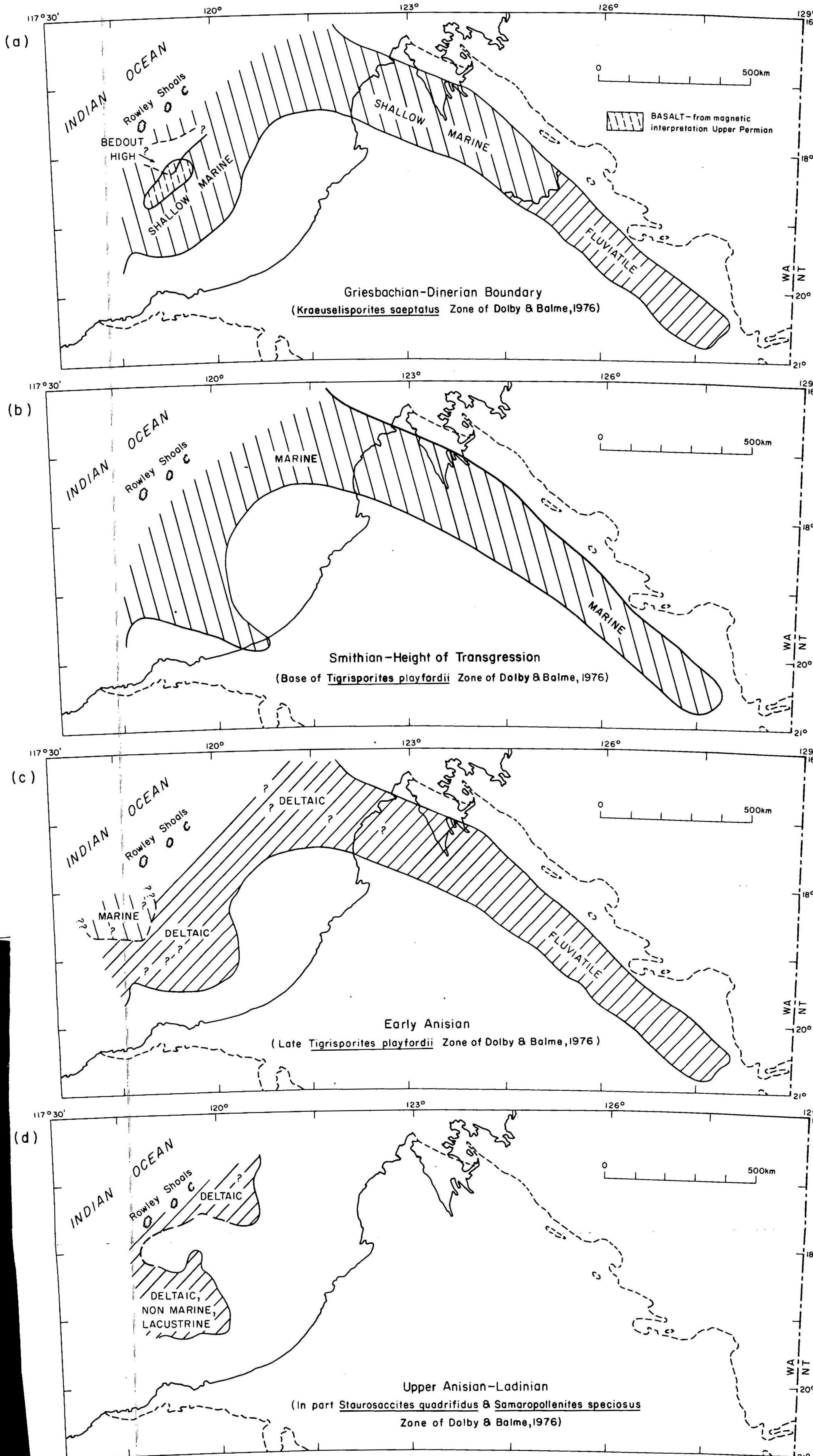

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Fig. 4

TRIASSIC PALAEOGEOGRAPHY OF THE CANNING BASIN

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gave way to the Falcisporites microflora (Helby, 1973) in later Scythian time. The characteristic Pleuromeia-Cylostrobus-Aratrisporites assemblage represents an opportunistic group which rapidly colonized the new niche resulting from the retreat of the sea (Balme & Helby, 1973).

As the sea regressed westwards the coastal plain became the site of meandering stream deposition and a continental climatic regime became established in the Fitzroy Graben, by early Middle Triassic time (Figure 4c). Middle and lower Upper Triassic rocks in the Bedout Sub-basin reflect the marshy and deltaic environment of that time. Fluviatile and lacustrine sediments were deposited on a deltaic plain which was occasionally transgressed by a shallow sea. The climate was probably semi-arid in the Bedout Sub-basin and continental in the Fitzroy Graben.

Triassic deposition came to a close with tectonism during the Late Triassic when movement on the bounding faults of the Fitzroy Graben caused the development of the east-west anticlinal structures and north-south faulting (Smith, 1968), and uplift in the Bedout Sub-basin.

