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CLIMATE OF THE PERMIAN IN AUSTRALIA

PALAEONTOLOGICAL EVIDENCE

by

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ABSTRACT

From the evidence of the marine invertebrate faunas, general changes in water temperature can be reconstructed with some degree of assurance. The reconstruction is based mainly on changes at generic level. With advances in stratigraphic knowledge it may become possible to use changes at the specific level to detect shorter term fluctuations in water temperature.

In Stage A (Sakmarian) time, cold water is indicated all over Australia from about present latitude 20° southwards - by close association of the faunas with glacial deposits, low diversity and genera such as Deltopecten, Eurydesma, Keeneia and Trigonotreta. At the end of this time a eustatic rise in sea level apparently marked the end of the main glacial period. Evidence for this eustatic rise is found also in South Africa, India and South America.

Stage B (Sakmarian to early Artinskian) is marked by an amelioration in climate, but cool temperatures prevailed. The amelioration is particularly distinctive in Western Australia with the entry of many forms with Tethyean relationships. Although some forms such as Eurydesma and Keeneia have not been found at this level in Western Australia, they persist in eastern Australia. Isolation of eastern Australia might be a complicating factor, but the presence of Eurydesma and Keeneia seems to indicate cooler conditions in eastern Australia. The faunas are more diverse and glaciation at sea level is no longer in evidence.

In Stage C and D (Artinskian and Kungurian) time a slow general warming is apparent in Western Australia: Tethyean faunal links are strengthened and the fauna diversified. In eastern Australia the faunas become more diverse. In New South Wales and Tasmania persistently cooler conditions than in Queensland are indicated by the continued occurrence of such forms as Deltopecten, Eurydesma and Keeneia.

In Western Australia no marine faunas are referred to Stage E (early Upper Permian) but in eastern Australia, the trends established earlier persist. In Queensland the close link with Western Australia and Tethyean forms seems to indicate both a northern sea connection and somewhat warmer conditions. Nowhere in Australia up to this time are any truly warm water faunas recognized.

Stage F (late Upper Permian) fauna are known only from Western Australia and can hardly be differentiated from other Tethyean faunas. The presence of Leptodus at the northernmost occurrences of Stage F can be taken to indicate tropical rather than warm temperate conditions.

In the earliest Triassic the fauna from the Geraldton area indicates warm water even further south.

Stage	Formation	No. of Species
C Artinskian	Coyrie and Madeline Formations	38
B Sakmarian to Artinskian	Callytharra and Fossil Cliff Formation	47
A Sakmarian	Carrandibby Formation Lyons Group and Holmwood Shale	21

A. Pelecypods and gastropods, Carnarvon and Perth Basins (after Dickins, 1963).

Stage	Fauna	No. of Species
E	Fauna IV	82
D	Fauna III	59
C	Fauna II	71

B. Pelecypods, gastropods and brachiopods, Bowen Basin, Queensland (after Dickins & Malone, 1973).

Table 1. Diversity in Australian Permian species

INTRODUCTION

The widespread evidence for glaciation has stimulated interest in the climate of the Permian of Australia, other southern continents and India. This evidence has been reviewed by Frakes & Crowell, 1969, 1970; Crowell & Frakes, 1971; Frakes, Matthews & Crowell, 1971, and Wanless & Cannon, 1966. Contemporaneous reefs, evaporites and indications of warm climate in other parts of the world have made this study of Permian climate even more tantalizing.

The association of some genera of marine invertebrates with glacial deposits together with low diversity and at some localities large numbers of individuals have been taken to indicate cold water (Dickins, 1957).

Diversity in Australian species are shown in the accompanying table. In the Bowen Basin no marine faunas referable to Stage B are known and the diversity may be compared with that in the Sydney Basin, where 16 species are known from the lower sandy unit of the Conjola Formation, (Dickins, Gostin & Runnegar, 1969, p.216), Wasp Head Formation (Gostin & Herbert, 1973) and about 15 species from the Allandale Formation (Dickins, 1968, p.36). Both formations are referred to Stage B.

The conclusions made here on changes in water temperature are based primarily on the generic composition of the faunas. Study of the temperature range of living forms has allowed interpretation of water temperatures during the Pleistocene and Tertiary where species are found, but this method, of course, is not applicable to the Permian. Detailed stratigraphical work on the Lyons Group for example which has marine faunas at the base and at places throughout the sequence, may show repeated appearance and disappearance of species reflecting fluctuations in the temperature. The geographical distribution of species and migration may also indicate temperature tolerance. Later in the report, the appearance of certain species in the Bowen Basin is considered to indicate cooler conditions.

