ISOTOPIC DATING OF A MIDDLE TRIASSIC MEGAFOSSIL FLORA FROM NEAR NYMBOIDA, NORTHEASTERN NEW SOUTH WALES

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Synopsis

A basalt flow, with a K–Ar isotopic age of 211±5 million years, is interbedded between two homotaxial Aniso-Ladinian fossil flora within the Nymboida Coal Measures underlying the far southwestern Moreton Basin. The Dalmally Basalt Member (new name) of the Bardool Conglomerate is a flow because it has a chilled base and coarse grained top, an increased size of feldspar phenocrysts and vesicles upwards, and it is concordant in dip and strike with the surrounding sedimentary rocks. Flint and Gould (1975) have recently correlated the rich fossil flora of the Basin Creek Formation, stratigraphically above the basalt flow, with the Aniso-Ladinian flora of the Esk Trough in southeastern Queensland. The fossil flora of the Cloughers Creek Formation, stratigraphically below the basalt flow, is essentially identical to that of the Basin Creek Formation. The basalt thus furnishes one well-documented isotopic date for Aniso-Ladinian Gondwanaland megafossil floras now recognised in eastern Australia, South Africa and South America.

In the description of the fossil flora of the Cloughers Creek Formation, G.R. proposes the following new species and varieties: *Lobifolia dejerseyi* sp. nov., *Dicroidium dubium* var. *tasmaniense* comb. nov. and *D. odontopteroides* var. *remotum* comb. nov.

INTRODUCTION

Diverse and in places well-preserved Triassic fossil floras are associated with an isotopically dated basalt flow within the Nymboida Coal Measures (Fig. 1). These rocks outcrop for a few miles around the small township of Nymboida, 35 km southwest of Grafton, northeastern New South Wales (Fig. 2). The Nymboida Coal Measures unconformably overly deformed Palaeozoic metasediments of the New England Fold Belt to the west. They form an isolated outcrop underlying terrestrial sediments of the far southwestern Moreton Basin (Day et al., 1974).

McElroy (1963) mapped the area around Nymboida in considerable detail. The megafossil flora of the area has been studied by De Jersey (1958) and Flint
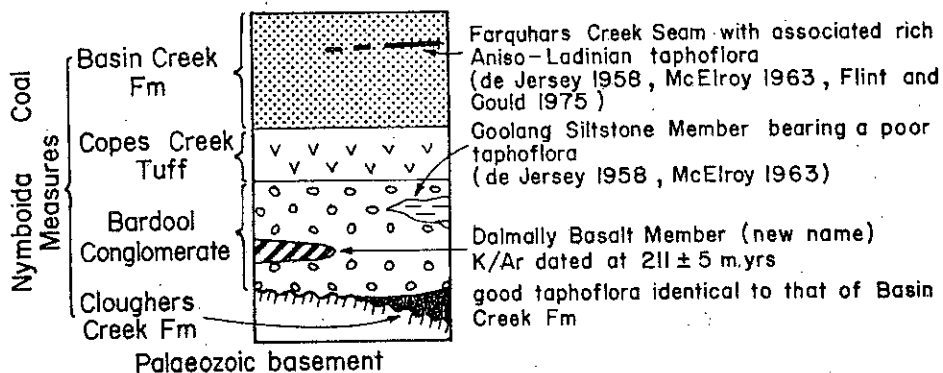

Fig. 1. Geological relationship of the isotopically dated basalt flow with the fossil floras and a lithological key to Fig. 2.

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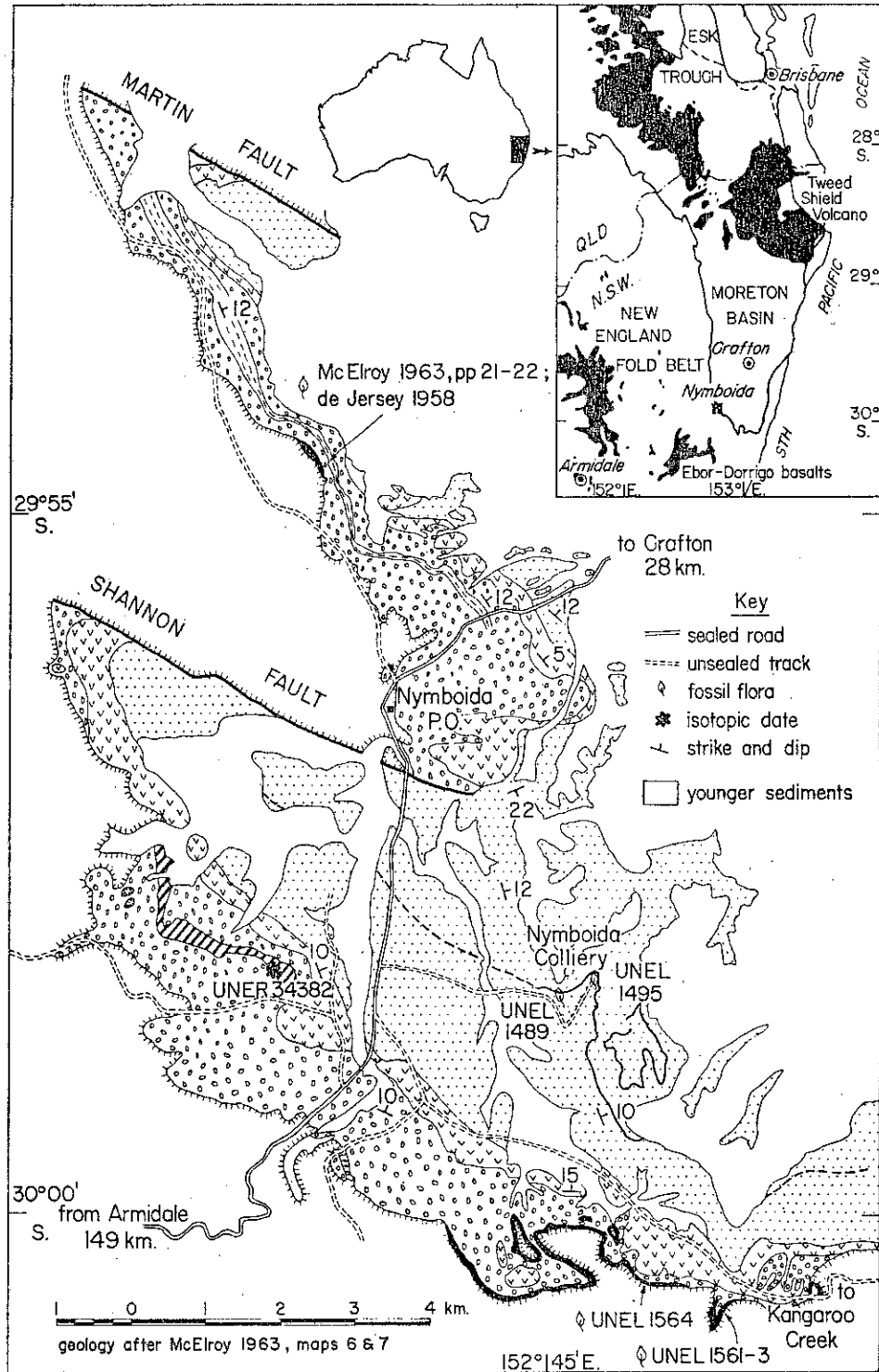
Fig. 2.   Geological map of the Nymboida Coal Measures.

and Gould (1975). Unfortunately, pollen and spores recovered from the Nymboida Coal Measures have been too poorly preserved to be of any biostratigraphic use (De Jersey, 1958 ; McElroy, 1963, p. 25 ; J. C. E. Flint, pers. comm.)

DALMALLY BASALT MEMBER (RETALLACK, NEW NAME)

Enclosing Formation. Bardool Conglomerate of the Nymboida Coal Measures, underlying the far southwestern Moreton Basin (McElroy, 1963).

Type Section. The basalt is about 15 m thick outside the meander bend on the true right bank of Copes Creek ("Nymboida" 1 : 63,360 military map, grid. ref. 808877).