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APPENDIX 1 - Lithofacies and interpreted palaeoenvironments

MILLYIT SANDSTONE

FACIES	LITHOLOGY	SEDIMENTARY STRUCTURES & BIOTA	PALAEOENVIRONMENTS
I	White and grey, fine to coarse quartzose sandstone, conglomerate lenses, micaceous, in part clayey, with micaceous siltstone and black claystone	Fining upward cycles, clay pellet and pebble horizons, trough crossbedding, cycles up to 5 m thick, foresets at 25°, some poorly to thin-bedded, medium-bedded sandstone, ripple cross-lamination in siltstone, plant fossils	Meandering stream deposits, overbank and channel sediments

BLINA SHALE

FACIES	LITHOLOGY	SEDIMENTARY STRUCTURES & BIOTA	PALAEOENVIRONMENTS
Facies IV a **Interbedded siltstone and sandstone**	Blue, grey, green (multi-coloured when weathered), carbonaceous siltstone; very fine, well sorted sandstone some fine to coarse; and micaceous shale, conchostracan coquinas, increasing amounts of coarser sand towards east. Some calcareous sandstone, overall coarsening upwards	Interbedded, laminated, ripple-marked, mud-cracked, clay pellets, sandstone stringers in siltstone, small-scale low-angle crossbedding, bioturbated, plant remains, bone beds, coquina, shell fragments, cut-and-fill in east, wave ripple marks, mudcurls, rainprints, slump and flowage structures	Regressive shallow marine-tidal flat, lagoonal, back swamp with channeling in part
Facies III Shale and siltstone	Green, greenish grey, micaceous siltstone, shale and claystone with minor sandstone as thin beds and stringers: in part glauconitic, in part calcareous, minor chert, in part pyritic	Laminated and thin-bedded, sandstone stringers, slump and flowage structures, small-scale crossbedding, bioturbated with abundant vertical burrows, foraminifera, conodonts	Shallow marine
Facies II **Shale and siltstone with varying amounts of sandstone increasing towards east**	Black, grey, green, violet, and white when weathered, siltstone shale, and claystone; fine to medium sandstone, micaceous unsorted to well sorted, sometimes carbonaceous, with rare feldspar and ? collophane, finely glauconitic in part, some pyrite	Well-bedded, thin to massive, ripple-marked, low-angle crossbedding in sandstone, thin lenses of clay pellets, thin conglomerate lenses, mud cracks, cross-laminated and laminated siltstone; bioturbated, horizontal and vertical burrows, pyritized plant fossils, conchostracan coquinas, shell fragments	Transgressive shallow marine interfingering with channel sandstone eastwards

4A BEDS

FACIES	LITHOLOGY	SEDIMENTARY STRUCTURES	PALAEOENVIRONMENTS
II Siltstone and shale	Grey, siltstone and shale, micaceous, glauconitic, with thin sandstone stringers	Fining upwards, acritarchs	Transgressive marine deposit

ERSKINE SANDSTONE

FACIES	LITHOLOGY	SEDIMENTARY STRUCTURES & BIOTA	PALAEOENVIRONMENTS
Facies I Crossbedded sandstone	Quartzose, micaceous sandstone, in part silty or well sorted, pebbly and conglomeratic, minor micaceous siltstone, grey, dark reddish brown, yellow, and white when unweathered; red, brown when weathered	Large-scale crossbedding, thin to massive bedded, fining upward cycles, scour-and-fill, intraformational clay pellet conglomerate in thick sandstone beds, plant fossils	Meandering stream deposits, channel and overbank deposits
Facies IV b Interbedded siltstone and sandstone	Carbonaceous siltstone in part sandy; carbonaceous grey well sorted sandstone and some thin shale, dark, grey. Siltstone red, yellow, white, and grey when unweathered; multicoloured when weathered	Laminated, thin-bedded, cross-laminated, low-angle crossbeds; containing lenses of crossbedded, medium-grained sandstone with clay pellet horizons; ripple marks, low amplitude and asymmetric; mud cracks, bioturbated, plant remains	Tidal flats with channels and marsh deposits, distributaries, possibly some estuarine sands.

CULVIDA SANDSTONE

FACIES	LITHOLOGY	SEDIMENTARY STRUCTURES & BIOTA	PALAEOENVIRONMENTS
I Sandstone and subordinate siltstone	White, quartzose sandstone, fine to coarse, pebbly in part, granule conglomerate, poorly to well sorted, micaeous in part; white and multi-coloured siltstone, kaolinitic	Fining upward cycles, sharp basal contacts (from gamma-ray pattern in BMR Cornish 2), clay pellet conglomerates, crossbedding in sandstone, laminated siltstone and finer sandstones, ripplemarks, mud cracks, warm tracks, plant fossils	Meandering stream deposits, with overbank and associated sediments
IVa Interbedded siltstone and sandstone	Grey, green, earthy red, black carbonaceous siltstone and interbedded green, quartzose sandstone, fine-grained, some coarse	Upward fining cycles less than 3 m thick (gamma-ray log), some siltstone beds 12 m thick with sharp upper contact, clay pellet conglomerate, some medium-bedded sandstone, laminated siltstone, bioturbated horizons and plant fossils, including pleuromeids	Mud flat to swamp deposits with distributary channels, possibly deltaic in part

BEDOUT BEDS

FACIES	LITHOLOGY	SEDIMENTARY STRUCTURES	PALAEOENVIRONMENTS
IVb Claystone-sandstone (2910-2938m)	Olive grey and multi-coloured (?weathering at unconformity) claystone, in part silty, grading to siltstone, grading upwards into light grey to greenish grey, medium to coarse sandstone, unsorted, sub-angular to sub-rounded, up to 10% clay matrix	Coarsens upwards from claystone to sandstone, cycle 24 m thick, no marine fossils	Prodelta and prograding distributary
I Sandstone to siltstone (2938-2997m)	Sandstone, as above, and siltstone and claystone as above; minor coal in sandstone	Fining upward cycles from sandstone to siltstone, 21 m thick	Fluviatile channels
III Interbedded sandstone and claystone (2997-3020m)	White to dark greenish grey sandstone, becoming very fine with depth, moderately well to well sorted, argillaceous; light grey siltstone, very well sorted, and dark grey arenaceous claystone	Interbedded, with marine fossils	Shallow marine shoaling sequence

