Triassic environments in the Canning Basin, Western Australia

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A review of the lithology, sedimentary structures and palaeontology, supplemented by original investigations, suggests that the Triassic system in the Canning Basin can be subdivided into four broad environmental episodes. The sequence records a slow transgression culminating in the Smithian, when the riverine plain in the southeastern Fitzroy Graben was drowned. The resulting shallow embayment in the Fitzroy Graben supported a much impoverished marine biota, made up of species tolerant of reduced saline conditions caused by substantial run-off of fresh water from surrounding streams. A regression began in the Spathian and continued throughout the later Triassic, although there were minor transgressions with marine incursions: the environment evolved into a low-relief coastal alluvial plain, with meandering streams and lakes. A general trend to increasing aridity is evident, with an increase red beds, and is correlated with the withdrawal of the Blina Sea. Finally in Ladinian time the region became an area of non-deposition and remained so until the early Jurassic.

Introduction

Triassic rocks in the Canning Basin (Fig. 1) have been described by Veevers & Wells (1961), McKenzie (1961), and Yeates and others (1975), and divided into four named onshore formations, and their unnamed offshore equivalents. Available interpretations of the depositional environment of the Canning Basin Triassic rocks are based only on the contained fauna and flora, or on lithological studies of small areas. This study integrates all known palaeontological, lithological and geochemical properties of the rocks into an assessment of the depositional environments of the Basin during the Triassic. The rocks are regarded as a genetically related sequence, and to represent an extended environmental episode.

Previously published information has been supplemented by examination of cores and cuttings, interpretation of subsidised logs of petroleum exploration wells, and subsidised seismic data. This information is assembled fully elewhere (Gorter, in prep.); this paper represents a synthesis drawn from that data.

Stratigraphy

Four formations have been formally defined in the onshore Canning Basin (Fig. 2). They are discussed fully by Veevers & Wells (1961), Yeates and others (1975), and Gorter (in prep.). None of the offshore units have been formalised and are here referred to as 'Beds', generally named after the well in which they were first penetrated.

Facies and environmental significance

It proved possible to distinguish five broad depositional environments in terms of facies. A facies is considered to denote the sedimentary record of an environment, or group of closely related environments. Facies were 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 diagrammatic lithological section (Fig. 3). Log analyses, especially the gamma-ray curve, aided determination of sedimentary succession. Named formations were broken down into facies groups, and all lithological parameters are listed along with the suggested environment of deposition and, broadly, the fossil content.

Facies I—Fluviatile

This facies is characterised by high-angle cross-bedding, dominance of sandstone, 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 and Culdiva Sandstone (Yeates and others, 1975), the Bedout Beds (2938 m to 2997 m from the gamma-ray curve). Finer clastics usually top the upward-fining sequences and are interpreted as overbank deposits (Allen, 1965).

Facies II—Transgressive

This facies is also characterised by a general fining upward sequence, however high-angle cross-bedding is absent, and glauconite and marine fossils (acritarchs and lingulids) are present. The facies is recognised in the basal Blina Shale (e.g. Blackstone No. 1, Meda No. 1, Langoora No. 1, BMR Lucas No. 13), and the 4A Beds in BMR Wallal No. 4A. The content of coarse clastics decrease upwards, and megaspores (in Blackstone No. 1, and Meda No. 1 (P. J. Jones, pers. comm.)) become scarcer.

Facies III—Marine

The marine facies is characterised by common marine fossils, a preponderance of laminated green and grey siltstone, claystone or shale, sandstone stringers, and glauconite. In Blackstone No. 1 this facies contains abundant foraminifera with conodonts. The facies is recognised in the Blina Shale (Blackstone No. 1, Langoora No. 1, Meda No. 1), lowermost Bedout Beds (Bedout No. 1, 2997 m to 3020 m) and Keraudren Beds (3124-3630 m in Keraudren No. 1). The marine facies grades downwards into the transgressive facies in all known sections, except at Bedout No. 1 where it directly overlies weathered Upper Permian basalt (BOC, 1971). Probably the Bedout High (Fig. 1) was inundated late in the transgression when coarser clastic deposits were not available from any nearby source area.