Derivation. After Dalmally Homestead, near where Copes Creek flows into the Nymboida River.

Description. McElroy (1963, pp. 49, 59) has described the outcrop, petrography and chemistry of this unit. The C.I.P.W. norm calculated from McElroy's analysis indicates a subalkaline (non-alkaline) basaltic composition. Several specimens illustrating the textural variation in this rock have been placed in the collections of the Geology Department, University of New England (UNER34382, 35367–35370).

Why the Dalmally Basalt Member is a Triassic Flow. The elongate outcrop of the basalt is concordant with the strike of the surrounding Triassic sedimentary rocks and completely within the outcrop of the Bardool Conglomerate (Fig. 2). The dip of the bench-forming top of the basalt is also the same as the dip of overlying conglomerate, sandstone and tuff. Concordance is also supported by the outcrop pattern of vertical texture variation in the basalt (Fig. 3) at the type locality.
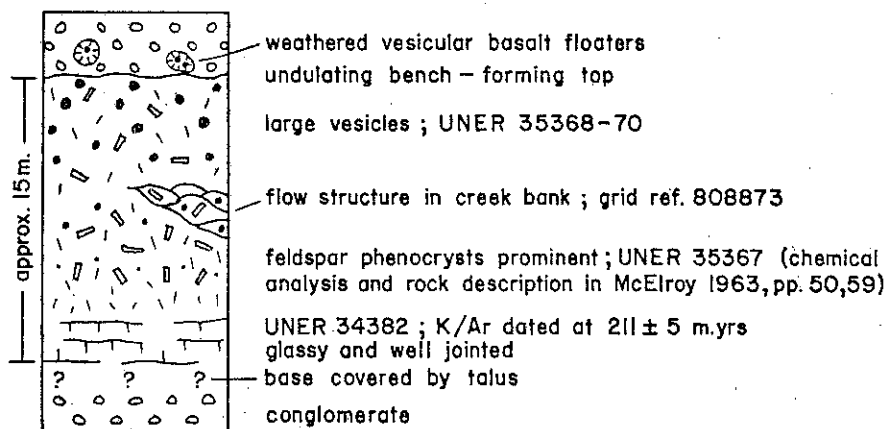

Fig. 3. Vertical texture variation in the Dalmally Basalt Member of the Bardool Conglomerate.

The basalt has a glassy, block-jointed base, and a more massive central portion containing feldspar phenocrysts. Amygdales and vesicles increase in abundance and size towards the top of the flow (Fig. 3). The vesicles are up to 3 cm in diameter and may be partly or completely filled with calcite, zeolites and quartz. Some rounded basalt floaters found on the hillside above the top of the basalt are very strongly vesicular and resemble basaltic scoria (Green and Short, 1971, fig. 162b). In the creek bank exposure at "Nymboida" grid. ref. 808873, coarsely vesicular basalt with lenticular flow structure appears to cut a shallow channel into the underlying well-jointed basalt.

The Cope's Creek Tuff, only 15 to 30 m above Dalmally Basalt Member, is evidence of associated Triassic pyroclastic activity in this area.

The Dalmally Basalt Member is chemically more similar to some Triassic basalts in southeastern Queensland than to subalkaline Tertiary basalts in northeastern New South Wales (Fig. 2; McElroy, 1963, p. 63). " The low Fe/Mg ratio and low K_2O content (0·35%) distinguish the Dalmally Basalt Member from the subalkaline volcanics in the southern portion of the middle Miocene Tweed Shield Volcano. Not enough is known about the Miocene basaltic lavas of the Ebor-Dorrigo area to make an effective comparison. Houston (1965) considered some volcanics from the base of the Triassic Ipswich Coal Measures in southeastern Queensland to be spilites, but there appears to be insufficient mineralogical data to warrant terming these rocks spilites *s.s.* The analysed volcanics are altered to varying degrees, but inspection of the analyses (Houston, 1965, table 1) suggests some chemical affinities with the Dalmally Basalt Member." (J.F.G. Wilkinson, pers. comm.)

ISOTOPIC AGE OF THE DALMALLY BASALT MEMBER

Unweathered plagioclase from near the base of the basalt (UNER34382) yielded a $^{40}K/^{40}Ar$ isotopic date of 211 ±5 million years. The determination was made by Dr D. C. Green (Isotope Laboratory, Department of Geology and Mineralogy, University of Queensland), who has also supplied the following ancillary data and constants : $\%K_2O$ (av.)=0·36 ; vol. radiogenic ^{40}Ar std.cc. = 0·02664 ×10^{-5} ; % radiogenic ^{40}Ar=86·6 ; λ_e=0·585 ×10^{-10}/yr ; λ_β=4·72 × 10^{-10}/yr ; $^{40}K/K$=1·19 ×10^{-4} mole/mole.

NEW FOSSIL PLANT LOCALITIES IN THE CLOUGHERS CREEK FORMATION

The Cloughers (pronounced " Cloggers " by the local residents) Creek Formation (McElroy, 1963) is the lowest formation of the Nymboida Coal Measures, underlying the Bardool Conglomerate in restricted areas (Figs 1, 2). Several new plant fossil localities have been given University of New England, Geology Department fossil locality numbers (UNEL-).

Only fragmentary remains were found associated with the coal seam at locality H of McElroy (1963, map 12), near the base of the Cloughers Creek Formation (Fig. 4). The following species are identified from the top of the seam (UNEL1561) :

Pteruchus dubius (Thomas) Townrow 1961
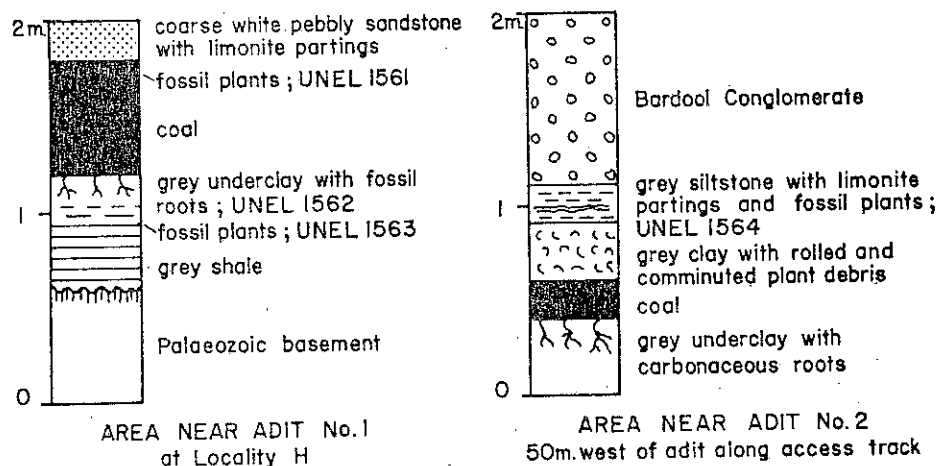*Lepidopteris madagascariensis* Carpentier 1935

Fig. 4. Geology of fossil plant localities in the Cloughers Creek Formation (locality H and adits are shown by McElroy, 1963, maps 12, 13).

The underclay of the coal seam (UNEL1562) contained only many-branched woody roots.

In well-bedded carbonaceous shale below the underclay (UNEL1563) all the fossil plant remains are very fragmentary. Comparison with more complete material from the Cloughers Creek Formation suggests the following species are present:

Lobifolia dejerseyi sp. nov.
Dicroidium lancifolium (Morris) Gothan 1912
D. odontopteroides var. *remotum* comb. nov.
D. zuberi (Szajnocha) Archangelsky 1968c
Rissikia media (Tenison-Woods) Townrow 1967b (cone)
Fructification type A
Fructification type B
Fructification type C

The best collection was obtained from a grey siltstone at the very top of the Cloughers Creek Formation on the track 100 m west of adit number 2 (UNEL1564; McElroy, 1963, map 13). The plant fossils have all been leached of organic matter and iron stained to varying extent. Some layers, consisting almost entirely of leaves without intervening sediment, form muddy solution planes in the rock. Asterisks indicate the more common forms.

