

# A LATEST DEVONIAN PALYNOFLORA FROM THE BUTTONS BEDS, BONAPARTE GULF BASIN, WESTERN AUSTRALIA

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A moderately well-preserved miospore flora has been obtained from the type section of the Late Devonian Buttons beds in the southwestern Bonaparte Gulf Basin, Western Australia. It is characterised by relatively abundant specimens of *Retispora lepidophyta* (Kedo) Playford, 1976 and by other trilete miospore species that collectively constitute the *R. lepidophyta* Assemblage as defined from the lower part of the Fairfield Group of the Canning Basin, Western Australia. On this basis, the Buttons beds are

datable as latest Devonian, probably within the interval Fa2d to Tn1a or early Tn1b of Belgian terminology. This palynological age determination is somewhat younger than previous, faunally based age assessments of the Buttons beds, which have suggested, not altogether unequivocally, an earlier Famennian age (i.e., doII $\beta$ -doIII, Falc-Fa2b). One new species of trilete cingulate miospores—*Lophozonotrites varionodosus*—is instituted herein.

## Introduction

In the Bonaparte Gulf Basin of northwestern Australia (Fig. 1), marine Devonian rocks are known from both outcrop and subsurface, and reach a thickness of at least 1800 m (Veevers & Roberts, 1968; Jones, 1968; Playford & others, 1975). Devonian sedimentation is believed to have begun in the early Frasnian (or perhaps late Givetian). Three depositional facies were recognised by Veevers & Roberts (1968): (a) the platform carbonate province, in the northwest of the basin; (b) the deeper-water, basinal shale province, known only from subsurface sections in the basin's north-central part; and (c) the platform conglomerate province to the southeast. The distribution of these provinces and correlation of their constituent rock units have been depicted by Veevers & Roberts (1968, figs. 4, 10) and Roberts & others (1972, correlation chart).

The present paper concerns the palynological characteristics of one of the basin's Late Devonian units, the Buttons beds; and is intended to supplement previously published biostratigraphic inferences based upon other palaeontological data from the unit.

## Buttons beds

The Buttons beds are a marine unit that is developed in the southern and southeastern portion of the Bonaparte Gulf Basin (Jones, 1968, fig. 1), specifically in the transitional area between the two platform provinces and in the general vicinity of the Precambrian Pincombe Range inlier. As defined by Veevers & Roberts (1968, pp. 59-64), the Buttons beds incorporate over 300 m of sandy and silty limestone with subordinate dolostone and sandstone. The type section (no. 105 of Veevers & Roberts, p. 62; figs. 30, 35) is located in the bed of the Ord River, just north of Buttons Crossing (Fig. 2); it is 350 m thick, but neither the base nor top is exposed.

The Buttons beds are considered to represent shallow water, inshore and offshore lagoonal deposits on the landward side of the reef complex embodied by the partly equivalent Ningbing Limestone. Thus, they are regarded (Veevers & Roberts, 1968, p. 59) as being

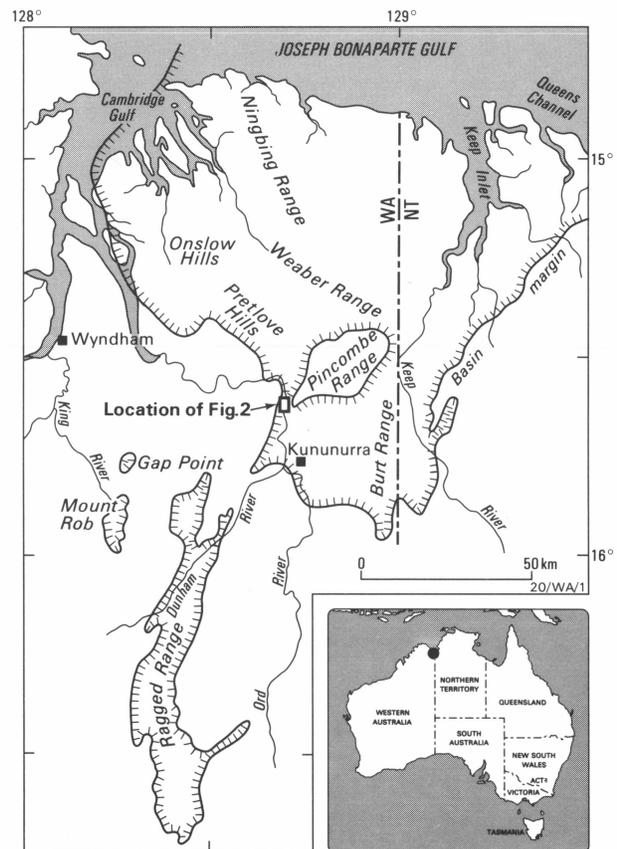
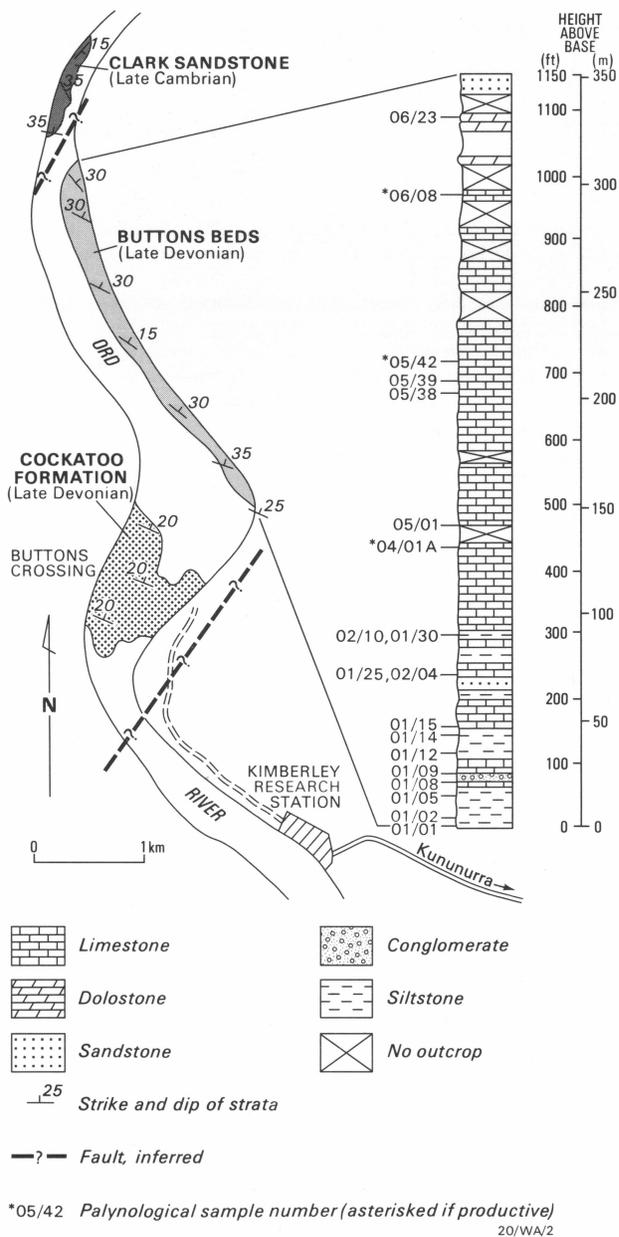