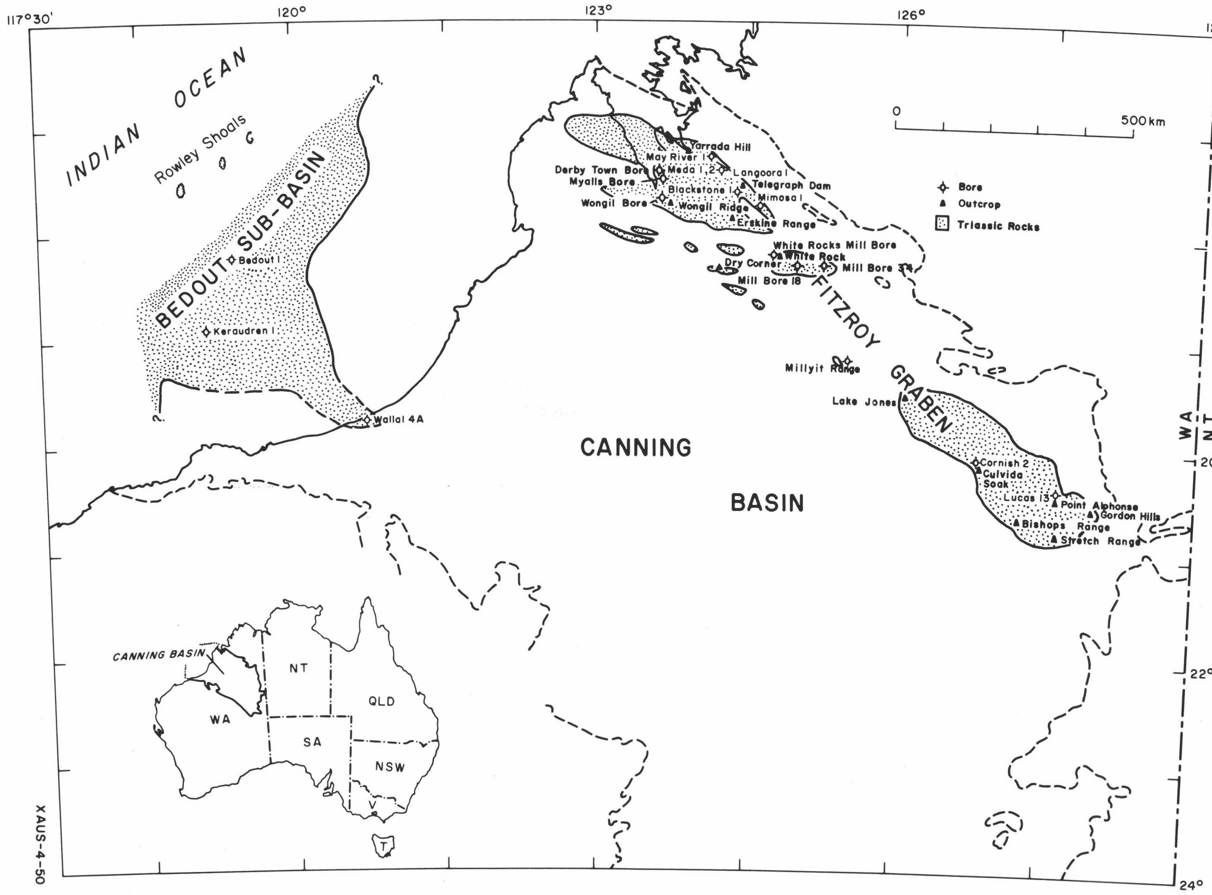

Figure 1. Locality map, showing known limit of preserved Triassic rocks.

Facies IV—Regressive

The major characteristics of this facies is a coarsening upwards trend, coupled with a decrease of marine fossils and an increase in land plants. The vertical sequence may terminate in two distinct sub-facies: regression may be accomplished by coastal aggradation (Sykes, 1974; 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 the upper part of the Blina Shale (e.g. at Erskine Hill (McKenzie, 1961)) and the lower Bedout Beds (Bedout No. 1 from 2911 to 2938 m), and deltaic channels (Facies IVb) by upward-coarsening sandstones (2960-3124 m in Keraudren No. 1).