In considering changes in water temperature it has been found convenient to make use of the stages proposed for the western Australian Permian (Dickins, 1963, 1969 See Fig. 2).

I am grateful to M.J. Clarke of the Geological Survey of Tasmania for supplying unpublished information (Clarke & Banks, in press) on species ranges in the Permian of Tasmania. These ranges seem to be consistent with the conclusions made in this report.

Stage A (Sakmarian)

Fig.1 Rock sequences referred to this stage are widespread and apparently occur in every state. The fauna predates the marine fauna of the Bowen Basin, Queensland, and has been called the Allandale Fauna by Runnegar (1967). It is well represented in Western Australia, Tasmania, New South Wales and Queensland. North of the present 20° parallel of latitude evidence for glaciation is ephemeral but over the southern half of the continent evidence for glaciation to sea level is widespread and clear cut. Characteristic genera are the pelecypods Eurydesma and Deltopecten, the gastropods Keeneia and species of Megadesmus, Myonia, Peruvispira and Ambikella*. Diversity is low but large numbers of individuals may be present. Brachiopods and bryozoans are less well represented than pelecypods.

Lowenstam (1964, p.229) gives a temperature of 7.7°C for a sample from the Lyons Group, 1500 feet below the top; based on oxygen isotopes.

The upper part of the stage is marked by widespread marine transgression in Australia. In the central part of Australia this transgression is particularly distinctive as the rest of the sequence appears to be non-marine. The earliest marine deposits of the southern part of the Sydney Basin belong here as well as the Carrandibby Formation of the Carnarvon Basin and the Allandale Formation of the northern part of the Sydney Basin. The Peruvispira from central Australia (Ludbrook, 1967) suggests this age and the recent work of Harris & McGowran (1971) seems to confirm this. Harris & McGowran in their paper suggested some eustatic control of sedimentation.

Fig. 2 Correlation of some Australian and overseas Permian sequences is shown in Fig. 2. The basis for this correlation is argued in Dickins & Thomas (1959) where the age of the Lyons Group is considered, and by Dickins (1961) when describing and considering the age of the marine fauna from the Dwyka Beds of South West Africa. Although Waterhouse (1970) has questioned some of these correlations, he has mis-interpreted our work and his conclusions are inadequate in that they are not based on a direct study of the faunas and the sequences from which they are derived.

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* This group of species has in Australia, most commonly been referred to under the name Ingelarella Campbell 1959. Ingelarella, however, appears to be a synonym of Ambikella Sahni and Srivastava, 1956 and it is proposed to use Ambikella here pending further clarification of the relationships of these faunas to Tomiopsis Benediktova, 1956 and Martiniopsis Waagen, 1883.

The Allandale Formation, the lower unit of the Conjola Formation (Wasp Head Formation), the marine transgression in central Australia, the upper part of the Lyons Group, the Umaria Beds, the marine horizon at the top of the Dwyka Beds, and the Bonete Formation afford evidence for a marine transgression which occurs stratigraphically immediately above the main glacial horizons in Australia, India, South Africa and South America. Present fossil evidence suggests these beds are late Stage A in age and that the widespread marine transgression reflects a post glacial eustatic rise in sea level.

Stage B (Sakmarian to early Artinskian)

Fig. 3 Changes are particularly marked in the fauna in Western Australia. If the brachiopods are taken into account, the changes are even more distinctive than shown in the table. The earlier fauna of a generalized Gondwana type lacks diversity. Many genera appear with Tethyean affinities. Among the brachiopods these include *Cleiothyridina*, *Phricidothyris*, and *Spiriferella*, *Platyceras*, *Retispila*, *Bellerophon*, *Euphemites*, and *Stachella* among the gastropods and among the pelecypods, limids, *Girtypecten*, *Euchondria* and *Edmondia*. None of these genera are known from eastern Australia. *Deltopecten* remains but *Keeneia* and *Eurydesma* have not been found. The martiniopsids are poorly represented. Some genera which persist are represented by different species. Bryozoan and brachiopods are particularly diverse. There is no ice action evident and temperate conditions seem to be indicated.