KERAUDREN BEDS

FACIES	LITHOLOGY	SEDIMENTARY STRUCTURE	PALEOENVIRONMENT
V Multi-coloured claystone (2460-2568 m)	Claystone, multicoloured, trace quartz silt and fine sand, micaceous, and minor aggreates of sandstone, argillaceous, very well sorted, occurs as irregular blebs, thin coal	Interlaminated, spores and pollen only	?Lacustrine
I Finging upward sandstone (2568-2801 m)	Dominantly sandstone, light grey, fine to granule, white clay matrix, poorly to moderately sorted, some well sorted, sub-angular to subrounded, trace clay minerals and pyritic cement, mica, with minor claystone, light grey, silty and arenaceous in part, multi-coloured in part, rare earthy coal	Fining upwards cycles from gamma-ray pattern, 15-30 m thick, sharp-based, coal at top of one cycle, spores and pollen only	Fluviatile sandstone, meandering stream profiles with development of ox-bow lakes probable
V Claystone-calcilutite (2801-2960 m)	Multi-coloured claystone with traces of quartz silt and micrite with calcultite, and interlaminated fine set, argillaceous in part, dolomitic, clayey, trace disseminated pyrite and sandstone, very fine to fine some granule, in lower part, moderately well to well sorted, poorly to moderately sorted in coarse fraction, argillaceous, calcareous calcite cement, trace pyrite cement and thin beds of grey siltstone with traces of mica and carbonaceous material and thin coal seams	Laminated and thin-bedded from sonic log, gastropods in calcilutite, fish scales and teeth (2845 m), ? conchostracans	Laucstrinal sequence

KERAUDREN BEDS continued

FACIES	LITHOLOGY	SEDIMENTARY STRUCTURE	PALAEOENVIRONMENT
IV b Coarsening upward sandstone (2960-3124 m)	Sandstone, grey, fine to granule, dominantly medium to coarse, poorly to moderately sorted, trace clay, trace to common pyrite cement, trace disseminated carbonaceous matter, trace to common calcite cement, minor claystone, dark grey and multi-coloured, silty, trace disseminated pyrite, grades in part to siltstone	Three coarsening upwards cycles, the lower not well defined, upper cycles 30-40 m thick, separated by claystone containing bryozoan fragments and arenaceous foraminifera, claystone with minor interlaminated sandstone at top of cycles	Delta, progradational channel sands, interdigitated with marine claystones caused by switching of channels across delta front
III Claystone and siltstone with minor sandstone and rare coal grading to dominant sandstone lower half (3124-3630 m)	Upper part (3124-3300 m): Claystone, grey silty in part with traces quartz sand, mica and traces of carbonaceous matter, argillaceous siltstone, grey, clay minerals, trace carbonaceous matter and minor sandstone, thin coal seams. Lower part (3300-3630 m): sandstone light grey, very fine to medium, some very coarse, moderately to moderately well sorted, coarser fraction less sorted, subangular to subrounded, trace to common kaolinite clay, silica cement, trace calcite and pyrite cement, and minor claystone, white to dark grey, silty, may be common kaolinite clay, trace quartz silt, mica, trace carbonaceous matter, grades in part to argillaceous siltstone	Upper part thinly bedded to laminated from gamma-ray and resistivity patterns and sidewall core samples, thicker sandstone beds increase with depth, claystone laminated, rare acritarchs, pleuromeids	Shallow marine or inter-distributary bay facies, lower part more proximal to delta front, upper part distal

KERAUDREN BEDS continued

FACIES	LITHOLOGY	SEDIMENTARY STRUCTURE	PALAEOENVIRONMENT
I Fining upwards claystone-sandstone (3630-3844 m total depth)	Cycles begin with sandstone, grey, very fine to granular, dominantly fine to medium, moderately to moderately well sorted, poorly sorted when coarse, subangular to subrounded, in part argillaceous and silty, with trace to common white kaolinitic clay, micaceous, trace carbonaceous matter, trace silica cement, trace pyrite cement, and grade up into claystone, white, brown to black, kaolinitic, trace to common mica, trace to common quartz silt, trace pyrite, trace carbonaceous matter, grading to minor siltstone	Fining upwards cycles on gamma-ray pattern, thickness range 10-60 m, no marine fossils, pleuromeids rare (1 species)	Fluviatile sequence, probably deposited by meandering streams