The regressive sequences at the top of the Blina Shale are notable for the lack of massive sandstone bodies. This absence is 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 under 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 cross-bedded sandstone (McKenzie, 1961) may represent a prograding distributary of a deltaic system advancing over the upper Blina Shale. The lithological association is similar to that of estuarine sands (Land, 1972), except for the lack of marine shelly fossils. Prograding distributary sands are also interpreted in the Keraudren Beds (between 2960-3124 m in Keraudren No. 1 from the gamma-ray curve pattern), and the upper Bedout Beds 2911 m to 2938 m in Bedout No. 1). These progradational sand bodies are included in Facies IVb, and always overlie Facies III with basal scour. In the Fitzroy Graben IVb always gives way to Facies I, but at Keraudren No. 1, it is overlain by a possible lacustrinal facies (Facies V).

Facies V—Lacustrinal

This facies is recognised only at Keraudren No. 1 (2801-2960 m and 2460-2568 m), and is characterised by thin-bedded and laminated claystone, and minor sandstone. It may also contain calcilutite (2825-2864 m in Keraudren No. 1). No marine fossils are present, but spores and pollen (Ingram, 1974), and coal, may occur. The claystones are multi-coloured, 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.

Pickard & High (1972) state that deposits bounded either by fluviatile units, as at Keraudren No. 1, or unconformities, and the presence of a non-marine fauna in sediments that could be ascribed either to a marine or lacustrinal origin, is suggestive of lacustrine deposition. A similar stratigraphic position between continental deposits was also stated to be characteristic of lacustrine deposits by Greiner (1974). The common presence of iron sulphides, and siliceous and calcitic cements (Hematite, 1974) also suggests lacustrine sediments (Picard & High, 1972).

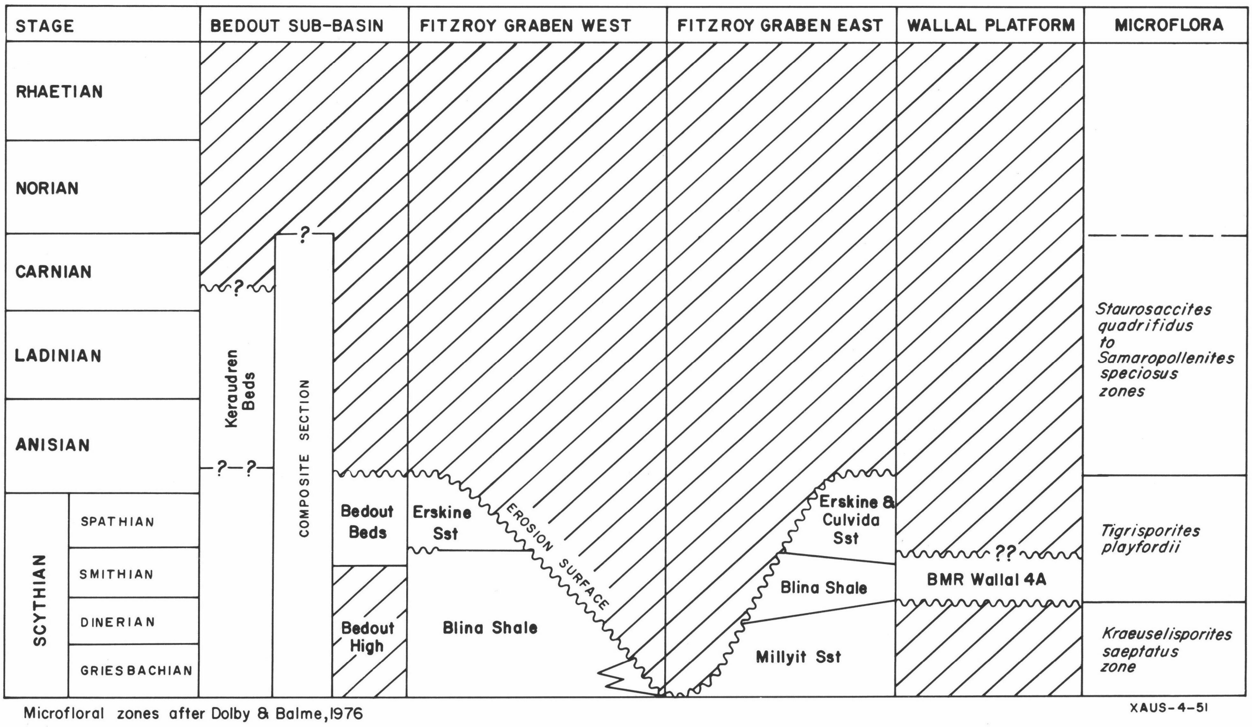

Figure 2. Age and correlation of Triassic rocks in the Canning Basin.