Figure 1. Locality map, Bonaparte Gulf Basin of Western Australia and Northern Territory. After Veevers & Roberts (1968, fig. 5).

laterally contiguous with part, 'probably the lower part', of the Famennian to ?Tournaisian Ningbing Limestone, which constitutes an extensively outcropping reefal unit in the platform carbonate province (i.e. around the western margin of the Bonaparte Gulf Basin). Both the Ningbing Limestone and Buttons beds are believed to be conformable on the underlying uppermost member (Jeremiah Member) of the Frasnian to early Famennian Cockatoo Formation. At one locality, Sorby Hills (Veevers & Roberts, 1968, fig. 37), the Buttons beds are unconformable on Precambrian siltstone. The top of the unit, where exposed, is said to have a disconformable relationship with overlying Early Carboniferous limestone of the Burt Range Formation (Veevers & Roberts, 1968, pp. 67, 70).

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**Figure 2.** Map and stratigraphic column of the type section of the Buttons beds.

The column shows generalised lithologies and sampling levels. Adapted from Veevers & Roberts (1968, figs. 30, 35).

At the type section, the base of the Buttons beds was regarded by Veevers & Roberts (p. 62) as being 'probably conformable' on the Cockatoo Formation, although uncertainty exists (Veevers & Roberts, pp. 33–34) because of structural complexity and incom-

plete exposure. The top of the type Buttons beds was regarded by the same authors as being in faulted juxtaposition with the Cambrian Clark Sandstone.

### Fauna and flora

Varied and often rich fossil assemblages have been reported from the Buttons beds, particularly at their type section (Veevers & Roberts, 1968, p. 62). Groups represented prominently include brachiopods (Roberts, 1971), ostracods (Jones, 1968), corals (Hill, 1954), calcareous algae (Veevers, 1970), bivalves, gastropods, stromatoporoids, crinoids, and lepidodendrid megaplants (viz. *Leptophloeum australe* (McCoy) Walton, 1926). Conodonts are infrequent (Druce, 1969). Plant microfossils have not previously been reported from the Buttons beds.

### Previous age assessments

The age of the Buttons beds has been assessed hitherto e.g. Roberts & others, 1972, p. 470) from fossil evidence—afforded principally by ostracods, brachiopods, conodonts, and megaplants—and also from the unit's inferred lateral equivalence with part of the reefal Ningbing Limestone (dated as early Famennian to possibly early Tournaisian). The bulk of the palaeontological data hitherto available indicates a Late Devonian (Famennian) age.