APPENDIX 2 - PART 1 : FAUNA AND ENVIRONMENTAL SIGNIFICANCE

FOSSIL GROUP	SPECIES	FACIES AND LOCALITY	ENVIRONMENTAL INTERPRETATION
Conodonts	Neohindeodella sp	Blina Shale facies III in Blackstone 1	Euryhaline, may occur either in hyposaline or hypersaline waters (Kozur, 1976)
	Neogondolella sp	Blina Shale facies III in Blackstone 1	Shallow water (Druce, 1973) genus. Kozur (1976) noted that Triassic gondolellids were extremely sensitive to raised salinities but tolerant of slightly brackish waters.
	Indeterminate forms	Blina Shale facies III in Blackstone 1 and Langoora 1.	Marine.
Foraminifera	Ammodiscus eregatus	Blina Shale facies III in Blackstone 1 and Meda 1 (P.J. Jones, pers comm).	Coldwater form (Crespin, 1958) but probably with wider tolerance.
	Indeterminate arenaceous forms	Keraudren Beds facies III at 2960 m in Keraudren 1 (Hematite, 1974).	Marine, probably benthonic and nearshore.
Ammonoids	Undescribed	Blina Shale facies IVa at Erskine Range (Balme, 1969b).	Marine - associated with conchostracans and amphibians and may have floated in after death in the manner of Nautilus shells, buoyed up by decay gases.
Bryozoans	Undescribed	Keraudren Beds facies III at 2960 m in Keraudren 1 (Hematite, 1974).	Most bryozoans live close inshore in shallow marine waters.
Phosphatic brachiopods	Lingula spp	Throughout Blina Shale except the bone beds at Wongil Ridge and Dry Corner (Brunnschweiler,1954) but present in bone beds at Erskine Range (McKenzie, 1961).	Primarily an inhabitant of low species diversity, near-shore faunas - in warm brackish to marine waters, in shallow depths (Ferguson, 1962). Lingulids small (2-5 mm), scarcer than conchostracans (Brunnschweiler, 1954), and are associated with vertical worm-burrows at M13 (Casey & Wells, 1964) and with foraminifera in Meda 1 (P.J. Jones, pers. comm.).

Bivalves	Undescribed forms	Blina Shale facies ?IVa at N22 and M51 (Casey & Wells, 1964) and facies III at Telegram Dam Bore (Crespin, pers. comm), as Anomia sp, with fish teeth and conchostrachans.	Shallow marine to tidal flat from facies association. Estuarine (Crespin, pers.comm.)
	cf pseudomonotis sp	Blina Shale in Mt Bannerman Sheet area (Veevers & Wells, 1961), probably facies IVa.	Oyster-like habit with one valve cemented to substrate. Shallow marine to tidal flat from facies association.
Conchostracans	Czycus spp (as Isaura and Estheria)	Facies II, III and IVa of Blina Shale (Veevers & Wells, 1961; MacKenzie, 1961; Casey & Wells, 1964; and facies V in Keraudren Beds from Keraudren 1.	Fresh to brackish water (Tasch, 1973). Probably lived on semi-emergent tidal flats in brackish pools and freshwater channels, washed into the marine environment by periodic flooding (Cockbain, 1974). May be so abundant as to form coquinas. Associated with Lingula at Erskine Range (MacKenzie, 1961), bivalves at M51 (Casey & Wells, 1964) and immediately below Diplocraterion at M52 (Casey, pers. comm.).
Insects	Undescribed	Blina Shale in White Rocks area, (Wade, 1936) possibly from facies III or IVa, from isopach data.	Associated with plant fossils (Wade, 1936).
Fish	Palaeoniscidae		
	?Myriolepis sp ?Apatolepis sp	Blina Shale at Wongil Ridge (Brunnschweiler, 1954) either from facies III or IVa.	Freshwater fishes (Romer, 1966).
	Indeterminate scales	Blina Shale facies II in Langoora 1.	Freshwater fishes (Romer, 1966).
	Catopteridae		
	?Brookvalia sp	Blina Shale at Wongil Ridge (Brunnschweiler, 1954) either facies III or IVa.	Unknown
	Sauricthyidae		
	Sauricthys sp	Blina Shale (Cosgriff, 1965) probably facies IVa.	?Marine

	Shark teeth	Blina Shale (Cosgriff, 1965) probably facies IVa.	Generally marine, although Romer (1966) noted - that pleurocanth sharks occur in Australian Triassic freshwater deposits.
	Indeterminate coalacanth	Blina Shale (Cosgriff, 1965) probably facies IVa.	Near-shore or shallow marine (Thomson, 1969).
	Indeterminate actinopterygians	Blina Shale (Cosgriff, 1965) probably facies IVa.	Marine or freshwater (Romer, 1966).
	Indeterminate teeth, scales, plates	Blina Shale facies III or IVa at Telegram Dam Bore (Crespin, pers. comm.), facies II and III in Meda 1 (P.J. Jones, pers. comm.) Blackstone 1 and Langoora 1 and facies II in Mimosa 1, facies V of Keraudren Beds in Keraudren 1.	Associated with conodonts and conchostracans and in facies associations suggesting both marine and non-marine forms present.
	Ceratodnotidae *Ceratodus* sp	Blina Shale (Cosgriff, 1965) from facies IVa.	Inhabited watercourses in arid regions (Romer, 1966), probably with a temperature range of 11-31 °C (Shaeffer, 1969). Probably washed into marine environment after death upstream in non-perennial streams.
Amphibians	Temnospondyls		
	Blinasaurus henwoodi	Blina Shale (Cosgriff, 1969) probably from facies IVa.	Inhabited streams where it was active benthonic predator (Cosgriff, 1974).
	Deltasaurus kimberleyensis	Blina Shale (Cosgriff, 1965) probably from facies IVa.	Active piscatorial swimmer in distributaries lakes and ponds in deltaic regions (Cosgriff, 1974).
	Trematosaurids		
	Erythrobatrachus noonkanbahensis	Blina Shale (Cosgriff & Garbutt, 1972) probably from facies IVa, 3-5 m from top of Blina Shale.	Marine, piscatorial (Romer, 1966).