In eastern Australia the changes are less distinct and the diversity is less. *Eurydesma* and *Keeneia* persist, the martiniopsids make up an important element in the fauna together with *Megadesmus*, *Astartila*, *Myonia* and *Vacunella*. In the first detailed examination of Tasmanian Permian faunas in recent years, Clarke & Banks (in press) emphasize the low diversity and persistence of *Eurydesma* and *Keeneia*. The fauna found in eastern Australia could be explained by the existence of barriers to migration but this seems unlikely as the same kind of differences persist into Stage C time when certainly some east-west migration took place. Probably the water temperature in eastern Australia remained lower than in Western Australia.

Stage C and D (Artinskian and Kungurian)

In Western Australia particularly during Stage D time tethyean links are stronger and the fauna presents a very different aspect to that found at the same time in eastern Australia. Compared with eastern Australia such pelecypods genera as Vacunella and Myonia and the martiniopsids are poorly represented. The brachiopods, particularly, are diversified with a number of lineages of spiriferids and productids. The diversification of the spiriferids is particularly striking. The Calceolispongia crinoids are represented by numerous species whereas in eastern Australia only a few forms are present. The faunas seem to indicate cool to probably warm temperature conditions

Fig. 4 Lowenstam's (1964, p.230) work on oxygen isotopes, indicate a water temperature of about 19-24°C for the Noonkanbah Formation of the Canning Basin during Artinskian time fitting the faunal data.

Some east-west migration took place in Stage C time. Forms closely related to the eastern Australian species Taeniothaerus subquadratus, Ambikella plana, Stutchburia randsi and Cancrinella farleyensis are found in western Australia and in eastern Australia species are found which are closely related to described species from western Australia (Dickins, 1970, p.22). Wass (1969) records similar relationships with the bryozoans. In eastern Australia the tethyean influence is considerably less and, in the main, development is indigenous. However, a north-south differentiation of the faunas can be recognized (Dickins in Olgers & Flood, in press). In Tasmania and New South Wales, forms taken to indicate cold water persist longer and in some cases, e.g., Keeneia, continue to the top of the sequence. Accordingly in the middle part of this time, cool temperate conditions are found in Tasmania and New South Wales whereas somewhat warmer conditions are found in Queensland. Eurydesma and Deltopecten continue in New South Wales almost to the top of this part of the sequence whereas in Queensland they are entirely absent and represented only by a few specimens.

Stage E (Early Upper Permian)

Fig. 5 In western Australia no marine faunas are referred to this stage. In eastern Australia, however, the youngest marine fauna are regarded as belonging here. In Queensland species related to Parallelodon subtilistriatus, Astartila fletcheris and Schizodus kennedyensis suggest a northern tethyean sea connection and somewhat warmer water. Despite the faunal links of Queensland with New South Wales and Tasmania (many species are common to all areas), the northern elements in Queensland are poorly represented or absent in the south. This gives a further indication of north-south climatic differences.

Up to this time no definite warm water faunas can be identified in Australia.

Stage F (Late Upper Permian)

Fig. 6 Marine faunas are known only from western Australia in the Canning and Bonaparte Gulf Basins. Tethyean links are the strongest at any time during the Permian. At the species level the fauna can hardly be differentiated from other tethyean faunas, (Coleman, 1957; Thomas, 1957; Dickins, 1963). In the Bonaparte Gulf Basin in the northernmost area of outcrop, Thomas (1957) has elaborated on the occurrence of the brachiopod *Leptodus*, a characteristic form of the warmer water Upper Permian faunas. This is the only definite evidence for warm water in Australia during the Permian.

A Lower Triassic marine fauna apparently indicating warm water, is recorded by Dickins & McTavish (1963) in the Kockatea Shale of the Perth basin, near Geraldton, Western Austalia.

COMMENTS

Fluctuations in temperature have been postulated by Waterhouse (1967) for the New Zealand Permian but parallel changes in Australia are not at present easy to substantiate. By implication *Aulosteges* might indicate warmer water and its presence in mid-Permian time (Stage E) in the Drake area of northern New South Wales may indicate a temporary warming whereas its general absence from the east when it was present in the west may indicate persistently cooler conditions in the east. On the other hand the occurrence of such forms as the brachiopods *Ambikella magna* and *Ambikella isbelli* at the beginning of Stage E time (i.e., slightly earlier than *Aulosteges* in New South Wales) seem to represent a cooler phase. The forerunners of *Ambikella magma* and *Ambikella isbelli* are well represented in New South Wales (e.g., see Dickins, 1968, p.33). In the Bowen Basin, however, the two species appear at about the beginning of Stage E time and have not been found higher in the sequence. Dr Bruce Runnegar has recently shown me a single specimen of *Deltopecten* from this part of the sequence in the Homevale area. This evidence suggests a temperature fluctuation during which species adapted to the generally cooler water in New South Wales were able to migrate into Queensland. This would fall within the Braxtonian Stage of New Zealand (Waterhouse, 1967).