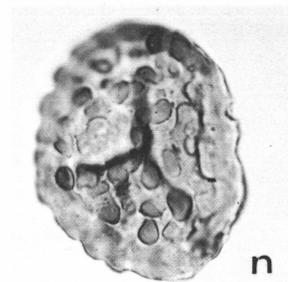
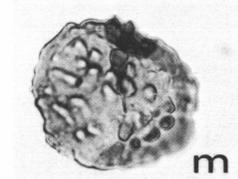
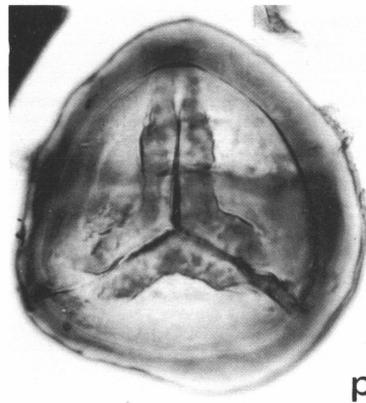
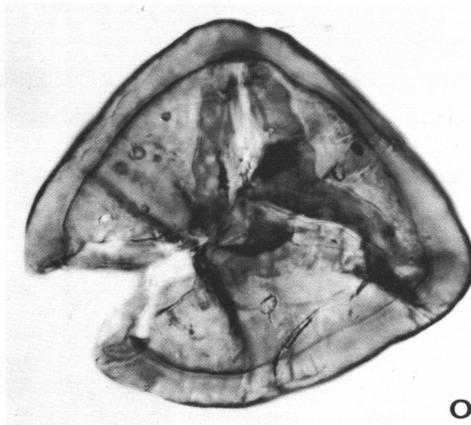
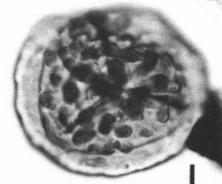
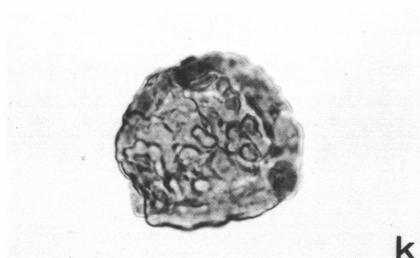
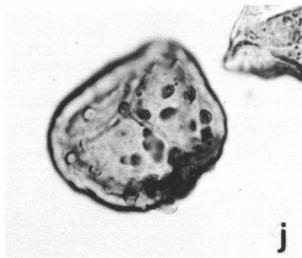
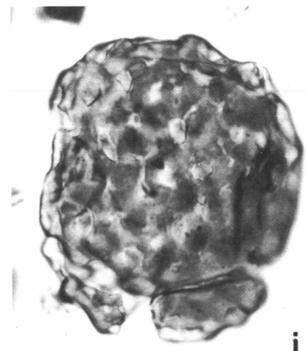
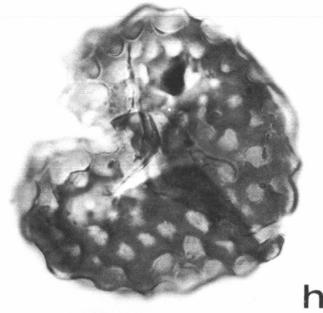
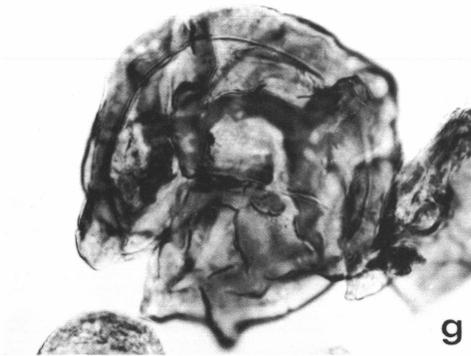
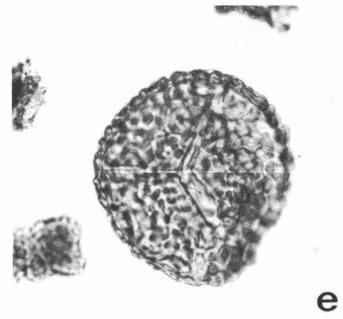
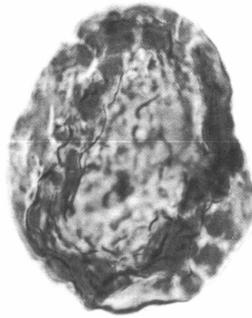
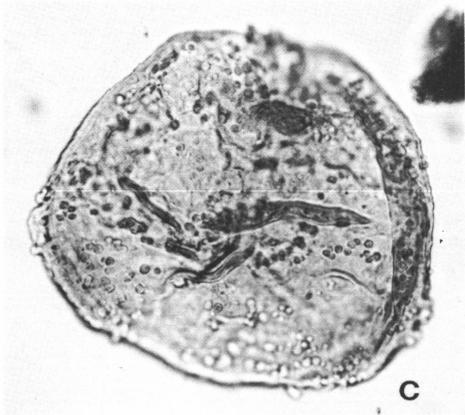
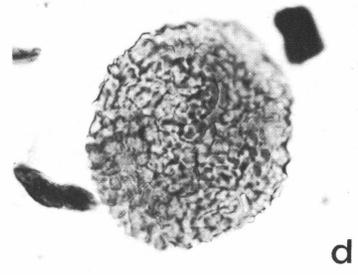
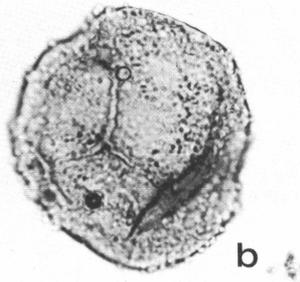
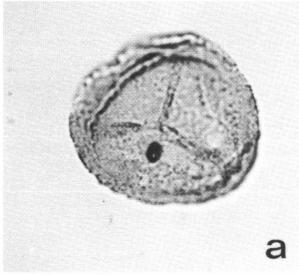
Attempts to refine the dating and correlation of the Buttons beds have rested primarily on a conodont specimen, and also on ostracods and brachiopods. Chronological significance has been attached by Jones & Druce (1966), Roberts & others (1967), and Roberts & others (1972) to the occurrence of a conodont that Druce (1969, pp. 111, 156; pl. 34, figs. 4a,b) termed *Polylophodonta* sp. A. This form, represented by a single specimen from the Buttons beds type section (250 m above base), was said to indicate an early Famennian (doII<sup>β</sup>–doIII) age (Roberts & others, 1967, p. 573; 1972, p. 470). It should be noted, however, that two other species of the meagre conodont fauna recorded from the Buttons beds—namely *Hindeodella corpulenta* Branson & Mehl, 1934 and *Spathognathodus* aff. *S. robustus* (Branson & Mehl, 1934)—are suggestive of a younger (Tournaisian) age (see Druce, 1969, charts 2,5).

