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COMPARISON OF PLANT MICROFOSSIL ASSEMBLAGES IN LATE PALAEOZOIC GONDWANA GLACIAL SEQUENCES

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ABSTRACT

Coeval plant microfossil assemblages of glacigene deposits of Gondwanaland are divisible on the basis of proportions of major morphological groups into two distinct types. They are the Australian-type (with a dominance of trilete spores and up to 10 per cent monosaccate pollen) and the Indian-type (dominated by monosaccate pollen with minor proportion of spores).

The lack of diversity of the Indian-type palynoflora is consistent with a parent flora adapted to harsh physical conditions such as a severe glacial environment. The Australian-type palynofloras, by contrast, suggest parent plant communities developed under milder conditions, perhaps peripheral to ice centres or experiencing a greater fluvial influence.

Recognition of Australian-type palynofloras associated with coal measure sequences in Tanzania, coeval with glacigene sequences elsewhere in Gondwanaland may indicate that the post glacial flora in the Gondwana countries was not simply the result of evolution and radiation in response to the end of widespread glaciation.

Key-words — Microfossils, Palynology, Gondwanaland, Glaciation, Late Palaeozoic (Australia).

साराँश

अन्तिम पेलियोज़ोइक गोंडवाना हिमनदीय अनुक्रमों से उपलब्ध लघुपादपाश्म समुच्चयों की तुलना – गेरी डेविड पॉविस

गोंडवानालैंड के हिमनदीय निक्षेपों के समकालीन लघुपादपाश्म समुच्चय प्रधान बाह्य-आकारिकीय समूहों के अनुपातों के आधार पर स्पष्टतया दो विभिन्न प्ररूपों में विभाजित किये जा सकते हैं। ये आस्ट्रेलियन-प्ररूप (त्रिअरीय बीजाणुओं से प्रभावी तथा 10 प्रतिशत तक एककोष्ठीय परागकणों से युक्त) तथा भारतीय-प्ररूप (बीजाणुओं के अल्प अनुपात के साथ-साथ एककोष्ठीय परागकणों से प्रभावी) हैं।

भारतीय-प्ररूप परागाणविक-वनस्पतिजात में विभिन्नता का अभाव घोर हिमनदीय वातावरण जैसी कठिन भौतिक परिस्थितियों के लिए अनुकूलित मूल वनस्पतिजात के अनुरुप है। इसके विपरीत ऑस्ट्रेलियन-प्ररूप परागाणविक वनस्पतिजात प्रस्तावित करते हैं कि मूल-पादप समुदाय सौम्य परिस्थितियों में विकसित हुए थे जो कि या तो शायद हिम केन्द्रों के इर्द-गिर्द परिवृत्तीय हों अथवा विस्तीर्ण नदीय वातावरण से प्रभावित हों।

तंजानिया के कोल-मेज़र्स अनुक्रमों से, जो कि गोंडवानालैंड में अन्यत्र हिमनदीय अनुक्रमों के समकालीन हैं, सहयुक्त आस्ट्रेलियन-प्ररूपी परागाणविक-वनस्पतिजातों का पाया जाना शायद इंगित करता है कि गोंडवाना देशों में अन्तिम हिमनदीय वनस्पतिजात विस्तृत हिमनदन की समाप्ति की अनुक्रिया में मात्र विकास एवं विकीरण का ही परिणाम नहीं था।

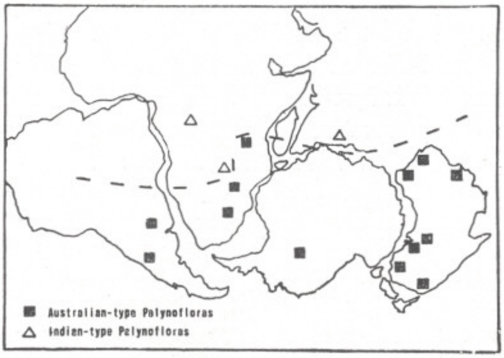
INTRODUCTION

IMMEDIATE pre-glacial plant microfossil assemblages have been recognized on both sides of the Australian continent and in the Paganzo Basin, Argentina. The assemblages are broadly comparable which suggests their parent floras were coeval. It follows, therefore, that similar climatic conditions characterised large areas of Gondwanaland just prior to the onset of glaciation. The oldest plant microfossil assemblages recorded in glacigene sediments in Gondwanaland are also known only from Australia and Argentina. These characterise the *Potonieisporites* Palynozone of Azcuy and Jelin (in press) and the comparable Stage 1 of Evans (1969).