Ustritsky (1972) has recorded a cooler phase in the Siberian Permian at about this time. If the cool phase in both areas is contemporaneous, a world-wide fluctuation in water temperature is indicated.

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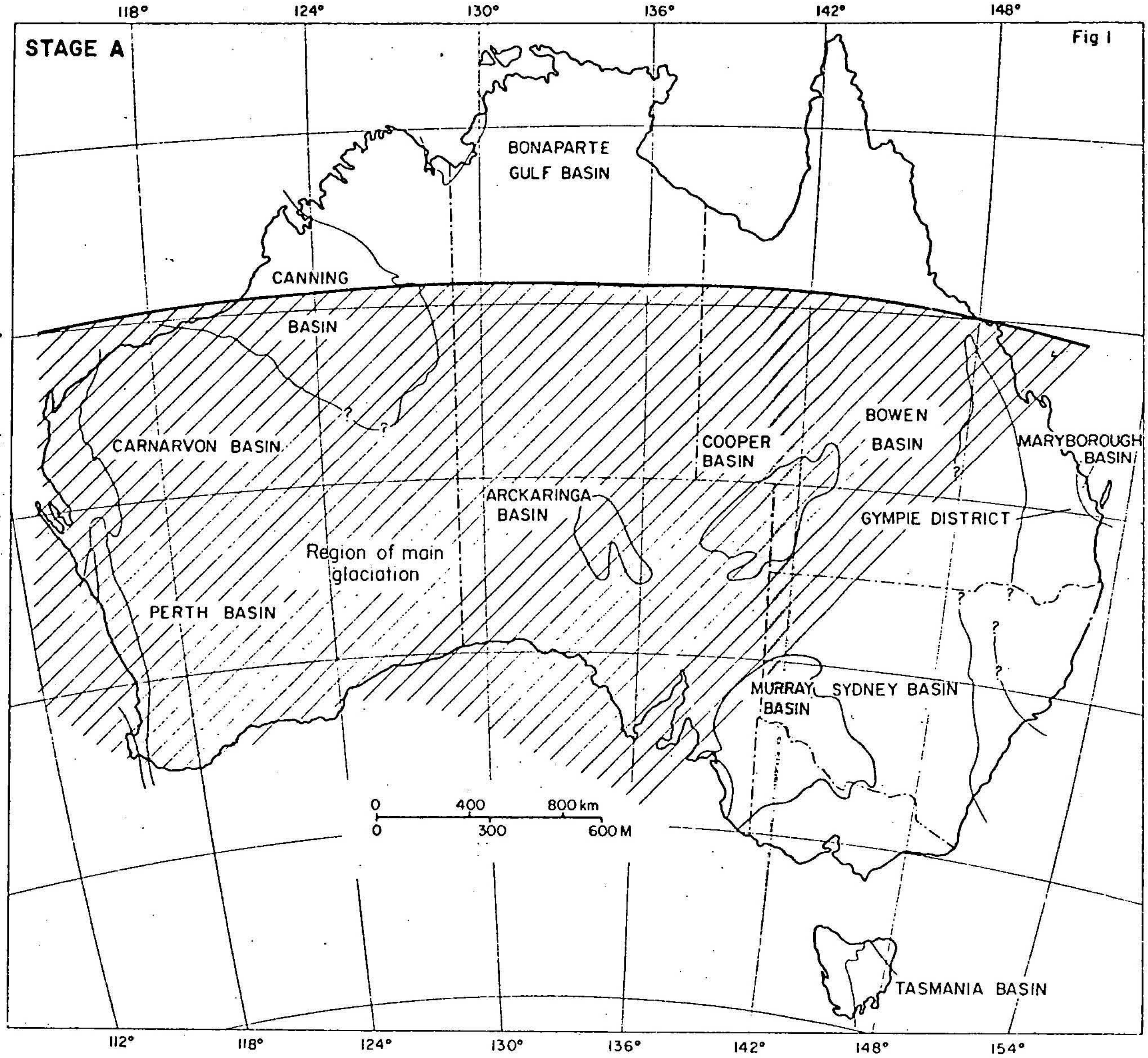