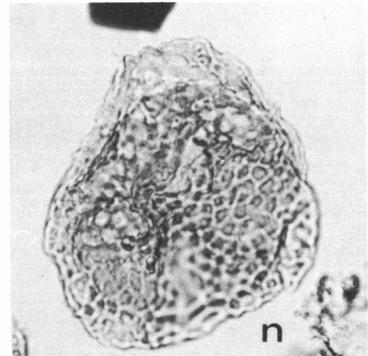
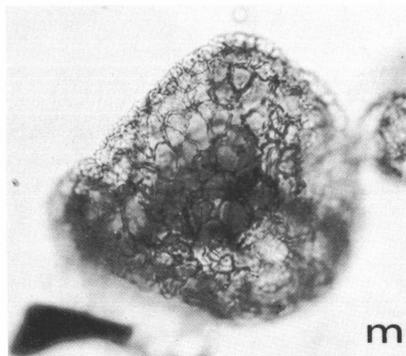
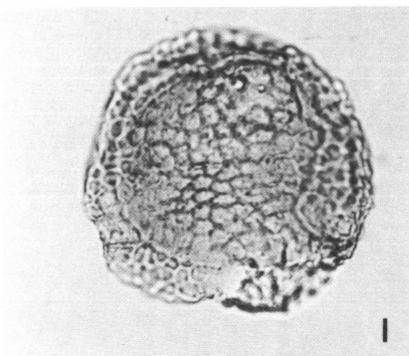
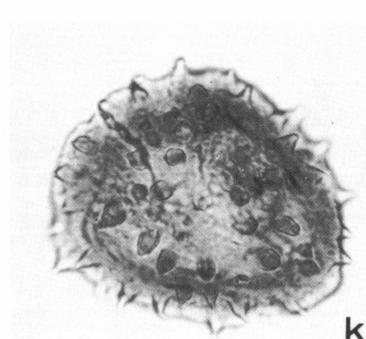
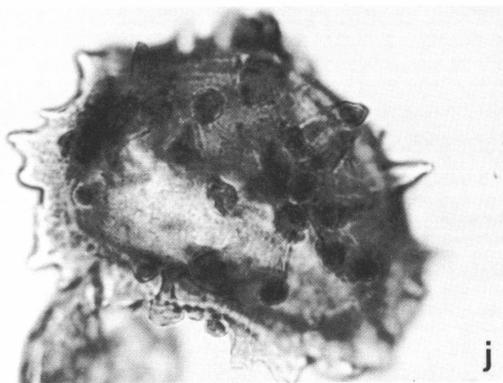
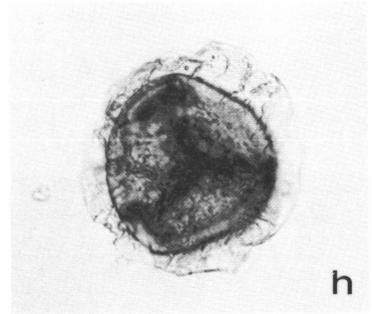
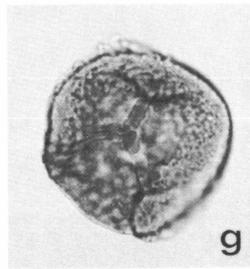
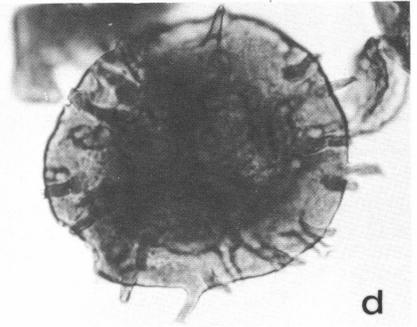
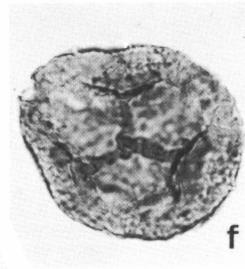
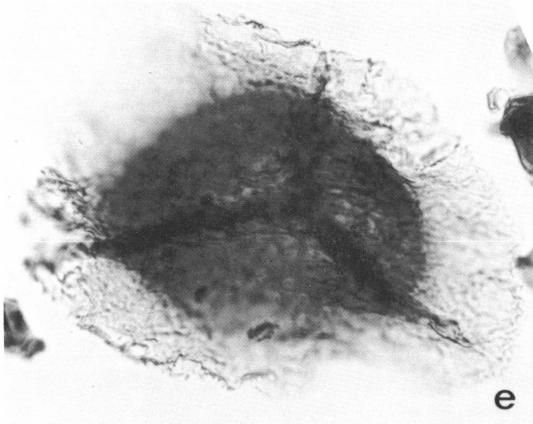
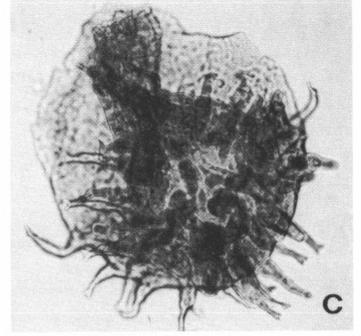
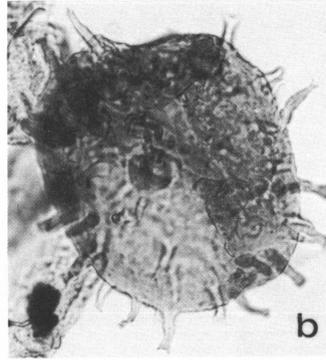
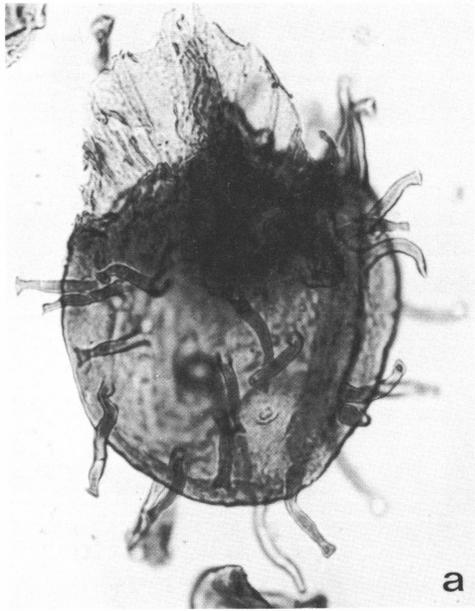
Jones (1968) proposed four, provisional, concurrent range zones based on ostracod faunas from the type section of the Buttons beds. The endemic complex of these faunas inhibited their application in overseas correlation; but they were applied to correlation on a local scale, suggesting, inter alia, that the Buttons beds are equivalent to the lower part of the Ningbing Limestone (in turn dated by conodonts as early Famennian:

**Figure 3.** Miospores from the Buttons beds (type section).

Magnification X500 unless otherwise indicated.