As pointed out by Kemp (1975), the major part of all Late Palaeozoic glacial deposits throughout the Gondwanaland countries, is characterized by plant microfossil assemblages comparable to Evans' Stage 2. Although broadly comparable, there exists many intrinsic differences between the assemblages and the sedimentary sequences in which they are found.

These assemblages contain abundant monosaccate pollen grains and simple trilete spores. They are also characterised by the first occurrence of taeniate-disaccate and monocolpate pollen grains in the geological record of Gondwanaland. Associated with the palynoflora are the oldest known macrofossil elements of the *Glossopteris* Flora. The purpose of this paper is to compare and contrast the dominant fundamental components (i.e. major morphological groups) of the assemblages. In order to document these effectively it is necessary to ignore the localised occurrence of certain distinctive endemic forms and the different taxonomic approaches used by workers on separate continents.

Two distinct, yet comparable plant microfossil assemblages characterise the Late Palaeozoic glacial sequences of Gondwanaland. For convenience they are herein termed the 'Australian' and 'Indian'-type palynofloras.



TEXT-FIG. 1 — Gondwanaland reassembly according to Smith and Hallam (1970), showing distribution of the two types of Late Palaeozoic glacigene plant microfossil assemblages.

AUSTRALIA

The major portion of the Late Palaeozoic glacigene sediments in Australia is characterised by the *Microbaculispora* Assemblage (Segroves, 1970) and *Microbaculispora tentula* Assemblage zone (Powis, 1979, unpubl.) in western Australia and Stage 2 (Evans, 1969) in eastern Australia. Their palynofloras typify the Australian-type assemblage. They contain rare taeniate and non-taeniate-disaccate pollen with most of the assemblage being composed of monosaccate pollen and trilete spores such as *Microbaculispora* spp., *Punctatisporites gretensis*, *Apiculatisporis cornutus*, *Brevitriletes levis*, *Calamospora* sp., *Horriditriletes ramosus*, and *Indotriradites* spp. Monosaccates are common to abundant constituents but rarely dominant, with the main percentage of the assemblage being made up by trilete spores. Disaccate pollen are also consistent components but rarely exceed 10 per cent of the assemblage.

ANTARCTICA

Monosaccates and trilete spores make up most of the palynoflora characterising Kyle's (1977) *Parasaccites* Zone from the glacigene Lower Victoria Group in Antarctica. It is therefore similar to the Australian-type palynofloras. Apart from the monosaccates, characteristic species occurring on both continents are *Microbaculispora* spp., *Cycadopites cymbatus*, *Indotriradites* (*Kraeuselisporites*) *splendens*, *Calamospora* sp. and forms similar to *Punctatisporites gretensis*. Disaccate pollen, most of which are taeniate, make up about 5 per cent of the Antarctic assemblages.

INDIA

The Late Palaeozoic glacigene strata in India are incorporated in the Talchir Formation. The plant microfossil assemblages from these strata contain only rare disaccates but are dominated by monosaccate pollen grains making up about 90 per cent of the palynoflora. Bharadwaj (1966, 1970) described the *Parasaccites* microflora from the Talchir Series (including the Karharbari Formation). The lower part of this palynoflora contains two plant microfossil 'complexes'. The assemblages of the Karharbari Formation are characterised by an abundance of non-taeniate-disaccates of the *Sulcatisporites*-type. Although the assemblage from this formation described by Lele and Makada (1974) does not agree with Bharadwaj's percentages, it does appear to be comparable to Stage 3 of Evans (1969). Only the palynoflora from the Talchir Formation is relevant, therefore, to the present discussion. The assemblages from the glacigene Talchir Formation were described by Lele and Karim (1971), Lele and Chandra (1973) and Lele (1975). Typical assemblages from the formation contain about 86 per cent monosaccates, 10 per cent disaccates (about 0·5 per cent taeniate) and only 3 per cent trilete spores. Such an assemblage typifies the Indian-type palynofloras. The spores present include forms assignable to *Microbaculispora* spp. and various apiculate and laevigate trilete spores of the *Calamospora*, *Punctatisporites* and *Horriditriletes* type. Zonate spores of the *Indotriradites* type are absent. Forms assignable to the monocolpate pollen *Cycadopites cymbatus* are also present in minor proportions.