Biofacies

An extensive literature search for the environmental tolerances of each element of the flora and fauna preserved within the Triassic rocks of the Canning Basin (autecology of Ager, 1963; Gorter, in prep., 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 (Table 1). Each biofacies is considered in the light of the significant contained fossils—fossils whose ecological limits are reasonably well known—and is then used to reconstruct a picture of the Triassic environmental succession.

Palaeogeography

Four palaeogeographic maps (Fig. 4a-d) were drawn to illustrate the environmental changes through the Triassic, and depict the interpreted distribution of the major depositional environments at a given point in time.

The Fitzroy Embayment (Griesbachian to Dienerian)

At the commencement of the Triassic the seas transgressed the basin. The full extent of this transgression is unknown because of subsequent erosion, but seismic data suggest that the Fitzroy Graben and Bedout Sub-basin were flooded. The beginning of the transgression (Fig. 4a) is marked in the onshore basin by fine-grained sandstone and siltstone (basal Blina Shale) which often contain glauconite and numerous acritarchs. In the northwestern Fitzroy Graben the 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 sediments (Millyit Sandstone) 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 also occupied the Bedout Sub-basin, but probably did not inundate elevated areas such as the Bedout High (Fig. 4a).

Facies I rocks are represented by the Millyit Sandstone, which was deposited in meandering rivers. The riverine plain supported a flora of ferns, equisetaleans, cycads, glossopterids, conifers and peltasperms (Paten & Price, 1975; White & Yeates, 1976) and rare *Dicroidium* sp. G. J. Retallack (personal communication) has suggested that some of the fossils identified as *Dicroidium* may be misidentifications of the basal Triassic plant *'Thinnfeldia' callipteroides* or similar plants (Townrow, 1966).

Facies II is represented by the basal Blina Shale and the 4A Beds; little is known of the palaeontology of the latter unit. However, both units contain acritarchs characterised by forms which indicate shallow marine, nearshore environments (Sarjeant, 1974). These acritarchs occur in great numbers: such swarms are interpreted by Dolby & Balme (1976) to indicate 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 (Tasch, 1975), further emphasises the transitional nature of the facies.

The poorly diversified microfloral assemblage (*Kraeueselisporites saeptatus* zone of Dolby & Balme, 1976) represents plants that grew in a specialised coastal environment (Balme, 1969a), which Dolby & Balme (1976) suggest developed following the early Triassic transgression of an older peneplained surface. The broad tidal flats formed were colonised 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.

BIOTA	Facies I	Facies II	Facies III	Facies IVa	Facies IVb	Facies V
Ammonoids						
Conodonts			x			
Forams			x			
Bryzoa			x			
Acritarchs		x	x			
Lingulids		x	x	x		
Bivalves				x		
Gastropods						x
Fish	?	x	x	m/f		x
Amphibians			?	m/f		
Reptiles			?	m/f		
Conchostraca		x	x	x		x
Pleuromids	1		x	x		x
Equisetaleans	?	?	?	x	x	?
Seleginellids		x	x	x		
Peltasperms	x					
Ferns	x	x	x		x	x
Cycads	x	x				x
Corystosperms	2	x	x		?	x
Coniferales	x	x	x	x	x	x

x—present; ?—probably present; m/f—marine and freshwater forms present; 1—caving suspected in cutting samples in Bedout 1; 2—recorded from top of the Millyit Sandstone.

Table 1. Check list of fossils recorded from Triassic rocks of the Canning Basin.

The Blina Sea (Smithian)

The major transgressive phase, which began in the early Triassic, culminated in the Smithian Sub-stage, and 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 Fitzroy Graben drowned (Figure 4b).