**a**—*Granulatisporites frustulentus* Balme & Hassell emend. Playford, 1971; median focus (X750), sample 05/42, prep. D547/1, 106.1 6.3, CPC 22149. **b**, **c**—*Apiculatisporis morbosus* Balme & Hassell, 1962: **b**—proximal focus, sample 04/01A, prep. D526/7, 112.6 13.0, CPC 22150; **c**—median focus, sample 06/08, prep. D546/1, 107.0 20.2, CPC 22151. **d**, **e**—*Convolutispora fromensis* Balme & Hassell, 1962: **d**—median focus, sample 04/01A, prep. D526/1, 97.6 10.9, CPC 22152; **e**—proximal focus, sample 04/01A, prep. D526/1, 103.5 10.9, CPC 22153. **f**—*Campotriletes balmei* Playford, 1976; median focus, sample 04/01A, prep. D526/1, 100.6 12.2, CPC 22154. **g**—*Reticulatisporites ancoralis* Balme & Hassell, 1962; proximal focus, sample 04/01A, prep. D526/1, 112.1 7.8, CPC 22155. **h**, **i**—*Brochotriletes textilis* (Balme & Hassell) Playford, 1976: **h**—proximal focus, sample 05/42, prep. D547/1, 107.8 21.6, CPC 22156; **i**—proximo-equatorial aspect, sample 04/01A, prep. D526/1, 111.1 6.6, CPC 22157. **j**—*Lophozonotriletes varionodosus* Playford sp. nov.: **j**—median focus, sample 04/01A, prep. D526/1, 112.3 10.5, CPC 22158; **k**—distal focus, sample 04/01A, prep. D526/8, 104.2 11.9, CPC 22159; **l**—distal focus, sample 06/08, prep. D546/1, 117.8 8.3, CPC 22160; **m**—distal focus, sample 04/01A, prep. D526/1, 102.4 6.9, CPC 22161; **n**—holotype, distal focus (X750), sample 04/01A, prep. D526/10, 109.1 12.7, CPC 22162. **o**—*Knoxisporites literatus* (Waltz) Playford, 1963: **o**—median focus, sample 04/01A, prep. D526/9, 103.5 13.8, CPC 22163; **p**—proximal focus, sample 04/01A, prep. D526/1, 112.4 22.5, CPC 22164.





Druce, 1969, p. 19). Jones (1968) noted, however, that six species from his zonal sequence are also known to occur in the late Famennian of the northern Canning Basin.

From several horizons in the type section of the Buttons beds, Roberts (1971) recorded four species of articulate brachiopods, including *Cyrtospirifer ningbingensis* Roberts, 1971, the characteristic species of his *C. ningbingensis* Zone which he recognised throughout the major (Famennian) part of the Ningbing Limestone. Although he acceded to prior suggestions of an early Famennian dating for the Buttons beds, Roberts (1971, p. 14) pointed out that one of his new species, *Cyrtospirifer depressus* (from the Buttons beds in the Burt Range area), closely resembles two Russian species of probable latest Devonian age, and therefore implies 'a younger age than indicated by ostracods'.

In summary, therefore, the invertebrate and conodont evidence accrued thus far signifies a Late Devonian, and certainly post-Frasnian, age for the Buttons beds, but it cannot be taken as clearly indicative of either early Famennian or late Famennian-earliest Tournaian.

## Materials and methods

All samples examined in the present study were collected in 1978 by BMR officers (R. S. Nicoll, P. J. Jones) from the type section of the Buttons beds, in the vicinity of Buttons Crossing, about 3–6 km north of the Kimberley Research Station. As depicted in Figure 2, the type section extends along the east side of the Ord River, and the samples studied span virtually the full exposure, which accounts for some 350 m of strata, although, as mentioned earlier, the base of the unit is not exposed and its top is faulted. Nineteen samples from 17 horizons in the type section were processed for their palynomorph content. Of these, only three samples proved to contain plant microfossils, mainly spores, in moderate states of preservation. The remainder were barren in a palynological context, yielding only sparse, indeterminate organic matter.

Details of the palynologically productive samples are as follows: Sample 04/01A—medium grey, carbonaceous, calcareous siltstone; 131.1 m above exposed base; palynological preparation no. D526. Sample 05/42—light grey, silty limestone; 213.3–216.4 m above exposed base; palynological preparation no. D547. Sample 06/08—light grey, silty limestone; 289.6–292.6 m above exposed base; palynological preparation no. D546.

The nineteen samples were subjected to conventional laboratory procedures for the extraction and concentra-

tion of plant microfossils (e.g. Playford, 1971, pp. 9–10), although concentrated nitric acid (5–10 minutes treatment) was used as macerant rather than Schulze solution, and 0.5 per cent potassium hydroxide solution was the subsequent clearing agent. Heavy-liquid separation (zinc bromide solution, in carefully controlled steps, from S.G. 2.0 down to 1.5) was followed by fine screening (mesh size 170  $\mu\text{m}$ ) to achieve the optimum concentration of palynomorphs. Three strew slides and about 15 single-specimen slides were made from each productive residue, using glycerine jelly as mounting medium.

Slides were examined with a Zeiss Photomicroscope II (no. Mx3237 of the Department of Geology and Mineralogy, University of Queensland). Stage-coordinates for illustrated specimens (Figs. 3, 4) are from the mechanical stage of that instrument. The specimens are deposited permanently in the Commonwealth Palaeontological Collection maintained by the Bureau of Mineral Resources, Canberra. Registered specimen numbers (prefixed 'CPC') refer to the official catalogue of that collection.