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	WEST. AUST. PERMIAN STAGES (Dickins, 1963)	BOWEN BASIN QUEENSLAND	SYDNEY BASIN, N.S.W. HUNTER VALLEY	SYDNEY BASIN, N.S.W. SOUTH COAST	CARNARVON BASIN, W.A.	PAKISTAN AND PENINSULAR INDIA	ARGENTINA	BRAZIL	SOUTH AFRICA
LOWER TRIASSIC		REWAN Fm	NARRABEEN GROUP	NARRABEEN GROUP					Beaufort Beds
UPPER PERMIAN	F	Blackwater Group (= Upper Bowen): Baralaba Coal Measures Gyranda Fm * 240	Newcastle Coal Measures Tomago Coal Measures	Illawara Coal Measures		Upper Productus Lst (Chhidru Lst)		Passa Dois Group: Rio Do Rasto Fm	
	E	Back Creek Group (= Middle Bowen): Blenheim Subgroup	Maitland Group: Mulbring Fm Muree Fm	Shoalhaven Group: Gerringong Volcanics * 250 Berry Fm Nowra Sst	? Kennedy Group	Middle Productus Lst (Wargal Lst)	? Tunas Fm ?	Estrada Nova Fm	
KUNGURIAN	D 2 / D 1	Gebbie Subgroup	Branxton Fm	Wandrawandrian Slst and Ulladulla Mdst	Byro Group	?		Irati Formation	Ecca Beds
ARTINSKIAN / LOWER PERMIAN	C	Tiverton Subgroup	Greta Coal Measures Dalwood Group: Farley Fm	Upper Unit of Conjola Fm	Wooramel Group	Lower Productus Lst (Amb Formation) ?		Tubarao Group: Guata Subgroup	
	B	Lizzie Creek (= Lower Bowen) Volcanics * 270	Rutherford Fm	Middle Unit of Conjola Fm	Callytharra Fm				
SAKMARIAN	A		Allandale Fm Lochinvar Fm	Lower Unit of Conjola Fm	Lyons Group	Umaria Beds Speckled Sst and Talchir Beds	Bonete Fm Piedra Azul Fm Sauce Grande Fm ?	Itarare Subgroup ?	Dwyka Beds

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* Radiometric age (million years)

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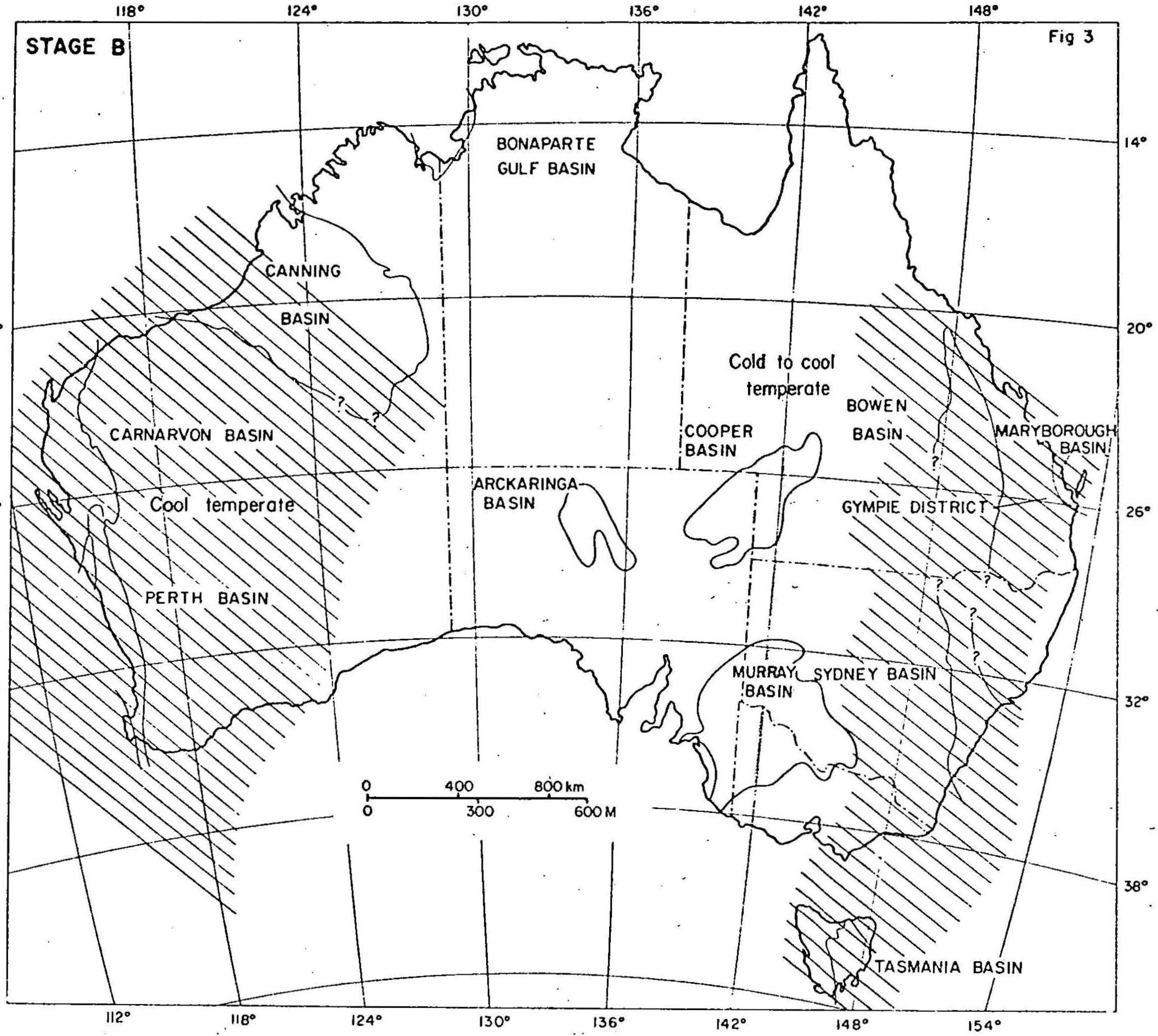
Fig. 2 Correlation of some Australian and Overseas Permian sequences