Arctopteris sp.
* *Cladophlebis gondwanica* Frenguelli 1947
C. mendozaensis (Geinitz) Frenguelli 1947
Lobifolia dejerseyi sp. nov.
Dicroidium dubium var. *tasmaniense* comb. nov.
D. eskense (Walkom) Jacob and Jacob 1950
D. incisum (Frenguelli) Anderson and Anderson 1970
D. odontopteroides var. *remotum* comb. nov.
D. superbum (Shirley) Townrow 1957
* *D. zuberi* (Szajnocha) Archangelsky 1968c
Pteruchus johnstonii (Feistmantel) Townrow 1962
Pilophorosperma sp. cf. *P. costulatum* Thomas 1933
Lepidopteris madagascariensis Carpentier 1935
Taeniopteris carruthersii Tenison-Woods 1883
* *Phoenicopsis elongatus* (Morris) Seward 1919
* *Sphenobaiera argentinae* (Kurtz) Frenguelli 1946
S. stormbergensis (Seward) Frenguelli 1948
Rissikia media (Tenison-Woods) Townrow 1967b (foliar spur)
Fructification type A

COMPARABLE FOSSIL PLANTS FROM THE BASIN CREEK FORMATION

The Basin Creek Formation is the uppermost formation of the Nymboida Coal Measures. Fossil plants from the Nymboida Colliery open cut(UNEL1489) and drives (UNEL1495) have been described by several authors (De Jersey, 1958; McElroy, 1963, p. 65; Flint and Gould, 1975). Since viewing the large private collection of Mr W. B. K. Holmes, we now realise that this flora is more diverse than previously thought. Certainly much interesting and worthwhile work could be done. However here we only list species which are directly comparable to those described from the Cloughers Creek Formation. We have added new species and emended others in the list of Flint and Gould (1975).

Cladophlebis gondwanica Frenguelli 1947
C. mendozaensis (Geinitz) Frenguelli 1947
Lobifolia dejerseyi sp. nov. (=*Hoegia* sp. De Jersey, 1958; =*Cladophlebis lobifolia* in Flint and Gould, 1975)

B

Dicroidium dubium var. *tasmaniense* comb. nov.
D. eskense (Walkom) Jacob and Jacob 1950
D. lancifolium (Morris) Gothan 1912
D. odontopteroides var. *remotum* comb. nov.
D. superbum (Shirley) Townrow 1957
D. zuberi (Szajnocha) Archangelsky 1968c (=*D. feistmantelii* and *Hoegia papillata* in Flint and Gould, 1975)
Pteruchus dubius (Thomas) Townrow 1961
P. johnstonii (Feistmantel) Townrow 1962
Pilophorosperma sp. cf. *P. costulatum* Thomas 1933
Lepidopteris madagascariensis Carpentier 1935
Taeniopteris carruthersii Tenison-Woods 1883 (=*T. lentriculiforme* in part of Flint and Gould, 1975)
Phoenicopsis elongatus (Morris) Seward 1919
Sphenobaiera argentinae (Kurtz) Frenguelli 1946
S. stormbergensis (Seward) Frenguelli 1948
Rissikia media (Tenison-Woods) Townrow 1967b (foliar spurs)
Fructification type C
Woody many-branched roots

COMPARABLE FOSSIL PLANTS FROM THE GOOLANG SILTSTONE MEMBER

McElroy (1963, p. 21) collected some fossil plants from the Goolang Siltstone Member of the Bardool Conglomerate, 3 km north of Nymboida post office (" Nymboida " grid. ref. 816944 : Fig. 2). We have emended De Jersey's (1958) determinations of these fossil plants :

Lobifolia dejerseyi sp. nov.

Dicroidium dubium var. *tasmaniense* comb. nov.

AGE AND UNITY OF FOSSIL FLORULES IN THE NYMBOIDA COAL MEASURES

Of the 23 fossil plant species recognised in the Cloughers Creek Formation 20 can be matched with very similar specimens from the Basin Creek Formation. The three fossil plant species not common to the two formations are rare leaves and fructifications. The two fossil plant species found in the Goolang Siltstone Member of the Bardool Conglomerate are also found in both the Cloughers Creek and Basin Creek Formations. Thus these three florules are essentially homotaxial and may be regarded as belonging to the same megafloral biozone. The fossil flora of the Nymboida Coal Measures is most similar to Aniso-Ladinian flora of the Esk Trough in southeastern Queensland (De Jersey, 1972 ; Flint and Gould, 1975).

RECOGNISING ANISO-LADINIAN GONDWANALAND MEGAFOSSIL FLORAS

Aniso-Ladinian flora of Gondwanaland are relatively distinct from older Scytho-Anisian floras (Banks et al., 1967 ; Townrow, 1967a ; Banks and Clarke, 1973). However they are not easy to distinguish from Carnian to Norian flora. Both younger Triassic flora have many elements in common. Both are very diverse and variably represented at individual localities. Nevertheless workers in South America, South Africa and Australia (Frenguelli, 1948 ; Du Toit, 1927 ; Flint and Gould, 1975) have attempted biostratigraphic separation, despite the opposing tendencies to resist dividing Middle to Late Triassic flora (Stipanicic and Bonetti, 1969) and to refer most of the richer Triassic flora to the Carnian (Anderson and Anderson, 1970). The difference between Aniso-Ladinian and Carnian to Norian fossil plant assemblages is outlined below for Australia, South Africa and South America. Many of the emended records listed here are new. Further intercontinental comparative work will be necessary before formal subdivisions can be proposed.

In eastern Australia the following species are confined to Aniso-Ladinian flora of the Esk Trough in Queensland and the Nymboida Coal Measures of New South Wales (see also Flint and Gould, 1975) :

Asterotheca hillae Walkom 1924

Dictyophyllum davidii Walkom 1917a

Cladophlebis gondwanica Frenguelli 1947

Lobifolia dejerseyi sp. nov. (=*Hoegia* sp. in De Jersey , 1958 ; =*Cladophlebis lobifolia* in Flint and Gould, 1975)

Kurtziana brandmayri Frenguelli 1944b (="*Thinnfeldia*" *eskensis* in Hill *et al.*, 1965, pl. T5, Fig. 3 only)

Dicroidium eskense (Walkom) Jacob and Jacob 1950

D. odontopteriodes var. *remotum* comb. nov.

Anthrophyopsis grandis Walkom 1928

Pseudoctenis eathiensis (Richards) Seward 1911

The following species are much more common in the Aniso-Ladinian rocks of the Esk Trough and the Nymboida Coal Measures than in the Carnian Ipswich Coal Measures (see also Jones and De Jersey, 1947, pp. 19, 31, 46) :

D. superbum (Shirley) Townrow 1957 (*s.s.*, lobed pinnules with clear venation)

Johnstonia coriacea (Johnston) Walkom 1925a (*s.s.*, narrow lamina with entire margins)

Taeniopteris carruthersii Tenison-Woods 1883 (=*T. lentriculiforme* of Flint and Gould, 1975, in part, and of Hill *et al.*, 1965)

T. crassinervis (Feistmantel) Walkom 1917a

Although common in the Ipswich Coal Measures, *Yabeiella* and *Fraxinopsis* have not been found in the Esk Trough or Nymboida Coal Measures. *Xylopteris elongata* (Carruthers) Frenguelli 1943 is common at some localities in the Ipswich Coal Measures, but rare in the Esk Trough and in the Brookvale shale lens of the Hawkesbury Sandstone in the Sydney Basin (probably Anisian ; see Helby, 1969).

Du Toit (1927, p. 293) states that the lower portion of the Molteno Beds (Stage C) in South Africa " has produced many genera and species, the majority of which appear again in stage D ; only a few are restricted to stage C, for example *Cladophlebis rösserti*, *Marattiopsis münsteri* and *Thinnfeldia narrabeenensis* ". However in a table (Du Toit, 1927, pp. 307-308) *Yabeiella ? dutoitii* Oishi 1931 (=*Marrattiopsis muensteri* of Du Toit, 1927) is only indicated for the middle Molteno Beds (Stage D). From this table the following species are confined to Stage C. Those marked with a + also occur in the Esk Trough of Queensland and the Nymboida Coal Measures of New South Wales.