## Palynology

The three palyniferous samples contain assemblages that consist largely of trilete miospores with minor proportions (<2.5 per cent) of diminutive simple acritarchs, mainly of the *Micrhystridium* type, and in one case (sample 05/42) of scolecodont fragments. Quality of spore preservation was sufficient to permit confident identification to specific level; the most varied and abundant assemblage was obtained from sample 04/01A (20 species recognisable). The taxonomic composition of the spore floras is essentially similar in the three samples, 14 species being common to at least two samples (Table 1).

One of the commonly occurring forms, which has previously been recorded from the Canning Basin as '*Lophozonotriletes* sp. A' of Playford (1976), is formally instituted below as a new species. All other spore taxa could be identified as previously named species. *Retispora lepidophyta* (Kedo) Playford, 1976 is the most numerous (up to 10 per cent of miospore flora).

## Systematic description

**Genus** *Lophozonotriletes* Naumova emend. R. Potonié 1958

**Type species.** *Lophozonotriletes lebedianensis* Naumova, 1953; by subsequent designation of Potonié (1958, p. 27).

**Discussion.** See Playford (1976, p. 28).

## Figure 4. Miospores from the Buttons beds (type section), continued.

Magnification X500 unless otherwise indicated.

**a–d**—*Hytriosporites porrectus* (Balme & Hassell) Allen, 1965: **a**—equatorial aspect, sample 04/01A, prep. D526/3, 114.8 19.5, CPC 22165; **b**—distal focus, sample 04/01A, prep. D526/1, 100.0 22.9, CPC 22166; **c**—equatorial aspect (X250), sample 04/01A, prep. D526/4, 108.6 10.9, CPC 22167; **d**—median focus, sample 04/01A; prep. D526/2, 99.6 14.8, CPC 22168. **e**—*Cirratrardites impensus* Playford, 1976; median focus, sample 04/01A, prep. D526/1, 105.6 4.3, CPC 22169. **f, g**—*Diaphanospora depressa* (Balme & Hassell) Evans, 1970: **f**—proximal focus, sample 04/01A, prep. D526/2, 92.6 4.8, CPC 22170; **g**—proximal focus, sample 04/01A, prep. D526/12, 106.7 12.0, CPC 22171. **h**—*Diaphanospora viciniata* Balme & Hassell emend. Evans, 1970; median focus, sample 04/01A, prep. D526/2, 112.0 11.9, CPC 22172. **i**—*Diaphanospora perplexa* Balme & Hassell emend. Evans, 1970; median focus, sample 06/08, prep. D546/1, 94.6 5.5, CPC 22173. **j, k**—*Hymenozonotriletes scorpius* Balme & Hassell, 1962 emend. Playford, 1976: **j**—distal focus, sample 05/42, prep. D547/1, 105.2 3.6, CPC 22174; **k**—median focus, sample 04/01A, prep. D526/11, 105.5 14.2, CPC 22175. **l–n**—*Retispora lepidophyta* (Kedo) Playford, 1976: **l**—median focus (X750), sample 04/01A, prep. D526/2, 94.2 4.1, CPC 22176; **m**—distal focus, sample 05/42; prep. D547/1, 101.2 16.7, CPC 22177. **n**—distal focus (X750), sample 04/01A, prep. D526/1, 110.7 13.5, CPC 22178.

**Table 1. Check list of palynological microfossils recorded from the three palynologically productive samples of the Buttons beds.**

	Sample nos.			Illustrations
	04/01A	05/42	06/08	
<i>Leiotriletes pulvereus</i> Balme & Hassell, 1962	•			
<i>Retusotriletes digressus</i> Playford, 1976	•			
<i>Granulatisporites frustulentus</i> Balme & Hassell emend. Playford, 1971	•	•	•	Fig. 3a
<i>Verrucosisporites nitidus</i> (Naumova) Playford, 1964	•	•		
<i>Apiculatisporis morbosus</i> Balme & Hassell, 1962	•		•	Figs. 3b, c
<i>Convolutispora fromensis</i> Balme & Hassell, 1962	•			Figs. 3d, e
<i>Camptotriletes balmei</i> Playford, 1976	•			Fig. 3f
<i>Reticulatisporites ancoralis</i> Balme & Hassell, 1962	•	•		Fig. 3g
<i>Brochoiriletes textilis</i> (Balme & Hassell) Playford, 1976	•	•		Figs. 3h, i
<i>Knoxisporites literatus</i> (Waltz) Playford, 1963	•		•	Figs. 3o, p
<i>Lophozonotriletes varionodosus</i> Playford sp. nov.	•	•	•	Figs. 3j-n
<i>Hystricisporites porrectus</i> (Balme & Hassell) Allen, 1965	•	•		Figs. 4a-d
<i>Cirratridites impensus</i> Playford, 1976	•		•	Fig. 4e
<i>Hymenozonotriletes scorpius</i> Balme & Hassell emend. Playford, 1976	•	•	•	Figs. 4j, k
<i>Auroraspora macra</i> Sullivan, 1968	•			
<i>Diaphanospora depressa</i> (Balme & Hassell) Evans, 1970	•	•	•	Figs. 4f, g
<i>Diaphanospora perplexa</i> Balme & Hassell emend. Evans, 1970	•	•	•	Fig. 4i
<i>Diaphanospora riciniata</i> Balme & Hassell emend. Evans, 1970	•	•	•	Fig. 4h
<i>Endosporites micromanifestus</i> Hacquebard, 1957	•			
<i>Grandispora clandestina</i> Playford, 1976	•			
<i>Retispora lepidophyta</i> (Kedo) Playford, 1976	•	•	•	Figs. 4l-n
Acritarchs	•	•	•	
Scolecodonts		•		

*Lophozonotriletes varionodosus* sp. nov.  
(Figs. 3j-n)

1976 *Lophozonotriletes* sp. A of Playford, pp. 30-31; pl. 5, fig. 9.