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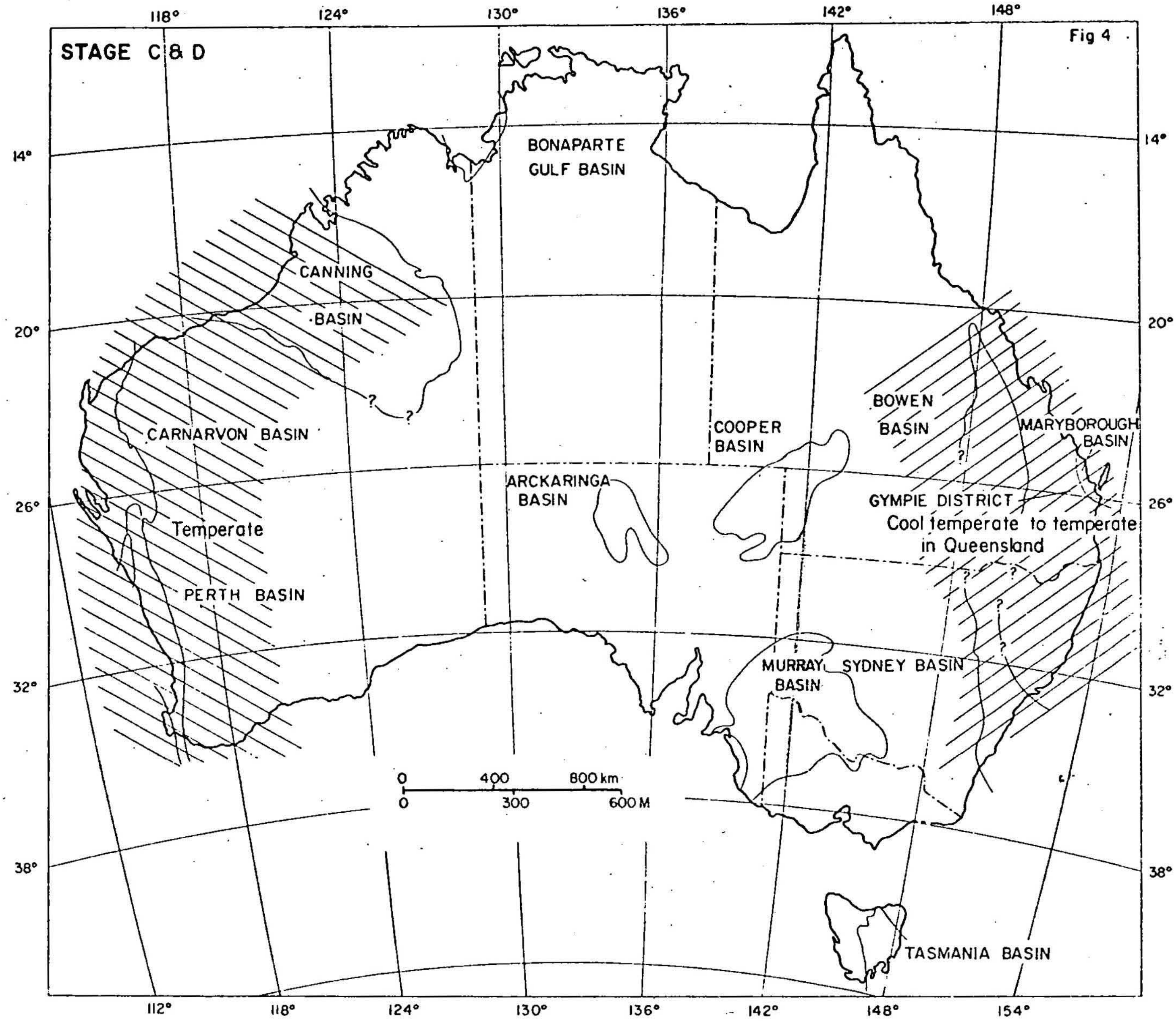