The marine Facies III is characterised by the presence of forms with wide ecological tolerance. The arenaceous foraminifer *Ammodiscus* is recorded from warm and cold-water deposits (Crespin, 1958), and presumably had wide tolerance. The acritarchs are of the same genera present in Facies II, while 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 eastern rivers. Seasonal flooding of rivers, and the flushing of fresh-water biota (reptiles, amphibians, fish, and plants) into the marine environment (see Cockbain, 1974) could explain the anomalous admixture of marine and fresh-water organisms (Table 1). Hyposalinity of the water is further suggested by the rarity of stenohaline invertebrates and the presence of lingulids indicating the presence of nearby river systems. Connections with the open sea are shown by the presence of marine fish, microplankton, conodonts, and ammonoids. The dominant microplankton are forms which Sarjeant (1974) suggests indicate inshore, partially enclosed environments in an immature ecosystem (Dolby & Balme, 1976). The abundance of U-shaped burrows of *Diplocraterion* is probably indicative of subtidal environments (Sellwood, 1970).

Of the two identifiable conodont genera present, *Neo*hindeodella is euryhaline, while *Neogondolella* was extremely sensitive to increased salinities, but could tolerate slightly brackish water (Kazur, 1972). This ability to inhabit waters with lowered salinity is compatible with the presence of lingulids and conchostracans, especially if the latter were washed into the marine environment by flooding.

The microflora, although inadequately 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, represents the maximum Smithian transgression. Of the plant types represented in the microflora of the Canning Basin, 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 reflecting the vegetation in the immediate vicinity of the marine environment (Chaloner & Muir, 1968).

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

The retreat of the Blina Sea (Spathian to mid-Anisian)

In latest Scythian time the sea receded from the Bedout High, the Wallal Platform and onshore Canning Basin (Fig. 4c). 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 part of the Culvida Sandstone. These transitional deposits are of interest for the plant communities were undergoing ecological change. The lower Scythian *Taeniaesporites* (= *Lunatisporites*) Microflora (Balme, 1964) gave way to the *Falcisporites* Microflora (Helby, 1973) in later Scythian time. The characteristic *Pleuromeia-Cylostrobus-Aratrisporites* assemblage represents an opportunistic group which rapidly colonised the new coastal mud-flat 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, by early Middle Triassic time, a continental climatic regime became established in the Fitzroy Graben.

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* (Potonié, 1970), although not confined to that genus, 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) suggested that *Pleuromeia* was a plant adapted to more desert-like conditions than earlier lycopods. However, Retallack (1975) has suggested that *Pleuromeia* grew in monotypic stands along the waters edge, and also 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 colonised the new ecological

PERIOD/ FORMATION	LITH- OLOGY	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	Kaolintic	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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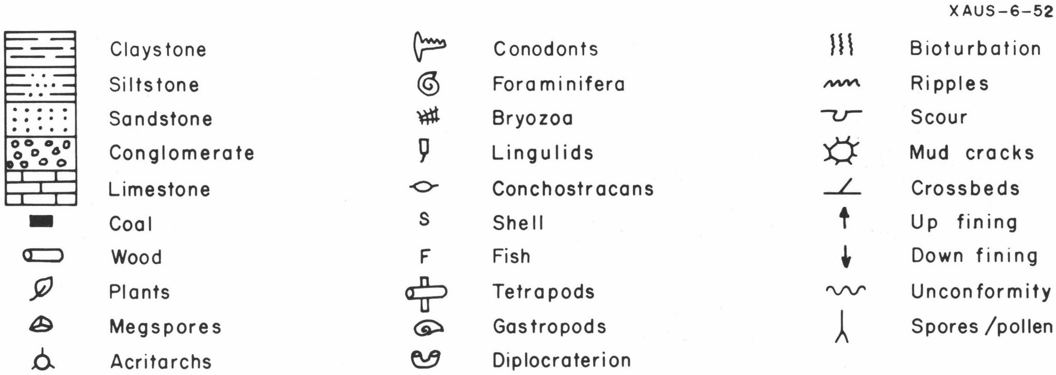

Figure 3. Summary chart of lithology, fossils, sedimentary structures, mineralogy, rock colouration and interpreted sedimentary environments of the Triassic rocks of the Canning Basin.