AFRICA

The most important palynostratigraphic work on the glacial strata of Africa has been carried out in Southern-Central Africa by Hart (1963, 1965, 1967, 1970), Rhodesia by Falcon (1973, 1975, 1975a), Zambia by Utting (1976, 1978), the northern Karroo Basin by Anderson (1977) and Zäire by Høeg and Bose (1960), Bose and Kar (1966, 1976, 1978) and Bose and Maheshwari (1966). Like India and Antarctica, no immediate pre-glacial palynoflora has been recognized in Africa. The glacial strata are incorporated in the Dwyka Series (including the Upper Dwyka shales). Within the Dwyka Series of southern Africa there are strata which contain both the Australian and Indian-type palynofloras.

The Lower Lukuga Group in Zäire and the Siankondobo Sandstone Formation and the Mukumba Siltstone of Zambia contain plant microfossil assemblages dominated by monosaccates (up to 98 per cent in the Mukumba Siltstone; see Utting, 1976; Hart, 1963). Bose and Kar (1978) report that except for localised high percentages of taeniate-disaccates, the palynomorph assemblages of the Formations glaciaires et périglaciaires in Zäire, are also dominated by monosaccates (minimum of 52 per cent).

Zone 1 of Anderson (1977), from the northern Karroo Basin, the oldest subzone of the *Virkkipollenites-Plicatipollenites* Assemblage of Falcon (1973, 1975) from Rhodesia and the $K2e_I$ Zone of Hart (1963) [later the *Cordaitina*-zone of Manum & Tien (1973)] from Tanzania have similar ratios of the major morphological groups to those of the Australian-type palynoflora. They all possess common to abundant monosaccates and forms assignable to *Microbaculispora* spp., *Calamospora* sp., *Punctatisporites gretensis*, *Horriditriletes ramosus* and *Apiculatisporis cornutus* as well as rare *Cycadopites cymbatus*. Anderson (1977, p. 54) states that of the thirty-one species recorded from his Zone 1, thirteen are known from western Australian palynofloras. Although Manum and Tien (1973) recognized transitional assemblages to the overlying disaccate pollen rich palynoflora in Tanzania, and suggested in fact that monosaccates did dominate in the *Cordiatina*-zone, Hart (1963) recorded about 10 per cent monosaccates with most of the remainder of the assemblage being made up of trilete spores and *Cycadopites Cymbatus*. They are, therefore, more similar to the Australian-type palynoflora.

SOUTH AMERICA

Azcuy (1979) outlined a palynostratigraphic subdivision of the Lower Gondwana deposits of South America. He defined, tentatively, five palynozones; the older three from material obtained from the Paganzo Basin, Argentina, and the younger two from sequences in the Tarija Basin, Bolivia and the Parana Basin, Brazil and Uruguay.

Palynozone I and II have more recently been referred to as the *Ancistrospora* and *Potonieisporites* palynozones respectively (Azcuy & Jelin, in press). Powis (1979, unpubl.) drew comparisons between these palynozones and the immediate pre-glacial and *Potonieisporites* Assemblage of Australia (Kemp *et al.*, 1977). Palynozone III, from the glacial Itararé Subgroup and its correlatives in Argentina, was described as being characterised by an assemblage of about 30 per cent monosaccates with spores (frequently zonate spores) making up to 50 per cent of the assemblage. This assemblage was correlated by Azcuy and Jelin (in press) with that characterising Zone 2 of Bharadwaj, Kar and Navale (1976) from similar strata. The distinguishing characteristics of Zone 2 are that it is dominated by trilete spores with monosaccate pollen grains subdominant. The important spore genera were recorded as *Punctatisporites* (*Callumispora*), *Microbaculispora* and *Indotriradites*. The palynofloras of the Late Palaeozoic glacigene deposits of South America are, therefore, more like the Australian-type than the Indian-type palynoflora.