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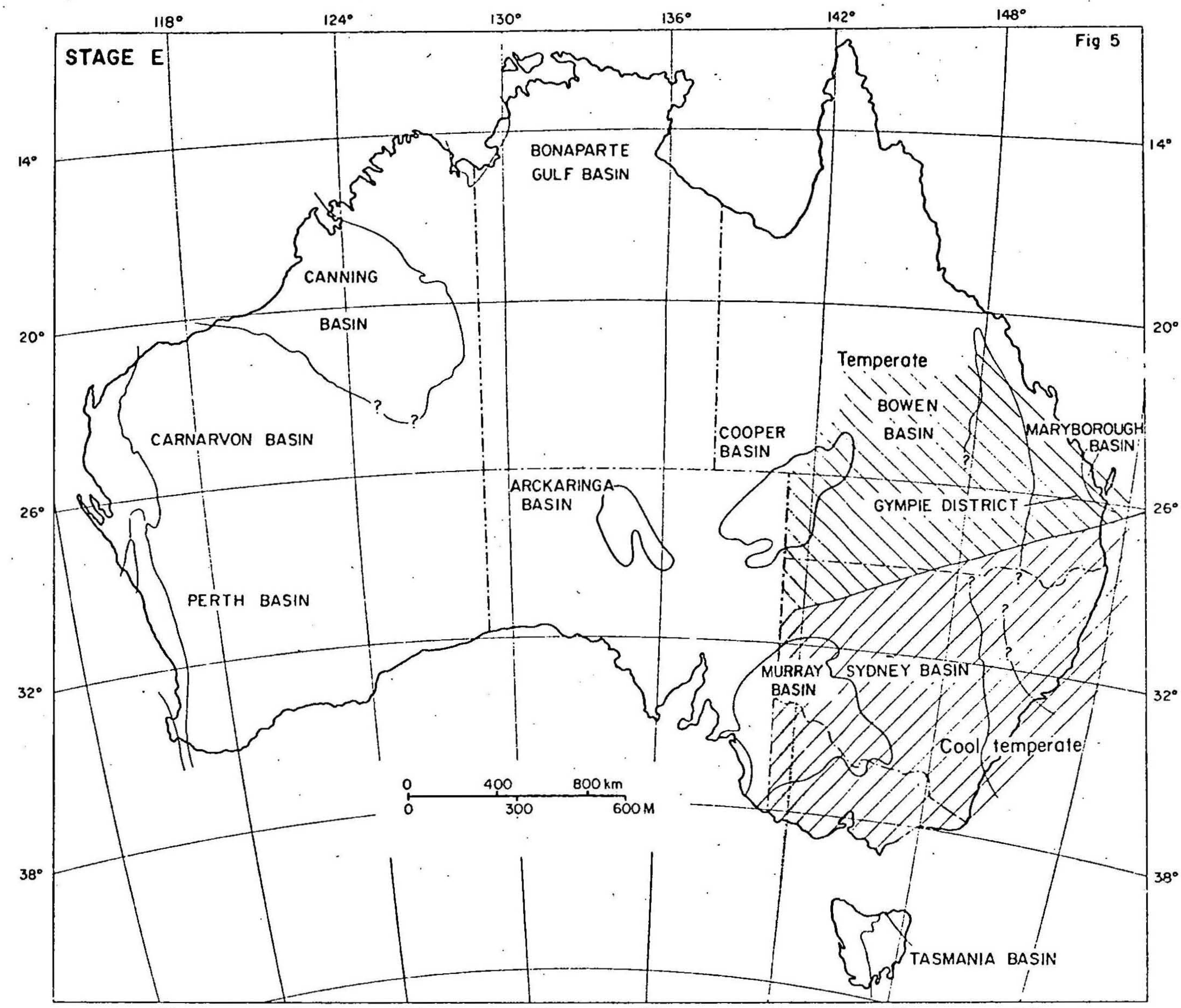