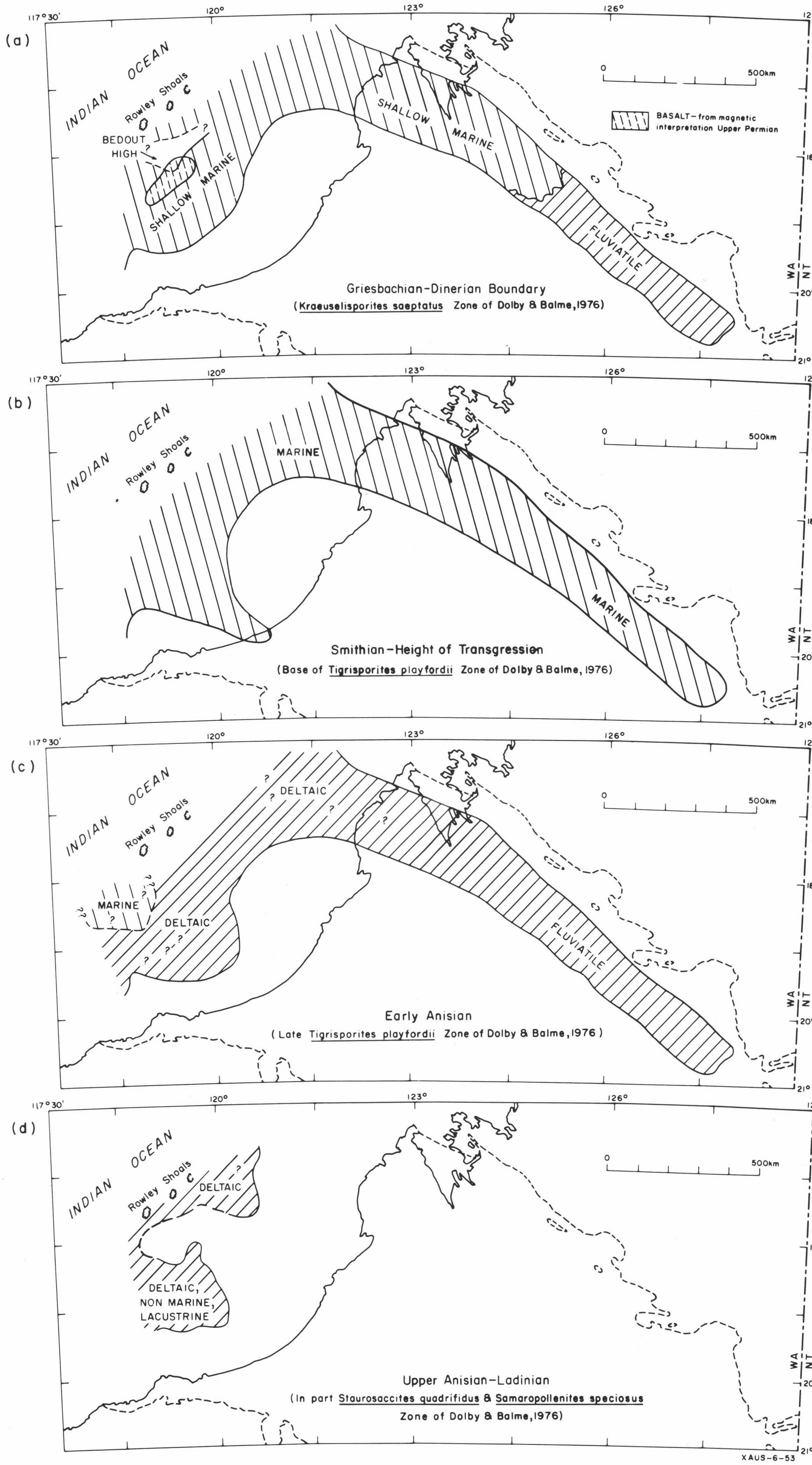

Figure 4. Palaeogeography. A. Griesbachian-Dinerian boundary (*Kraeuselisporites saeptatus* Zone); B. Height of Smithian transgression (base of *Tigrisporites playfordii* Zone); C. Early Anisian (late *Tigrisporites playfordii* Zone); D. Late Anisian-Ladinian (in part *Staurosaccites quadrifidus* and *Samaropollenites speciosus* Zones. Zones from Dolby & Balme, 1976.

niche after the retreat of the sea. Kauffman (1970) noted that environmental crisis associated with regression is often accompanied by rapid changes in environmental parameters, and accelerated evolution at the species level. This is reflected by the rapid diversification of *Aratrisporites* apparent in younger rocks.