+*Cladophlebis gondwanica* Frenguelli 1947 (=*C. roesserti* of Du Toit, 1927)

+*Dicroidium eskense* (Walkom) Jacob and Jacob 1950 (=*Thinnfeldia narrabeenensis* of Du Toit, 1927)

D. sp. cf. *D. odontopteroides* (Morris) Gothan 1912 (very like *Dicroidiopsis crassa* var. *prolungata* Menendez 1951 ; =*Thinnfeldia rhomboidalis* of Du Toit, 1927)

+*D. superbum* (Shirley) Townrow 1957 (=*Thinnfeldia feistmanteli* var. *trilobita* of Du Toit, 1927)

+*Taeniopteris crassinervis* (Feistmantel) Walkom 1917a

Pseudoctenis sp. cf.

P. ballii (Feistmantel) Seward 1917

P. fissa Du Toit 1927

Fabré and Greber (1960) have also identified many of these species in a flora from the Molteno Beds near Morija, Basutoland. Their *Dictyophyllum ellenbergii* is closest to the Aniso-Ladinian species *D. davidii* of Australia (Walkom. 1917a ; Flint and Gould, 1975) and *D. tenuifolium* of Argentina (Bonetti and Herbst, 1964).

This distinction is not apparent in Anderson's (1974) review of the Molteno flora Her list contains many new species and combinations but there are no accompanying illustrations or descriptions. If her distribution chart is rearranged in the stratigraphic succession of fluvial cycles given by her, only five out of 104 listed species do not occur in cycle 2. These five are mainly new species and all of apparently little stratigraphic value. Within cycle 2, those of Du Toit's (1927) Stage C and Stage D plants which can be made out from the list, occur in separate localities.

Frenguelli (1948) noted the following species as typical of the lower levels in Argentine Triassic basins :

+*Neocalamites carrerei* (Zeiller) Halle 1908

+*Asterotheca fuchsii* (Zeiller) Solms-Laubach 1899 (=*A. truempyi* of Frenguelli, 1948, according to Townrow, 1957)

? +*Cladophlebis roylei* Arber 1901

Chiropteris barrealensis Frenguelli 1942e

+*Kurtziana brandmayri* Frenguelli 1944b

+*Dicroidium dubium* var. *tasmaniense* comb. nov.

+*D. lancifolium* (Morris) Gothan 1912 and/or *D. eskense* (Walkom) Jacob and Jacob 1950 (=*Displasiophyllum acutum* of Frenguelli, 1948)

+*D. odontopteroides* var. *remotum* var. nov. (=*D. remotum* of Frenguelli, 1948)

+*D. zuberi* (Szajnocha) Archangelsky 1968c (=*Zuberia feistmantelii*, *Z. sahnii* and *Z. zuberi* of Frenguelli, 1944a, 1948)

Xylopteris spinifolia (Tenison-Woods) Frenguelli 1943

+*Taeniopteris daintreei* McCoy 1875 (separate from *T. spatulata sensu* Frenguelli 1944b, pp. 387–388, *non* Walkom 1917a, p. 30)

Voltziopsis angusta (Walkom) Townrow 1967c (=*Walkomia primula* of Frenguelli, 1944b, according to Townrow, 1967c)

Many of these species (marked with a +) are also known from the Esk Trough in Queensland and the Nymboida Coal Measures in New South Wales. Only questionable remains of *Cladophlebis roylei* have been found in the Esk Trough and Ipswich Coal Measures (Walkom, 1917a, p. 5 ; Frenguelli, 1947, p. 27). *Kurtziana brandmayri* has been figured from the Esk Trough by Hill et al. (1965, pl. T5, Fig. 3 only as "*Thinnfeldia*" *eskensis*). *Xylopteris spinifolia* has not been found in the Esk Trough or the Nymboida Coal Measures, but is known from the younger Ipswich Coal Measures (Jones and De Jersey, 1947). *Taeniopteris daintreei* (*s.s.* Frenguelli, 1944b) includes leaves, like that figured by Flint and Gould (1975, pl. 3, fig. 9) and Hill et al. (1965, pl. T8, fig. 4) as *T. lentriculiforme* from the Nymboida Coal Measures and the Esk Trough. *Chiropteris barrealensis* has only been found at one locality in the Barreal-Hilario Basin of Argentina (Frenguelli, 1942e).

Voltziopsis angusta is known from the upper Narrabeen Group of the Sydney Basin, New South Wales, possibly from Tanganyika, Africa, and also immediately above a 2 m thick sandstone near the base of the Triassic sequence in the Cacheuta Basin, Argentina (Townrow, 1967c). The sandstone in Argentina contains largely *Dicroidium zuberi* (=*Zuberia feistmantellii*, in Frenguelli, 1944b), but also *Equisetites* sp., *Sphenopteris* sp., *Pterophyllum* sp., *Nilssonia* sp. cf. *N. taeniopteroides* and a (?) cone (Frenguelli, 1944b). This assemblage is most similar to that of the upper Narrabeen Group of the Sydney Basin, New South Wales, of late Scythian to early Anisian age (Helby, 1969).

In addition to the species listed by Frenguelli, *Dictyophyllum tenuifolium* (Bonetti and Herbst, 1964) from Paso Flores and the basal formation of the Barreal-Hilario Basin in Argentina also has Aniso-Ladinian affinities.

We can now most easily recognise Aniso-Ladinian assemblages from the Esk Trough and Nymboida Coal Measures in Australia ; the lower Molteno Beds (Stage C of Du Toit. 1927, or cycle 1 and part of cycle 2 of Anderson, 1974) in

South Africa; the Las Cabras Formation of the Cacheuta Basin (excluding the lowest two *Voltziopsis* and *Dicroidium zuberi* dominated localities of Frenguelli, 1944b) and the Potrerillos Formation in the Challao-San Isidro Basin (Frenguelli, 1948) in Argentina.

The Aniso-Ladinian flora from the Esk Trough and the Nymboida Coal Measures were probably diverse forest assemblages on a broad coastal plain between a hilly region to the west and the Eopacific ocean to the east. A generally similar habitat and geographic continuity probably explains why comparison of fossil flora from the Esk Trough and Nymboida Coal Measures works so well (Flint and Gould, 1975). This also explains similarities with Argentine and South African plant megafossil successions.

Gould and Retallack (in Bourke et al., in press) found that Aniso-Ladinian and Carnian to Norian flora could not be so easily distinguished inland of the old Triassic dividing range, near Delungra, New South Wales. An Aniso-Ladinian age for this flora rests largely on the presence of *Lobifolia dejerseyi* sp. nov. (=*Cladophlebis lobifolia* in Bourke et al., in press), the abundance of *Johnstonia coriacea s.s.* and the rarity of *Xylopteris elongata*. One of us (G.R.) has examined some fossil plants from Antarctica in the collections of the New Zealand Geological Survey (partly described by Townrow, 1967a) and Victoria University, Wellington (localities collected on VUWAE 16 1971–1972 in Barrett and Webb, 1973). These appear to be inland plant associations because they are similar to the Delungra florule. The distinction between Aniso-Ladinian and Carnian to Norian flora may prove difficult to make here. This distinction is even more difficult to make in floras from Mount Potts, Benmore Dam and near Corbies Creek in New Zealand (New Zealand Geological Survey collections) where very few distinctive Aniso-Ladinian forms are present. These New Zealand flora appear to be specialised coastal communities associated with Kaihikuan (=Ladinian) marine rocks.

ISOTOPIC TIME SCALE WITHIN THE TRIASSIC

Up to the present, the isotopic time scale within the Triassic has been based on terrestrial sediments with extrusives. There is every indication that future progress will rely on more detailed knowledge of fossil plants and vertebrates and their correlation with marine stages. Our K-Ar date of 211 ± 5 million years for an Aniso-Ladinian fossil flora can be regarded as one of the more reliable points for the scale.