	Undescribed trematosaurids	Blina Shale (Cosgriff & Garbutt, 1972) probably from facies IVa, 3-5 m from top of Blina Shale.	Marine piscatorial (Romer, 1966).
Reptiles	Undescribed ?Icthyosaur	3-5 m from the top of the Blina Shale (Cosgriff & Garbutt, 1972) probably from facies IVa	Marine (Romer, 1966).
	Undescribed ?thecodont	Blina Shale (Warren, 1972) probably from facies IVa	Terrestrial (Romer, 1966).
	Capitosaurs	Blina Shale (Warren, 1972) probably from facies IVa	? crocodile-like habit (Warren, 1972).
	Undescribed vertebrates	Lake Jones area (A.N. Yeates, pers. comm.) probably from facies IVa from lithology and stratigraphic position.	Associated with coprolites and mud-cracks (A.N. Yeates., per. comm.), shallow marine tidal flat deposit.
Trace Fossils			
	<u>Diplocraterion</u> sp	Blina Shale at Erskine Range from facies III and IVa and in the south eastern area (Yeates et al., 1976).	Subtidal shallow marine (Sellwood, 1970).
	<u>Rhizocorralium</u> sp	Erskine Sandstone at C23 Bishops Range (Casey & Wells, 1960; Yeates et al., 1976 Veevers, 1962) in facies IVb.	Generally regarded as a tidal flat indicator.
	<u>?Chondrites</u> sp	Blina Shale (J. Gilbert-Tomlinson, pers. comm.) probably in facies IVa,	Deep marine (Seilacher, 1967) but note identification is tentative.
	<u>?Thalassinoides</u> sp	Blina Shale (J. Gilbert-Tomlinson, pers. comm.) probably in facies IVa.	? crustacean burrow, tidal flats.

APPENDIX 2 : PART 2 - FLORA AND ENVIRONMENTAL SIGNIFICANCE

FOSSIL GROUP	SPECIES	FACIES AND LOCALITY	ENVIRONMENTAL SIGNIFICANCE
Coniferaleans	Brachyphyllum crassum	Siltstone and sandstone facies (IVa) of Blina Shale (White & Yeates, 1976) at M38.	With cone scales, Equisetum and rootlets
	Araucarites sp	In siltstone and sandstone, facies IVa) of Blina Shale at M15 (White, 1961), Erskine Sandstone at L35, M24, M38 and L331, A13, A93 L100 (White & Yeates, 1976) and Culvida Sandstone at C02107 (White & Yeates, 1976).	At M15 with abundant conchostracans, may have occupied higher ground than vegetation around sea level.
	Araucarian core scales	Facies IVa and Blina Shale at L331, A13, A93, A100, M38, M15 (White & Yeates, 1976), Erskine Sandstone at L35 and Culvida Sandstone at Co 2107.	
	Guthoerlisporites cancellosus	Blina Shale Facies II (Sidewall core at 105 m, Mimosa 1,(Dolby, 1973), Keraudren Beds Facies V and III (Ingram, 1974).	Gymnosperm pollen of early Voltziacean conifer (Staplin et al., 1967).
	Leuckisporites spp	Blina Shale Facies III (Cuttings between 73 and 186 m in Meda 1, Balme 1958) Erskine Sandstone of Derby Town Bore (82-186.5 m, Balme, 1956) and Blina Shale (?Facies IVa) of Derby Town and Bakers Bore (Balme, 1956).	?Voltziacean conifer (Staplin et al., 1967).
	Pityosporites sp	4A Beds in BMR Wallal 4A (Core 6, Balme, 1963b) Facies II.	Bisaccate pollen of coniferalean affinites (Cahloner, 1969) possibly identical with Alisporites.
	Samaropollenites peciosus	Bedout Beds at 2908 - 2911 in Bedout 1 (BOC, 1971) Facies III and IVb; Keraudren Beds Facies III (Ingram, 1974).	Coniferalean or pteridosperm (E.M. Truswell, pers. comm.).
	Taeniaesporites cf noviaulensis	Erskine Sandstone (Facies -IVb) at Erskine Hill (Balme, 1963) and Facies IVa of Blina Shale; Keraudren Beds Facies III (Ingram, 1974), Bedout Beds Facies I.	Gymnosperm pollen from Rissikia - type conifers (Townrow, 1967a) of coastal plant communities (Balme & Helby, 1973), the sudden increase in T. sp in the flora may indicate increasing aridity (Balme, 1963a).

Appendix 2: Part 2 - Flora (contd)

FOSSIL GROUP	SPECIES	FACIES AND LOCALITY	ENVIRONMENTAL SIGNIFICANCE
Coniferaleans continued	Striatites cf T. antiquus	Blina Shale (Facies IVa?) probably from Derby Town, Myalls and Bakers Bores (Balme, 1963).	Associated with Voltziopsis wolganensis in New South Wales (Townrow, 1967b).
	T. obex	Blina Shale (Facies IVa) probably from Derby Town, Myalls, and Bakers Bores (Balme, 1963).	Coniferalean, possibly from Rissikia-type plants.
	Chordasporites australiensis	Keraudren Beds Facies III (Ingram, 1974).	Possibly like Leuckisporites (Chaloner, 1969).
	Protohoploxypinus spp	Blina Shale (Facies II) in core 3 BMR Lucas 13 and at 105 m in Mimosa 1 (Dolby, 1973); Keraudren Beds Facies V, III:	Gymnosperm pollen. P. samoilovichi similar to pollen from Rissikia-type cones (Townrow, 1967a).
Ferns	?Phlebopteris alethopteroides	Culvida Sandstone at Culvida Soak (White & Yeates, 1976), Facies I.	Pteridophytic fern.
	Otozamites sp	Erskine Sandstone (Brunnschweiler, 1954), ?Facies I or IVb.	Probably a misidentification or from Jurassic rocks.
	Gleichenites sp	Erskine Sandstone (Brunnschweiler, 1954), ?Facies I or IVb.	One of the two dominant plants, but probably a misidentification.
	Cladophlebis australia	Crossbedded sandstone facies of Millyit Sandstone at M29 (D. Hill, pers. comm.), Facies I.	Possibly a misidentification, may be ?Yabiella sp, associated with conchostraca equisetaleans and Dicroidium (as Thinnfeldia cf lancifolia, D. Hill). May represent Osmundacean ferns (Andrews, 1961 Cladophlebis-like fronds also bourne by Lepidopteris sp (Townrow, 1966).
	?Yabiella sp	Millyit Sandstone at C31 (White, 1961), Facies I.	Fern, probably equivalent to ?Cladophlebis of Hill (1956) but more probably the leaf of Fraxinopsis and thus an early conifer (Retallack, pers. comm.).