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 cryptogram 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 marginal marine 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 environments were intimately associated. Freshwater and marine fish are also present, represented by marine Icthyosaurs and non-marine Capitosaurid reptilians. Marine (*Erythrobatrachus,* Cosgriff & Garbut, 1972) and fluviatile (*Blinasaurus,* Cosgriff, 1969) amphibians (Cosgriff, 1974) are found in this facies, further attesting to the alternating environment. 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 during seasonal periods of high rainfall. The streams probably entered the sea all year round, but high discharge may have caused ephemeral sheet flooding (Cockbain, 1974) of the tidal flats, and dilution of seawater, as suggested by the low diversity of stenohaline forms.

A seasonal climate is also supported by the presence of the lung fish *Ceratodus,* probably with a climatic range of 11-31°C (Shaeffer, 1970), which may have inhabited ephemeral streams away from the coastal area.

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, ?Schizoneura* and coastal lycopods with associated conifers.

The coastal plain (mid-Anisian to Ladinian)

Middle and lower Upper Triassic rocks in the Bedout Sub-basin reflect the marshy and deltaic environment of that time (Fig. 4d). 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 (red beds, dolomite), 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 produced east-west anticlinal structures and north-south faulting (Smith, 1968); and also uplift in the Bedout Sub-basin.

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

In Facies I rocks of the Erskine Sandstone *Dicroidium* and related plants are dominant, ginkgoaleans make their first appearance. Fossils are rare in this facies, probably because of oxidising conditions inherent in a continental environment. Glossopterids are reported (White & Yeates, 1976), but could probably be better assigned to the Triassic plant *Chiropteris* which has similar venation. 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 because of the possibility 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.

Facies IVb is recognised in Keraudren No. 1 between 2960 and 3124 metres. Arenaceous foraminifera occur in several horizons (Hematite, 1974), and bryozoan fragments occur at 2960 metres. Coarsening upwards cycles between 2955 and 3035 metres are interpreted as progradational channels. Claystone above the uppermost 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 No. 1. The sequence above the progradational facies (2960 m) contains a dolomitic calcilutite unit from which conchostracans, fish and gastropods were collected from cutting samples. 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 colonised inland lakes, as in the Russian Moscow Basin (Strok & Gorbatkina, 1977). However, as *Aratrisporites* has recently been isolated from lycopod cones other 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) in the Sydney Basin. As suggested by the contained microflora, the hinterland was vegetated by *Dicroidium* (*Falcisporites*), conifers (*Guthoerlisporites*), ferns, and possibly cycads. The upper deposits in Keraudren No. 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.

Conclusions

From the above description of the sedimentary history of the Triassic succession of the Canning Basin and the contained biota some conclusions of the general history of the area and the effect of the overall transgression-regression on the biota may be drawn.

The sequence records a slow transgression culminating in the Smithian, when the riverine plain in the south-eastern Fitzroy Graben was drowned. The resulting shallow embayment in the Fitzroy Graben supported a much impoverished marine biota, made up of those species which could tolerate reduced saline conditions caused by substantial run-off of fresh water from streams around the shallow sea. A regression began in the Spathian and continued throughout the later Triassic, although there were minor transgressions with marine incursions: the environment changed into a low-relief coastal alluvial plain, with meandering streams and locally developed lakes. A general trend to increasing aridity is also evident, with an increase in red beds, and is correlated with the withdrawal of the Blina Sea. Finally from Ladinian time the area became an area of non-deposition until the early Jurassic.

The major transgressive-regressive cycle is of great interest as it accompanies, or perhaps resulted in, the transition from the early Triassic *'Thinnfeldia' callipteroides* flora to the later Triassic flora, dominated by *Dicroidium,* and the coeval development of a *Pleuromeia* flora in the coastal mud-flat area left by the retreating sea. Aspects of this transition have been touched on by Retallack (1975) in the Sydney Basin, and similar situations are recorded by Kauffman (1970) in North America, and Chaloner & Muir (1968) from Europe. Detailed palynology and macrofloral collections are not yet available from the Triassic rocks of the Fitzroy Graben or Bedout Sub-basin, but what is known supports the concept of floral change in response to climatic fluctuation and the transgressive-regressive cycle. Similar floral transitions can be expected at any major eustatic event (see Gussow, 1976). Further study of this problem and its application is recommended.

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