**Diagnosis.** Spores radial, trilete. Amb subcircular to roundly subtriangular; periphery gently, irregularly undulating. Laesurae distinct, more or less straight; simple or accompanied by very narrow lip development towards proximal pole; extending near or almost to cingulum's inner margin. Distal surface, including cingulum, conspicuously sculptured with verrucae that are somewhat variable in terms of shape, size, and spacing. Basal diameter of verrucae 2-11  $\mu\text{m}$  (usually up to 6  $\mu\text{m}$ ), height 1.5-3.5  $\mu\text{m}$ ; basal outline varies from subcircular to irregularly rounded-elongate, tops from rounded to flattened. Verrucae mainly discrete (up to 10  $\mu\text{m}$  apart), but sometimes coalescent basally in groups of 2, 3, or (rarely) 4. Proximal exine, and non-verrucate distal exine, laevigate to faintly scabrate.

**Dimensions** (15 specimens). Overall equatorial diameter 44 (56) 71  $\mu\text{m}$ ; diameter of spore cavity 33 (41) 60  $\mu\text{m}$ .

**Holotype.** Preparation D526/10, 109.1 12.7, CPC 22162; Fig. 3n. Proximal aspect. Amb subcircular, equatorial diameter 45  $\mu\text{m}$  overall, diameter of spore cavity 35  $\mu\text{m}$ ; narrowly lipped laesurae almost attain inner margin of cingulum; mainly discrete distal verrucae, 2-6  $\mu\text{m}$  in basal diameter, 1.5-2  $\mu\text{m}$  high, irregularly distributed (up to 6.5  $\mu\text{m}$  apart); equatorial margin (of cingulum) irregularly undulant due to verrucate sculpture.

**Type locality.** Type section of Buttons beds, Ord River, Bonaparte Gulf Basin, Western Australia (see Fig. 2); sample 04/01A, 131.1 m above exposed base of section.

**Name derivation.** Lat., *vario*, to vary; *nodus*, swelling, knob.

**Comparison.** See Playford (1976, p. 31) for comparison with Russian Late Devonian/Tournaisian species described by Naumova (1953) and Kedo (1957, 1963).

**Distribution.** *Lophozonotriletes varionodosus* sp. nov. has been encountered in all three palyniferous samples of the Buttons beds examined herein (Table 1). It is known also from a latest Devonian sample of the Fairfield Group (i.e., Yellow Drum Sandstone), Canning Basin, Western Australia (Playford, 1976); and from the lower part of the Mount Eclipse Sandstone, Ngalia Basin, Northern Territory (Playford, unpubl. data).

### Correlation and age of the palynoflora

All constituent miospore species of the Buttons beds palynoflora are known to occur in the lower part of the latest Devonian-Early Carboniferous Fairfield Group (i.e., Gumhole Formation and overlying Yellow Drum Sandstone: Druce & Radke, 1979) of the northern Canning Basin, Western Australia (see Balme & Hassell, 1962; Playford, 1976). Indeed, the majority of the species present have been reported as confined vertically to the lower Fairfield; while several (viz. *Granulatisporites frustulentus*, *Verrucosisporites nitidus*, *Convolutispora fromensis*, *Knoxisporites literatus*, *Diaphanospora* spp., and *Endosporites micromanifestus*) are known to extend into the younger part of the Fairfield Group (Laurel Formation). In terms of Playford's (1976) Fairfield assemblages, the Buttons beds palynoflora is unmistakably representative of the *Retispora lepidophyta* Assemblage. The latter occurs not only in the Gumhole Formation and Yellow Drum Sandstone, but has also been recovered from the lower part of the Mount Eclipse Sandstone of the Ngalia Basin, Northern Territory (Playford, unpubl. data), the lower part of the Gilberton Formation of the Georgetown Block, north Queensland (Foster & Playford, unpubl. data), and the Ravendale Formation of the Balcannia Trough, New South Wales (Evans, 1968; Roberts & others, 1972, p. 485).

Dating of the *Retispora lepidophyta* Assemblage has previously been discussed by Playford (1976, p. 55), who concluded that it is assignable to the latest Devonian, viz. latest Famennian, Fa2d, to Strunian (Etroeungt), Tn1a, or early Tn1b, of Belgian terminology. This conclusion was based upon abundant published information that the widely reported, virtually ubiquitous, nominate taxon is confined vertically to the above-mentioned, immediately pre-Carboniferous interval (Fa2d-Tn1a or early Tn1b); see, for instance, Strel (1974), McGregor (1979, p. 177, text-fig. 8). Moreover, the age assessment was consonant with microfaunal data from the Fairfield Group (see discussions by Playford, 1976, pp. 6-8, Druce & Radke, 1979, and references cited in both papers).

With respect to the distribution of *Retispora lepidophyta*, there have been some recent suggestions that its stratigraphic range might be somewhat less restricted than has hitherto been acknowledged. Firstly, it should be noted that several Russian palynologists (e.g. Raskatova, 1974; Kedo, 1974) have indicated intermittent and sparse representation of *R. lepidophyta* in older Famennian deposits, i.e. prior to the plenitude and consistency of occurrence of that species in latest Famennian-earliest Tournaisian strata.