The Triassic period probably ranged from 200 to 240 million years ago (Green and Webb, 1974). As Tozer (1964) notes, the minimum $^{207}Pb/^{235}U$ age of 218 ± 5 million years for Carnian pitchblende ores has been much debated. Also an upper limit only is given by the 193 million year old Palisades Sill which intrudes sedimentary rocks with Norian plants and vertebrates. Stipanicic (1969) records "Middle to Upper Triassic" floras in Argentina overlying 222 and 228 ± 20 million year old porphyrites at Los Menucos and a 194 ± 25 million year old granite in the Chihuiu-Tronquimalal Basin. As with this South American data, many K-Ar dates from southeastern Queensland (Green and Webb, 1974) cannot be correlated with the geological time scale until we know more about the floras and their geological relationships to the dated rocks.

SYSTEMATIC PALAEOBOTANY OF THE CLOUGHERS CREEK FORMATION (G.R.)

In this section plant fossils from the Cloughers Creek Formation are described and compared. Comparable specimens from the Basin Creek Formation are listed but not described or figured here. Synonymies have been compiled according to the informal system of Matthews (1973) only for new or unclear specific concepts. The suprageneric classification is after Scagel et al. (1968). University of New England Geology Department fossils are prefixed by UNEF- and localities by UNEL-.

DIVISION PTEROPHYTA

ORDER FILICALES

UNCLASSIFIED FERN FORM GENERA

Genus ARCTOPTERIS Samylina 1964

Arctopteris sp.

Fig. 5C

1927 *Cladophlebis concinna* ; Du Toit, p. 318, pl. 18, fig. 1.

Description. The single specimen found (Fig. 5C) shows two parallel pinna fragments. The pinnules have rounded apices and coalesce at the base. The lateral veins form an acute angle to the pinnule midvein and are simple or once forked.

Comparison. This fragment cannot be included in *Cladophlebis* (*s.s.* Frenguelli, 1947 ; Herbst, 1971) because of its non-falcate, rounded, basally coalescing pinnules. There is no definite anastomosis of the basal secondary veins of contiguous pinnules as in *Merianopteris* (Arber, 1905, p. 144). The fragment agrees best with the form genus *Arctopteris* (Lebedev, 1974).

The very similar *Merianopteris major* (Feistmantel, 1881, p. 83, pl. 19A figs. 9–11 ; Arber, 1905, p. 144, fig. 34 ; Surange, 1966, fig. 42) could be placed within *Arctopteris*, but differs from our specimen in its larger unveined basal interpinnular area.

A more common group of Gondwanaland leaves differ from this specimen in their sinuous midrib and secondary veins arising at a less acute angle. These are probably best referred to *Cladophlebis mesozoica* and *C. kurtzii* (Frenguelli, 1947 ; Herbst, 1971). They include *Merianopteris major* of Tenison Woods (1883), *Cladophlebis concinna* of Jones and De Jersey (1947) and Flint and Gould (1975), *Cladophlebis wielandii* of Jain and Delevoryas (1967) and probably also *Pecopteris concinna* of Feistmantel (1881) and Surange (1966).

Occurrence. A similar specimen is figured by Du Toit (1927) from the middle Molteno Beds at Konings Kroon, South Africa (Stage D of Du Toit, 1927, and cycle 2 of Anderson, 1974).

Genus CLADOPHLEBIS Brongniart emend. Frenguelli 1947 : 12

Cladophlebis gondwanica Frenguelli 1947

Figs 5D–5F

Description. The large number of specimens found (UNEF14663–14668, UNEF14645, UNEF14659, UNEF14714) suggest that this species was locally abundant near the depositional site of UNEL1564. The primary and secondary rachis are very thick and woody for this genus. The pinnules may appear lobed and basally constricted but this is due to fracture of the rock matrix around an irregularly recurved leaf. The secondary veins generally dichotomise twice and arise very obliquely from the pinnule midvein.

Comparison. This species closely resembles *C. grahamii* (Frenguelli, 1947), but in that species the secondary veins are doubly forked only at the base of the pinnules.

Occurrence. As defined by Frenguelli (1947, p. 32), this species is known from the lower Molteno Beds (Stage C) of South Africa, the Rhaetic or Norian of Tonkin in Vietnam, the (?) Keuper Yenchang Formation of northern Shensi in China, the Triassic of Paso Flores and the Liassic of Piedra Pintada in Argentina, and the Jurassic of Grahamland, Ceylon and India.

Comparable Basin Creek Formation material. UNEF13363/4 from UNEL1489 are part and counterpart of a similar but larger frond than any from the Cloughers Creek Formation.
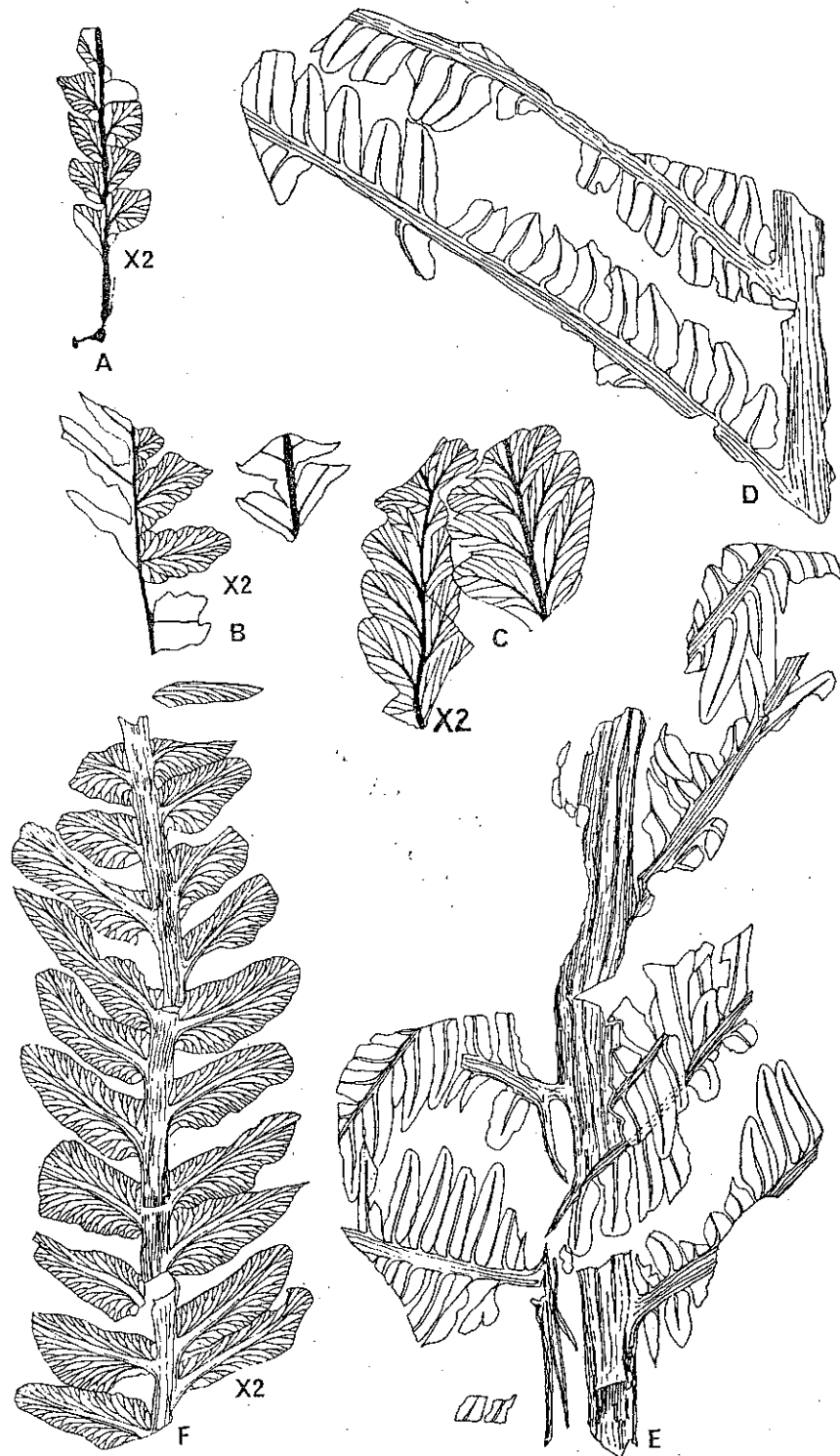
Fig. 5. A. *Lobifolia dejerseyi*. B. *Cladophlebis mendozaensis*. C. *Arctopteris* sp.. D–F. *Cladophlebis gondwanica*. A. UNEF14669, ×2; B. UNEF14681, ×2; C. UNEF-14676, ×2; D. UNEF14663, natural size; E. UNEF14666, natural size; F. UNEF14714, ×2. All from UNEL1564.