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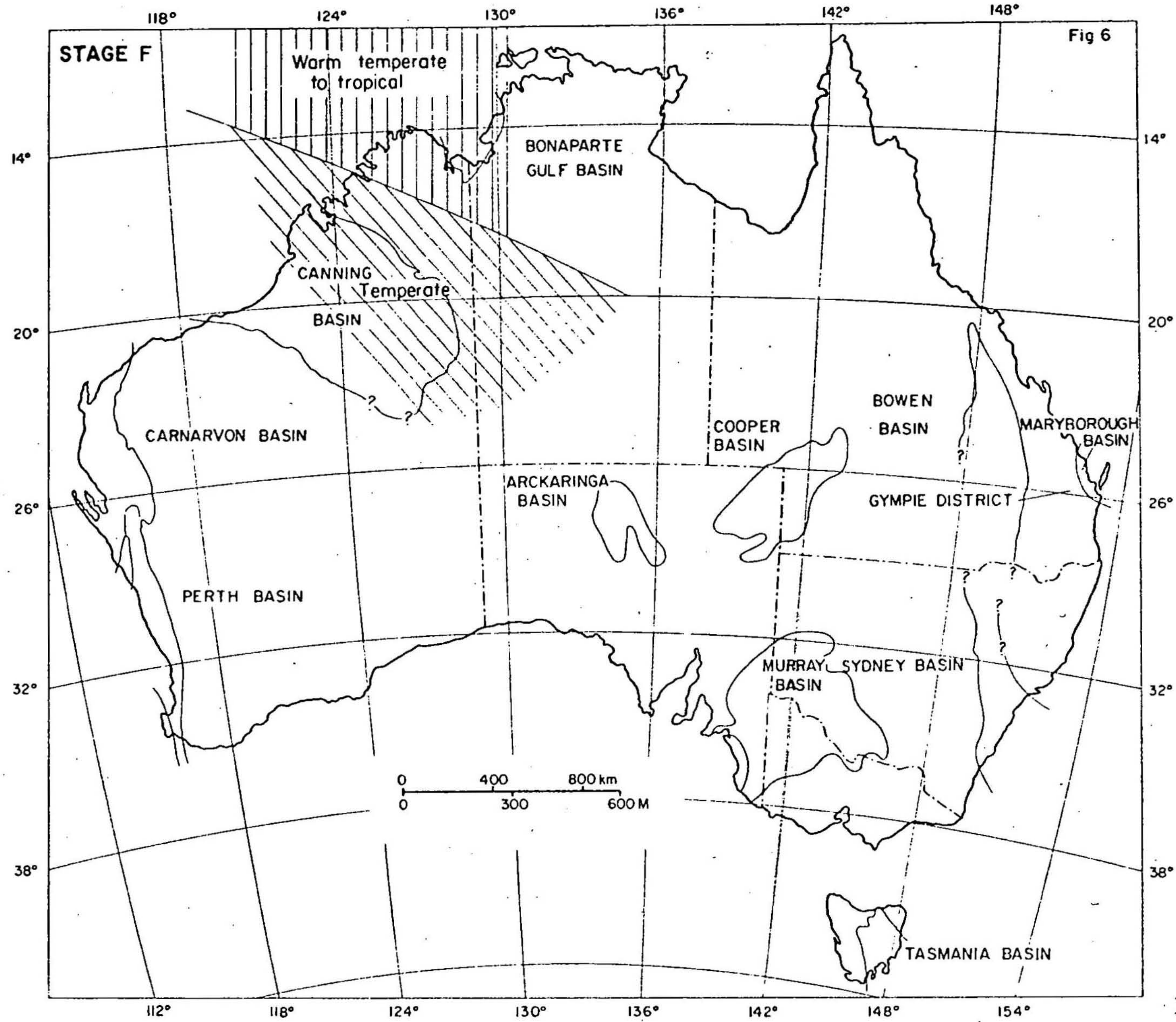

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