Appendix 2: Part 2 – Flora (contd)

FOSSIL GROUP	SPECIES	FACIES AND LOCALITY	ENVIRONMENTAL SIGNIFICANCE
Ferns continued	Taeniaeopteris sp	Culvida Sandstone at C8, probably similar stratigraphical position as C62 (Facies I).	Foliage of several fern groups including marattiaceans (Andrews, 1961). Note that some marattiacean spores present more likely to be a cycadophyle (Retallack, pers. comm.).
	Osmundacidites senectus	Facies II of Blina Shale at 105 m in Mimosa 1 (Dolby, 1973), Blina Shale (Balme, 1963a) and Erskine Sandstone (Balme, 1963a).	Spores of Osmundacean ferns (Chaloner, 1969).
	Osmundacidites spp	Culvida Sandstone (Facies I) from Core 1 in BMR Cornish 2 (Paten & Price, 1976).	Osmundacean ferns (Cahloner, 1969).
	Osmundacidites wellmani	Bedout Beds Facies IVb.	
	Dictyophyllidites mortoni	Facies II of Blina Shale at 105 m in Mimosa 1 (Dolby, 1973).	Spores from Dipteridacean ferns (Chaloner, 1969).
	Punctatisporites fungosus	Blina Shale (Balme, 1963a) from Facies III and IVa of Derby Town, Myalls and Bakers Bores.	Fern, possibly of marittalean affinities (Chaloner, 1969) but may be a lycopod (see below).
	Apiculatisporites globosus	Keraudren Beds Facies V (Ingram, 1974).	Fern.
	Verrucosisporites carnavonensis	Keraudren Beds Facies V (Ingram, 1974), Keraudren Beds Facies III.	?Polypodian fern (Chaloner, 1969).
	Calamospora impexa	Keraudren Beds Facies V (Ingram, 1974), Keraudren Beds Facies III.	?Sphenopsid (Chaloner, 1969).
	Cyclogranisporites arenosus	Keraudren Beds Facies III (Ingram, 1974), Bedout Beds Facies IVb.	Fern of ?marattitalean type (Potonié, 1975).
	C. congestus	Bedout Beds Facies IVb.	Fern of ?marattitalean type (Potonié, 197
	Annulispora sp	Bedout Beds Facies IVb.	Matoniacean fern of Phlebopteris-type.

Appendix 2: Part 2 - Flora (contd)

FOSSIL GROUP	SPECIES	FACIES AND LOCALITY	ENVIRONMENTAL SIGNIFICANCE
Ferns continued	Polypodites ipswiciensis	Bedout Beds Facies IVb	Polypodian fern (Chaloner, 1969).
	Baculatisporites comauensis	Bedout Beds Facies IVb.	Polypodian fern (Chaloner, 1969).
	Punctatosporites walkomi	Bedout Beds.	May represent sphenopsids (Bharadwaj, 1966).
Glossopterids	Glossopteris indica G. angustifolia G. ampla G. longicaulis	Crossbedded sandstone facies of Millyit sandstone (at CR1185, CR1187 and 7.5 km west of Micha Bore - White & Yeates, 1976), Millyit Sandstone at Gordon Hills (L11 - White, 1961), and Erskine Sandstone at M24 (White, 1961), L330 and L331 (White & Yeates, 1976) and at Erskine Range (White, 1958).	Glossopteris suggests a more temperate climate, lacking cold adapted Gangamopteri (Surange, 1975). These forms are all long-ranging and presumably had a wide environmental tolerance. Plumstead (1958) suggested that glossopterids were deciduous, this may indicate seasonal climate.
	Vertebraria indica	Crossbedded sandstone facies of Millyit Sandstone at CR1187 (White & Yeates, 1976), Erskine Sandstone (Facies IVb) at L331 and at Pt. Alphonse	Gould (1975) advanced evidence that Vertebraria was the rhizome of Araucarioxylon arberi which probably bore Glossopteris leaves and that the plant was possibly adaopted to a semi-aquatic environment. At M22 V. sp is associated with equisetaleans, strengthening the above argument.
Equisetaleans	Equisetum sp	Crossbedded sandstone facies of Millyit Sandstone at C31, M29 (Facies I). Upper siltstone and sandstone facies of Blina Shale (Facies IVa). Interbedded siltstone and sandstone facies of Erskine Sandstone at L35, M24 (White, 1961), Facies IVb. Culvida Sandstone at CO2081, CO2107, (White	Hydrophytic plants (Batten, 1974) which probably grew in all delta environments and near-shore shallow marine areas with freshwater dilution.