Cladophlebis mendozaensis (Geinitz) Frenguelli 1947

Fig. 5B

Description. The only specimen (Fig. 5B) found at UNEL1564 shows two parallel pinna fragments of a presumably bipinnate frond. The slender pinna rachis bears erect subtriangular to slightly falcate, alternate, lobulate, basally constricted pinnules. The lateral veins dichotomise twice before reaching the pinnule margin. The leaf surface is finely punctate as if covered in small hair bases, similar to the South American material (Frenguelli, 1947, p. 62).

Comparison. This specimen is most similar to those figured by Frenguelli (1947, pl. 12, figs 1–6) and generally similar to the diagrams of Herbst (1971, figs 12, 13, 20).

There is some debate whether forms with elongate pinnules should be separated as *Cladophlebis johnstonii* (Jain and Delevoryas, 1967) or given varietal status within *C. mendozaensis* (Herbst, 1971). Either outcome does not affect the identification of the material from the Nymboida Coal Measures dealt with here.

Occurrence. This species has only been previously identified in Argentina. Frenguelli (1947) describes and figures specimens from the Potrerillos Formation of the Cacheuta Basin and the Los Rastros Formation of the Ischigualasto-Villa Union Basin. It has also been recorded from the Chihuiu Formation of the Chihuiu-Tronquimalal Basin (Menendez, 1951) and also from the El Tranquilo Basin (Herbst, 1971).

Comparable Basin Creek Formation material.   A large portion of a small bipinnate frond (UNEF14121) from UNEL1489.

Genus LOBIFOLIA Lebedev and Rasskazova 1968

Lobifolia dejerseyi Retallack sp. nov.

Fig. 5A

?1891 *Thinnfeldia odontopteroides* ; Etheridge, p. 10, pl. 2, figs 1, 2.
 1924 *Cladophlebis lobifolia* ; Walkom, p. 81, text fig. 2, pl. 15, fig. 2.
 1928 *Cladophlebis lobifolia* ; Walkom, p. 460.
v1958 ?*Hoegia* sp. ; De Jersey, p. 86, text figs 3, 4.
?1961b *Cladophlebis* sp. (cf. *C. shensiensis*) ; Lele, p. 73, pl. 2, fig. 15.
 1975 *Cladophlebis lobifolia* ; Flint and Gould, pl. 1, figs 4, 5, 6.
 (1976) *Cladophlebis lobifolia* ; Gould and Retallack in Bourke *et al.*, pl.1, fig. 1.

Holotype. UNEF14102 ; a well-preserved frond fragment figured by Flint and Gould (1975, pl. 1, fig. 4).

Type locality. UNEL1489, open cut workings of Nymboida Colliery ; Farquhars Creek Seam (member) of the Basin Creek Formation, Nymboida Coal Measures New South Wales (McElroy, 1963) of Aniso-Ladinian age (Flint and Gould, 1975).

Derivation. In honour of Dr N. J. De Jersey of the Queensland Geological Survey Palynological Division.

Diagnosis. *Lobifolia* in which the basal pinnules of the pinna have acute apices and the basal margin constricted basiscopically and flared acroscopically. Midvein of the pinnules arising near the basiscopic margin, dissolving before half its length into once or twice forked lateral veins radiating evenly at very acute angles to each other. Pinnules progressively narrower and more falcate (cladophleboid) towards the pinna apex.

Description. These are large bipinnate fronds with a stout striated primary rachis and long opposite or alternate pinnae. The pinnules are opposite to subopposite, strongly inclined forward, broadly triangular, acutely pointed and

more or less falcate.   The basal pinnules of the pinnae have a broad basal margin, auriculate basicopically and flared, sometimes almost lobate, acroscopically The basicopic lobe of the lowermost pair of pinnules of the pinnae may overlap the primary rachis.   The basal auriculation and flaring of the pinnules becomes less marked towards the pinna apex, where the pinnules are narrower and more falcate (cladophleboid) in appearance.   The strong midvein of the pinnules arises close to the basiscopic margin but dissolves into lateral veins before half its course to the pinnule apex.   The lateral veins dichotomise once or twice, evenly radiating from near the origin of the midvein at a very acute angle to each other.

The fragment (Fig. 5A) from UNEL1564 is the smallest known specimen. The holotype is of intermediate size.   Fronds may have pinnules up to $12 \cdot 7$ mm long (UNEF14715).

Dimensions of the holotype.   Preserved rachis length $=80 \cdot 9$ mm;   maximum rachis width (lower end) $=3 \cdot 9$ mm; minimum rachis width (upper end) $=1 \cdot 6$ mm; lowest right pinna length $=75$ mm;   second lowest left pinna rachis width $=0 \cdot 9$ mm;   third lower pinnule on second lowest left pinna, width along pinna rachis $=6 \cdot 4$ mm, length along midvein $=9 \cdot 3$ mm, veins at margin $=22$.

Comparison.   Of the species described by Lebedev and Rasskazova (1968), our material is closest to *Lobifolia novopokrovskii* but has more constricted pinnule bases and more acutely angled, less copiously forked lateral veins than the Russian species.   *Cladophlebis goeppertiana* of Du Toit (1927, p. 319 fig. 1) may prove to be another Gondwanaland species of *Lobifolia*.   Its pinnules are longer and lateral veins at a less acute angle to the pinnule midrib than in *L. dejerseyi.*

Remarks.   The genus *Lobifolia* (Lebedev and Rasskazova, 1968) separates from the form genus *Cladophlebis* some of the species previously excluded by Frenguelli (1947, pp. 40–41).   These are characterised by basally constricted and lobed lower pinnules of the pinnae, which may overlap the primary rachis. *Lobifolia* leaves possibly belong to the family Dicksoniaceae as the genus includes sterile leaves of *Eboracia lobifolia* (Harris, 1961, figs 62, 63).

Occurrence.   This species is known from the Nymboida Coal Measures (De Jersey, 1958; Flint and Gould, 1975) and the Gunnee Beds near Delungra (Gould and Retallack in Bourke *et al.*, in press), New South Wales, and the Esk Trough (Walkom, 1924, 1928), Queensland.   It may also occur in a bore near Leigh Creek, South Australia (Etheridge, 1891), and in the middle Gondwana Beds of the South Rewa Basin, India (Lele, 1961b).

Cloughers Creek Formation material.   One fragment (Fig. 5A) from UNEL1564 and an isolated pinnule (UNEF146701) from UNEL1563.

Goolang Siltstone Member material.   Specimens described by De Jersey (1958) as ?*Hoegia* sp., now lodged in the Australian Museum, Sydney (AMF48236, AMF48235).

Basin Creek Formation material.   In addition to the holotype the following have been collected from UNEL1489: UNEF14103 (Flint and Gould, 1975, pl. 1, fig. 6), UNEF14104 (Flint and Gould, 1975, pl. 1, fig. 5), UNEF14715.

DIVISION PTERIDOSPERMOPHYTA
ORDER PTERIDOSPERMALES
Family CORYSTOSPERMACEAE
Genus DICROIDIUM Gothan emend.   Townrow 1957 : 26

Current opinion (Anderson and Anderson, 1970; Archangelsky, 1968c; Boureau and Doubinger, 1975) is somewhat divided on which of the six genera recognised by Frenguelli (1943) for *Dicroidium*-like leaves are worth retaining.