COMPARISON

As previously stated, all the palynofloras of the Late Palaeozoic glacigene deposits in Gondwanaland are broadly comparable and are, therefore, probably coeval. It follows, therefore, that the glaciation was synchronous throughout Gondwanaland in the Late Palaeozoic (Powis, 1979, unpubl.).

The Indian-type palynoflora, dominated by monosaccate pollen grains, suggests a parent flora specialised in response to narrow constraints produced by a high stress physical environment (e.g. a glacial environment) and therefore characterised by an abundance of the same vegetation type. The vegetation which produced the monosaccate pollen was, therefore, specialised to withstand severe glacial conditions. The greater thicknesses of true tillites in India and the Congo also suggest a more severe glaciation than that experienced in Australia.

It is reasonable to presume, therefore, that coeval plant microfossil assemblages with a greater diversity of palynomorphs, particularly pteridosperms, and a non-dominant percentage of monosaccates would be the result of a parent flora existing in a less severe environment, viz., peripheral to ice centres or experiencing a greater fluvial influence.

It is interesting to note, that both the Australian-type and Indian-type palynofloras, recorded from glacigene sequences, have also been recorded from African sequences with a dominantly non-glacial, sandstone lithology, including minor shales and coal measures (Utting, 1976, 1978; Manum & Tien, 1973). Discussing their overlying *Vesicaspora*-zone in the Tanzanian coalfields, Manum and Tien (1973) also stress the significance of the same assemblage occurring throughout a stratum of varying lateral sedimentary facies, viz., shale and coal to sandstone. They conclude that the floral change represented by their two distinct palynofloras which took place over a large area, was "controlled by significant changes in the physical environment that were not of a local nature". The palynofloras in the coalfields of Tanzania appear to be coeval with glacigene sedimentation elsewhere in Gondwanaland but as would be expected in a coal swamp environment, the strata are characterised by the Australian-type palynofloras.

In the Zambian sequence, the partially glacigene Mukumbu Siltstone and its equivalent, the Siankondobo Sandstone, are characterised by Indian-type palynofloras. This suggests that the area experienced harsh physical conditions during the period of glaciation. Palynofloras equivalent to post glacial assemblages elsewhere in Gondwanaland, characterise the conformably, overlying carbonaceous sequence. The palynofloras exhibit a marked increase in the percentage of trilete spores and decrease in the monosaccate pollen (becoming subdominant). This floristic change coincides with the first carbonaceous strata. This is further evidence indicating that the waning stages of the Late Palaeozoic glaciation were accompanied by diversification of the vegetation and under suitable conditions coal formation.

A model for the formation of these carbonaceous sequences has recently been put forward by Le Blanc Smith and Eriksson (1979). They proposed that shallow-rooted Arctic vegetation developed on abandoned outwash plains overlying deltaic deposits, formed by the deceleration of sedimentary rates with the retreat of the glaciers. The resulting peats, they said, were the precursors to the present coal seams. Such a model may satisfactorily explain the occurrences of post-glacial carbonaceous sediments, but does not account for the localised occurrences of coals contemporaneous with large thicknesses of glacigene sediments in the same region.

The two examples from Africa show that the parent floras of comparable palynofloras (whether Australian or Indian-type) occurred in a variety of environments during the Late Palaeozoic glaciation. These were followed by a major floristic modification in post-glacial times (Balme, 1980), which was also represented by broadly comparable palynofloras characterising many different sedimentary facies. Colonisation of new niches exposed during the waning of the glacial phase with climatic ameleoration is, therefore, possibly not the sole reason for the floristic modifications which occurred after the main phase of glaciation in Gondwanaland in the Late Carboniferous-Early Permian.

CONCLUSIONS

Despite minor differences in specific composition and taxonomic treatments in the glacigene plant microfossil assemblages, there are two distinct types of assemblages. They are broadly correlatable and coeval and reflect the severity of glaciation experienced in particular regions. Recognition of comparable assemblages in coal-measure sequences to those of contemporaneous glacigene deposits, further suggests that the post glacial flora in the Gondwana countries was not necessarily a product resulting solely from a recolonisation of the glaciated terrain.

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