Appendix 2 : Part 2 - Flora (cont)

FOSSIL GROUP	SPECIES	FACIES AND LOCALITY	ENVIRONMENTAL SIGNIFICANCE
Equisetaleans continued	Schizoneura sp	In Culvida Sandstone at C1 (White & Yeates 1961) and in Erskine Sandstone (Brunnschweiler, 1954), Facies ?IVa and ?IVb as ? S. sp	Pteridophytic plants which grey in wet, swamp areas (Plumstead, 1973).
	?S. gondwanensis	In Erskine Sandstone, probably the interbedded siltstone and sandstone facies, at Erskine Range (White, 1958), Facies IVb.	
	Phyllotheca? sp	Millyit Sandstone at L10 (White, 1961), Facies I.	Associated with (?=Thinnfeldia caliperoides) and Equisetum, may be a misidentification of Equisetum.
Ginkgophytes	Ginkgoites sp	Erskine Sandstone at A100 (White & Yeates, 1976), Culvida Sandstone at C62 and Culvida Soak (White, 1961), all Facies I.	Tertiary and Recent ginkgoes inhabited temperate environments (Penny, 1969) in upland areas. The presence of these forms in the Triassic indicates continental environments.
	Baeria sp	Culvida Sandstone at C62 (White, 1961), Facies I.	
Cycadopsids	Eury-cycadolepis sp	Millyit Sandstone at M29 (White, 1961), Facies I.	
	Cycadolepis sp	Facies I of Erskine Sandstone at A92 (White & Yeates, 1976) and Millyit Sandstone at M29 (White, 1961), in the conifer pollen and seed.	Gymnosperm pollen, similar to that derived from several groups including ginkgoaleans and cycads.
	Cycadopites sp	Facies II of Blina Shale in Mimosa 1 (Dolby, 1973).	
Corystosperms	Dicroidium spp D. elongatum D. lancifolium I. fiestmantelli ?Sphenopteris superba	Facies I of Millyit Sandstone at M29 and M31 (White, 1960; 1961); Millyit Sandstone at C02102b and C02017 (White & Yeates, 1976) and M29 and C31 (White, 1961), Culvida Sandstone at Culvida Soak, C8, C62, C02076 (White, 1961; White & Yeates, 1976; Retallack, 1974).	Probably formed a healthy flora on raised ground above the equisetalean dominated swamp flora (Retallack, 1976). At M29, M31 with Equisetum, ?Yabiella (=?Cladophlebis reported by Hill, 1956, letter on file), Lepidopteris stormbergensis, Cycadolepis, Eury-cycadolepis, and glossopterids. (White 1960; 1961; White & Yeates, 1976). In Culvida Sandstone with L. madagascarensis, Ginkgoites sp and indeterminate plants (Retallack, 1974).

Appendix 2 : Part 2 – Flora (contd)

FOSSIL GROUP	SPECIES	FACIES AND LOCALITY	ENVIRONMENTAL SIGNIFICANCE
Corystosperms continued	Dicroidium acuta	At 100 m in Erskine Sandstone of Myalls Bore (Antevs, 1913), probably in Facies I.	= D. Zuberi (Retallack et al., 1977).
	"Danaeopsis" hughesi (=?Dicroidum narrabeenensis)		
	Pteruchus barraelensis	Culvida Sandstone at C62 (Retallack, 1974, Facies I.	Fructification of Dicroidium.
	Linguifolium sp	Culvida Sandstone at C62 (White, 1961), Facies I.	Leaves of Dicroidium.
	L. Denmeadi	Culvida Sandstone at C62 (White, 1961), Facies I.	
	Falcisporites spp	Facies II and III of Blina Shale (Cores 1, 3, BMR Lucas 13, Paten & Price, 1976). Culvida Sandstone (Facies I) in BMR Cornish 2 (Core 1, Paten & Price, 1976); Erskine Sandstone in Derby Town and Myalls Bores (Balme, 1965); Keraudren Beds Facies V, I, III: Bedout Beds Facies IVb and III.	Pollen of Dicroidium complex, possibly Rienitzia or Xylopteris-like plants (Douglas, 1969) which may have bourne Pteruchus-like fertile organs.
	Alisporites cf parvus	Bedout Beds Facies III.	Dicroidium pollen (Chaloner, 1969; Surange, 1975). Note Townrow (1962) placed A. parvu… with coniferaleans.
Lycopodians	Isoetites elegans	Blina Shale in Derby Town Bore (Teichert, 1950), possibly Facies III or IVa.	Small hydrophytic lycopod, herbaceous, spores dispersed by water. Recent Isoetes lives totally submerged in freshwater. Probably lived in fresh to brackish pools.
	Pleuromeia sp	Erskine Sandstone at Yarrada Hill (Foord, 1890; 1890; Brunnschweiler, 1957; Retallack, 1975), Facies IVb.	Occupied monotypic stands along the shore face and shallow tidal flats (Retallack, 1975).
	Cylostrobus sp	Erskine Sandstone at Yarrada Hill (Foord, 1890; Brunnschweiler, 1957; Retallack, 1975),Facies IVb	Floating seed of Pleuromeia with Aratrisporites microspores (Retallack, 197…
	Pleuromeid chizome	Erskine Sandstone at A100, M37 (White & Yeates, 1976).	