All these have more or less similar cuticles. In addition to *Dicroidium*, I believe that only *Johnstonia* and *Xylopteris* should be retained. These are easy to recognise and sometimes characterise probable xerophytic florules. Along with Townrow (1957), Bonetti (1966) and Archangelsky (1968c), I include *Diplasiophyllum*, *Dicroidiopsis* and *Zuberia* within *Dicroidium*.

> *Dicroidium dubium* (Feistmantel) Gothan 1912 var. *tasmaniense* (Anderson and Anderson 1970, *non* Johnston 1887) Retallack comb. nov.
> Figs. 6D, E.
> ?1887 *Neuropteris tasmaniensis* ; Johnston, pl. 2, fig. 2.
> ?1888 *Neuropteris tasmaniensis* ; Johnston, pl. 23, fig. 2.
> 1899 *Thinnfeldia incisa* ; Solms-Laubach, p. 599, pl. 14, figs 3–4.
> p1908 *Thinnfeldia odontopteroides* ; Seward, p. 92, text figs 3B, 4 only.
> 1928 *Thinnfeldia talbagarensis* ; Walkom, p. 46, pl. 17, fig. 1.
> p1944d *Dicroidiopsis dubia* ; Frenguelli, p. 521, 1am. 1, fig. 1 only, 1am. 2.
> 1947 *Thinnfeldia talbragarensis* ; Jones and De Jersey, p. 17, text figs 9, 10, pl. 1, fig. 5.
> *1958 Dicroidium* sp., : De Jersey, p. 84.
> 1965 " *Thinnfeldia* " *talbagarensis* ; Hill Playford and Woods, pl. T4, fig. 5.
> 1970 *Dicroidium tasmaniensis* ; Anderson and Anderson, chart 9.

Varietal lectotype. N-UU786 figured by Anderson and Anderson (1970, chart 9).

Description. The two specimens from UNEL1564 (Figs 6D), E) are typical for this variety. Their short relatively broad pinnae have rounded pinna lobes and the lateral veins curve strongly from the midrib to become almost perpendicular to the margin.

Comparison. This variety has shorter, broader pinnae with well rounded lobes unlike the holotype of *Dicroidium dubium* (Feistmantel) Gothan 1912 (*Gleichenites dubius* of Feistmantel, 1878, refigured as *Gleichenia dubia* by Feistmantel, 1890). For the same reasons this variety differs from *Sphenopteris bergina* Jones and De Jersey, 1947, which is a forking frond with *Dicroidium*-like cuticle and a junior synonym of *Dicroidium dubium s.s.* The shorter, smaller, narrower, less coriaceous, more distinctly veined pinnae of this variety are quite unlike *Dicroidium australe* and *D. walkomii* of Jacob and Jacob (1950). *Dicroidium incisum* (*sensu* Anderson and Anderson, 1970) has more obliquely directed lateral venation and less strongly asymmetrically incised pinna margins.

Remarks. Of the many names applied to bipinnatifid *Dicroidium* leaves the earliest valid record is *Gleichenites dubius* of Feistmantel (1878). Johnston (1888, 1896) included bipinnatifid fronds under *Thinnfeldia polymorphum* and *Neuropteris tasmaniensis*. However his drawings are poor and the specimens cannot be found. Some Jurassic leaves of *Thinnfeldia talbragarensis* Walkom 1921 are very similar but definitely unforked (Australian Museum specimen number AMF2664). Townrow (1965) includes these Jurassic leaves in *Pachypteris crassa*.

Occurrence. In Australia this variety occurs in the Esk Trough (Walkom, 1928), the Ipswich Coal Measures (Jones and De Jersey, 1947 ; Hill *et al.*, 1965), and the Nymboida Coal Measures (Flint and Gould, 1975). It is also known from cycle 2 of the Molteno Beds (Anderson, 1974) of South Africa, La Ternera in Chile (Solms-Laubach, 1899) and the Ischichuca Formation of the Ischigualasto-Villa Union Basin, Argentina (Frenguelli, 1944d).

Comparable Goolang Sitstone Member material. The specimen of *Dicroidium* sp. which De Jersey (1958) compares with *Thinnfeldia talbragarensis* Walkom 1921.

Comparable Basin Creek Formation material. UNEF14716 from UNEL1489.

Dicroidium eskense (Walkom) Jacob and Jacob 1950

Fig. 6F

?1896 *Thinnfeldia Buftoni* ; Johnston, fig. 18.
?1903 *Thinnfeldia rhomboidalis* ; Seward, pl. 8, fig. 1.
?1921 *Thinnfeldia* sp. ; Seward and Holttum, p. 41, pl. 11B.
  1927 *Thinnfeldia narrabeenensis* ; Du Toit, p. 333, pl. 18, fig. 3.
*1928 *Thinnfeldia eskensis* ; Walkom, p. 459, pl. 27, fig. 2, pl. 28, fig. 1.
  1943 *Diplasiophyllum moltenense* ; Frenguelli, p. 300.
  1958 *Dicroidium narrabeenense* ; De Jersey, p. 84.
p1965 " *Thinnfeldia* " *eskensis* ; Hill, Playford and Woods, pl. T5, fig. 4 only.
p1967a cf. *Diplasiophyllum acutum* ; Townrow, p. 464, fig. 3E only.
  1975 *Dicroidium eskense* ; Flint and Gould, pl. 2, fig. 3.

Holotype. University of Queensland number UQF1733, figured by Walkom (1928, pl. 28, fig. 1).
Description. Only one specimen (Fig. 6F) was found at UNEL1564, but this species is quite common in the Basin Creek Formation. In addition to the relatively oblique lateral veins, constricted bases and acute apices of the pinnae noted by Walkom (1928), a characteristic feature of these leaves is a deep sinus in the basal acroscopic margin of pinnae in the middle part of the length of the primary rachis.
Comparison. *Dicroidium eskense* may agree in size with unipinnate forking fronds which have been referred to *Dicroidium narrabeenense* (Dun) Townrow 1957, *Dicroidium hughesii* (Feistmantel) Townrow 1957, *Dicroidium lancifolium* (Morris) Gothan 1912 and *Dicroidium acutum* (Walkom) Jacob and Jacob 1950. However it differs from all these in its more oblique lateral venation and the acroscopic sinus and basiscopic constriction of the pinna bases. Fragments of *Dicroidium eskense* may be confused with the unforked leaves of *Kurtziana* (Frenguelli, 1942d, 1944b). In *Kurtziana* the pinna midribs are attached on top of the rachis or to a central ridge of the rachis. One of the specimens of " *Thinnfeldia* " *eskensis* figured by Hill et al., (1965, pl. T5, fig. 3) is probably *Kurtziana brandmayri* Frenguelli 1944b. *Dicroidium eskense* combines the diagnostic characters of both *Dicroidiopsis* and *Diplasiophyllum*. These genera of Frenguelli (1943) are not widely accepted (Townrow, 1957, p. 29).
Remarks. *Thinnfeldia buftonii* (Johnston, 1896, fig. 18) may prove to be the holotype and senior synonym of this species. However Johnston's figure is unclear and the specimen cannot be found. The specimen described as *Dicroidium eskensis* by Jacob and Jacob (1950, p. 111) is more likely a frond of *Dicroidium lancifolium* (Morris) Gothan 1912.
  The forking specimen from the Cloughers Creek Formation (Fig. 6F) and a further forking specimen (part and counterpart UNEF13346, UNEF13350) from the Basin Creek Formation indicate unequivocally that these leaves belong within the genus *Dicroidium*.
Occurrence. This species is best known from the Esk Trough (Walkom, 1928 ; Hill et al., 1965) of Queensland, the Nymboida Coal Measures (De Jersey, 1958 ; Flint and Gould, 1975) of New South Wales and the lower Molteno Beds (Stage C of Du Toit, 1927, and cycle 2 of Anderson, 1974) of South Africa.
Comparable Basin Creek Formation material. UNEF13334 (Flint and Gould, 1975, pl. 2. fig. 3), UNEF13346 and UNEF13350 (part and counterpart of a forking frond), and UNEF14609, all from UNEL1489.