Dr. P. J. Jones has courteously drawn the writer's attention to a paper by Chizhova & Bouckaert (1976), concerned primarily with a comparison of ostracod faunas in Devonian-Carboniferous boundary strata from Belgium and the Russian Platform. These authors (pp. 22-23) alluded to a publication by Nenastieva (1975), who had reported abundant representatives of *R. lepidophyta* (as '*Hymenozonotriletes lepidophytus*' and the varieties *minor* and *tener*) from the Zelenetsky 'Horizon' of the Timan-Pechora region in the north-eastern sector of European U.S.S.R. On palynological grounds, Sennova (1972) and Nenastieva (1975) correlated the Zelenetsky Horizon with the Kudayarovsky and Ozersky Beds of the central Russian Platform, and with the Zavolzhsy Horizon of the Volga-Ural region, which are regarded as Fa2d-Tn1a age equivalents (Reitlinger & others, 1979, fig. 1; McGregor, 1979, text-fig. 7). However, Chizhova & Bouckaert (1976) asserted that the ostracods and foraminiferids associated with Nenastieva's material favour an older age: specifically, early late Famennian (Fa2a $\beta$ -Fa2b), within the *Platyclymenia* (ammonoid) Zone. Reitlinger & others (1979, p. 33), following a detailed discussion of the lines of evidence available up to 1975, concluded that the question of the age of the Zelenetsky Horizon has yet to be resolved among Soviet palaeontologists, who date it variously 'as being equivalent to the *Platyclymenia*, *Gonoclymenia*, and/or basal *Wocklumeria* Zones, depending on the group of organisms on which the assessment is based'; i.e. within an age range of Fa2b-Fa2d (and possibly Tn1a).

More recently, Dr. M. Strel (written communication, 18 January, 1982) has advised on his and Dr. T. V. Byvsheva's re-examination of Nenastieva's (1975) material. This confirmed Sennova's (1972) observations that 'true' *Retispora lepidophyta* makes its first appearance, not at the base of the Zelenetsky Horizon, but in the upper part of the lower ("*Entomozoe* beds") section of the Horizon. This assumes some importance in the light of the findings of Chizhova, Bouckaert, &

others (1979) on conodont faunas from one of the boreholes (Vezhaiou 825) studied by Nenastieva (1975) and from another (Numylg 1) in the Timan-Pechora region. Bouckaert and his co-authors (p. 29) concluded that the lower portion of the Zelenetsky Horizon contains, successively, faunas of the *Palmatolepis marginifera* Zone, *Scaphignathus velifer* Zone, *Polygnathus styriacus* Zone, and of the lower and middle parts of the *Bispathodus costatus* Zone (see Fig. 5). Therefore, Chizhova, Bouckaert, & others (1979) considered that the *Entomozoe* beds correspond, in Belgian terminology, with the interval Fa2a-Fa2d (partly). Strel concluded his written communication by stating his belief that the introduction of *Retispora lepidophyta* postdates the middle *styriacus* Zone.

The upper stratigraphic limit of *R. lepidophyta* appears to be fully accepted as more or less coincident with the Devonian-Carboniferous boundary, notwithstanding current debate about the precise placement of that boundary and faunal criteria appropriate for its recognition (Paproth, 1980, p. 287; Van Veen, 1981, pp. 68-70). The latter author, however (p. 86), pointed to possible slight extension of the species into basal Carboniferous sediments in two sections of the Ardenno-Rhenish Basin.

From the above discussion, it seems clear that *R. lepidophyta* is abundantly characteristic of palynofloras of the latest Devonian (Fa2d to Tn1a or early Tn1b), but that its introduction, in some regions at least, could well date from significantly earlier in the Famennian. There remains an obvious need for more adequate substantiation of these older occurrences (e.g. Raskatova, 1974) in terms of illustration/description of the spores and of associated, potentially age-definitive faunas (cf. Paproth & Strel, 1970; Sandberg & others, 1972; Becker & others, 1974).

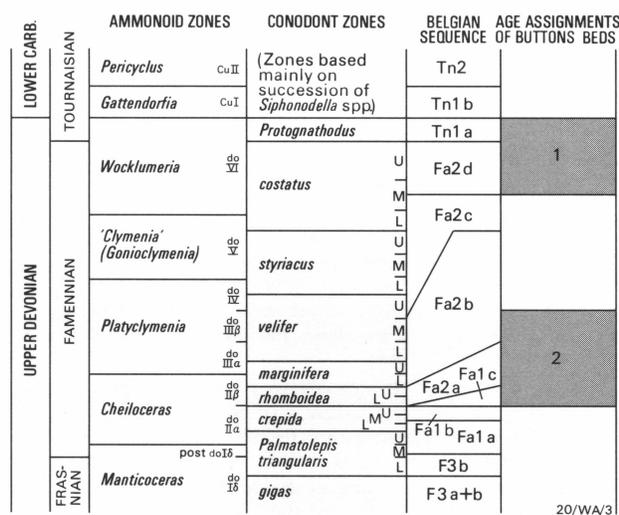


Figure 5. Chart showing disparate datings of the Buttons beds within the Late Devonian.

In extreme right-hand column, position 1 is based on palynological data presented herein; position 2 is based on palaeozoological data of previous authors as cited in text. Standard (European) subdivisions of the younger part of the Upper Devonian are adapted from Ziegler (1971, 1979) and House (1979); and of the initial part of the Lower Carboniferous from Ross (1979).

Taking into account the specific identity of the Buttons beds palynoflora with the faunally dated *Retispora lepidophyta* Assemblage of the lower Fairfield Group, as well as the above evaluation of the known distribution of *R. lepidophyta* itself, it seems reasonable to regard the subject palynoflora and its host sediments as latest Devonian in age. This is somewhat younger than the age proposed earlier on faunal grounds, although of course both assessments fall within the Famennian or at least the post-Frasnian Late Devonian interval (Fig. 5).

The stratigraphic implications of a latest Devonian dating are such as to:

- (a) introduce a hiatus (disconformity), spanning much of the Famennian, between the Buttons beds and the underlying Jeremiah Member of the Famennian Cockatoo Formation;
- (b) correlate the Buttons beds with the upper rather than the lower part of the Ningbing Limestone; and
- (c) minimise or perhaps eliminate the supposed hiatus between the Buttons beds and the succeeding Early Carboniferous Burt Range Formation, as suggested, for instance, by Jones (1968, fig. 7) and Roberts & others (1972, correlation chart).

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