Appendix 2 : Part 2 - Flora (contd)

FOSSIL GROUP	SPECIES	FACIES AND LOCALITY	ENVIRONMENTAL SIGNIFICANCE
Lycopodians (continued)	Lycopodiopsis pedroanus	In Erskine Sandstone at Erskine Range, probably Facies IV, recorded as cf Lycopodiopsis pedroanus (White, 1958) and Erskine Sandstone at M24, M37 (White, 1961), L331 L329, L1002, L1001A, B, A93, A101, A100 and M2030 (White & Yeates, 1976), probably all Facies IVa.	At erskine Range with badly preserved Glossopteris leaves and of Schizoneura gondwanensis (White, 1958). Probably a misidentification of Pleuromeia habitat as above, an opportunistic species which colonized the sere resulting from regression of sea (Retallack, 1975; Balme & Helby, 1973).
	Aratrisporites spp	Rare in Blina Shale, Facies III (Core 1 BMR Lucas 13 (Paten & Price, 1976). Culvida Sandstone (basal) in Core 1, BMR Cornish 2, Facies I or IVa; Blina Shale (Facies IVa) core 3, BMR Cornish 2. Erskine Sandstone (probably facies IVb) in Derby Town and Myalls Bores (Balme, 1969); Keraudren Beds Facies V, III, I: Bedout Beds Facies IVb and I (possibly caving from cuttings).	Microspore of Cylostrobus (Retallack, 1975) or other lycopod (Retallack, 1977 pers. comm.).
	Punctatisporites spp	Rare in core 6 from BMR Wallal 4A, Facies II, 4A Beds (Balme, 1963b).	Potonie & Kremp (1954) found P. sp in fructifications of pleuromeid lycopods. Balme (1963b) records these forms as zonate they are presumably thin lycopodian (Chaloner, 1969).
Selaginellitid lycopods	Lunbladispora sp	Facies II of Blina Shale from 105 m in Mimosa 1 (Dolby, 1973).	Selaginellitid lycopod or pteriodophyte.
	Kraeusellisporites spp	Facies II of Blina Shale in Mimosa 1 at 105 m (Dolby, 1973). BMR Cornish 2 (Core 3), Facies IVa of Blina Shale.	Salaginellitid lycopod (Dettman, 1963).
	Deusoisporites spp	Blina Shale (Facies IVa) in BMR Cornish 2.	Selaginellitid lycopods (Dettman, 1963). In northern hemosphere (Habib & Groth, 1967 abundant in transgressive phase but abruptly replaced by other lycopods in regressive phase.

Appendix 2 : Part 2 - Flora (contd)

FOSSIL GROUP	SPECIES	FACIES AND LOCALITY	ENVIRONMENTAL SIGNIFICANCE
Selaginellitid lycopods	D. playfordi	Facies II Blina Shale from 105 m in Mimosa 1 (Dolby, 1973).	Selaginellitid lycopod.
	cf Cirratriradites sp	Rare in core 6, BMR Wallal 4A, 4A Beds	A genus associated with herbaceous, selaginellitid lycopods (Cahloner, 1954) may be either Densoisporites or Kraeusellisporites.
Acritarchs	Micrhrystridium fragile	Facies II of Blina Shale, sidewall core at 105 m, Mimosa 1 (Dolby, 1973).	Nearshore, shallow marine forms in transitional environments, Sarjeant (1974); Paralic (Wall, 1971); Lagoonal (Balme, 195
	M. exilium	Facies II of Blina Shale, sidewall core at 105 m, Mimosa 1 (Dolby, 1973).	
	M. stellatum	Facies II of Blina Shale, sidewall core at 105 m, Mimosa 1 (Dolby, 1973).	Balme & Dolby (1976) interpret 'swarms' of acritarchs as indicative of immature marine ecosystems.
	M. setasessitante	Facies III of Bedout Beds, BEDOUT 1 (Wall, 1971).	
	M. multispinum	Facies III of Bedout Beds, BEDOUT 1 (Wall,1971).	
	M. lymensis var rigidum	Facies III of Bedout Beds, BEDOUT 1 (Wall,1971).	
	M. cf fragile	Facies III of Bedout Beds, BEDOUT 1 (Wall,1971).	
	Veryhachium reductum	Facies II of Blina Shale, sidewall core at 105 m, Mimosa 1 (Dolby, 1973), and interbedded sandstone and claystone facies of Bedout Beds, BEDOUT 1 (Wall, 1971), Facies III.	
	V. riburgensis	Facies II of Blina Shale, sidewall core at 105 m, Mimosa 1 (Dolby, 1973) and Keraudren Beds Facies III.	
	Hystrichosphaeridium spp (spinose, smooth and sekose forms)	4A Beds in BMR Wallal 4A (Balme, 1963b), Facies II.	
	Palaeotetradinium hyalodernum	4A Beds in BMR Wallal 4A (Balme, 1963b), Facies II.	

Appendix 2 : Part 2 - Flora (contd)

FOSSIL GROUP	SPECIES	FACIES AND LOCALITY	ENVIRONMENT SIGNIFICANCE
Acritarchs continued	P. cf Hyalodernum	Blina Shale in Bakers Bore and Derby Town Bore (Balme, 1956), probably Facies III.	
	Undescribed hystricosphaerids	Blina Shale in Bakers Bore and Derby Town Bore (Balme, 1956), probably Facies III.	
	Undescribed acritarchs	Keraudren Beds at 2810-3565 m in Keraudren 1 (Ingram, 1974), Facies III.	
	Leiosphaerida sp	Facies II of Blina Shale, sidewall core at 105 m, Mimosa 1 (Dolby, 1973).	
	Undescribed spinose acritarchs	Blina Shale, Cores 1, 2, 3 of BMR Lucas 13 (Paten & Price, 1973), Facies II, III; and Facies III, Keraudren Beds.	
Peltasperms	Lepidopteris stormbergensis	Millyit Sandstone at M29 (White, 1961; White & Yeates, 1976) Facies I	Low waterside herb (Townrow, 1960).