Dicroidium incisum (Frenguelli) Anderson and Anderson 1970

Figs 6A–6C

p1927 *Pachypteris incisa* ; Du Toit, text fig. 8A only.
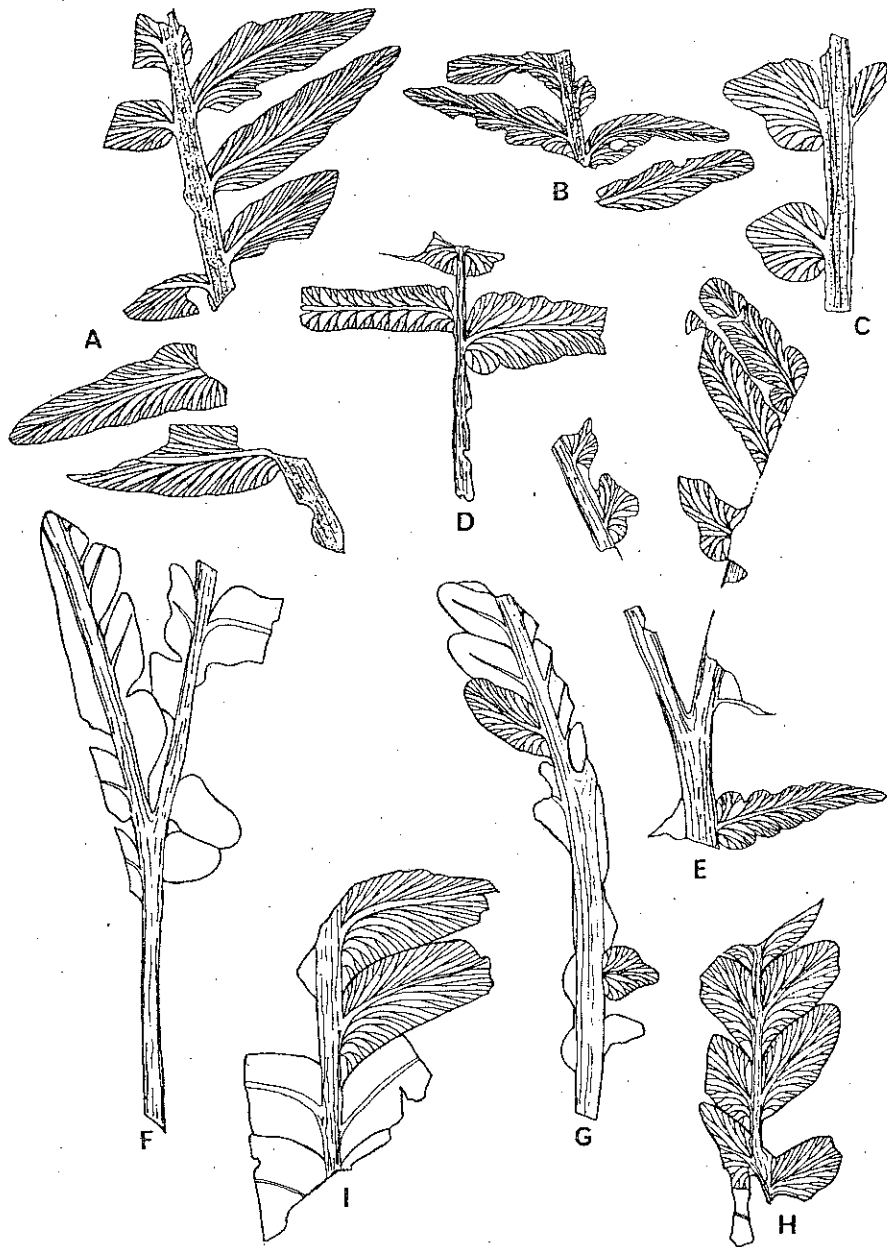 1928 *Neuropteridium moombraense* ; Walkom, p. 463, pl. 27, fig. 4.

Fig. 6. A–C. *Dicroidium incisum.* D–E. *D. dubium* var. *tasmaniense.* F. *D. eskense.*
G–H *D. odontopteroides* var. *remotum.* I. *D. lancifolium.* A. UNEF14651; B. UNEF-
14660; C. UNEF14642; D. UNEF14681; E. UNEF14659; F. UNEF14682; G. UNEF-
14653; H. UNEF14700; I. UNEF14698. All from UNEL1564. All natural size.

*1943 *Dicroidiopsis incisa* ; Frenguelli, p. 289.

1947 ?*Neuropteridium* sp. ; Jones and De Jersey, p. 33, text fig. 21.

?1952 *Pachypteris* sp. ; Gordon and Brown, p. 5, pl. 1, fig. 1.

?1969 *Dicroidium incissum* ; Stipanicic and Bonetti, p. 1093.

1970 *Dicroidium incisa* ; Anderson and Anderson, chart 9.

1975 *Dicroidiopsis incisa* ; Boureau and Doubinger, p. 664, fig. 568 *bis*.

Description. This species is easily recognised by its somewhat constricted pinna bases, its asymmetrically and weakly lobed pinna margins and very clear lateral veins at an acute angle to the pinna midvein. One leaf (Fig. 6A and its counterpart UNEF14652) is evidently part of a forking frond, because of the smaller pinnae inside the rachis curve. Fig. 6B is a more delicate fragment from near the apex of the frond. Fig. 6C is a more robust portion of rachis below the fork.

Comparison. *Dicroidium incisum* is distinct from *D. eskense* (Walkom) Jacob and Jacob 1950 in its lobate pinna margins and less constricted pinnae bases without an acroscopic sinus. The pinnules and their lobes have a less rounded outline in *D. incisum* than in *D. dubium* var. *tasmaniense* comb. nov. and *D. australe* and *D. walkomii* of Jacob and Jacob (1950). The pinnules of *D. incisum* are more broadly lanceolate and less coriaceous than in the holotype of *Dicroidium dubium* (Feistmantel) Gothan 1912.

Remarks. The Cloughers Creek Formation material is identical to one of the fronds Du Toit (1927, text fig. 8A) referred to " *Pachypteris incisa* (Saporta) *pars.*". Frenguelli (1943) made Du Toit's fig. 8A the type of an essentially new concept : " *Dicroidiopsis incisa* Du Toit sp.". Anderson and Anderson (1970) cite Du Toit's fig. 8A and figure a comparable range of forms called " *Dicroidium incisa* ". They place the other specimens of *Pachypteris incisa sensu* Du Toit (1927) in an informal group agreeing in concept with *Xylopteris ? natalensis* Frenguelli 1943. Some unfigured South American records of this species are difficult to interpret. " *E. incisa* " in Archangelsky's (1968a) list is probably a misprint as it follows species of *Dicroidiopsis*. *Dicroidium incissum* of Stipanicic and Bonetti (1969) could refer to *D. incisum* (Frenguelli) Anderson and Anderson 1970, *Xylopteris ? natalensis* Frenguelli 1943 or some other species, as it was described in an unpublished thesis (Bonetti, 1963) which I have not seen.

Occurrence. This species is known from the lower and middle Molteno Beds (Stages C and D of Du Toit, 1927, and cycle 2 of Anderson, 1974) in South Africa, and the Esk Trough (Walkom, 1928) and Ipswich Coal Measures (Jones and De Jersey, 1947) in Queensland.

Dicroidium lancifolium (Morris) Gothan 1912 (*s.s.* Anderson and Anderson 1970)

Fig. 6I

Description. A small fragment (Fig. 6I) was found at UNEL1563.

Comparison. Fig. 6I has broad pinnae, probably with rounded apices, most like those figured by Kurtz (1921, pl. 18, fig. 246) as *Thinnfeldia intermedia*. *Dicroidium lancifolium* is distinguished from *D. odontopteroides* by its more elongate pinnae, as in the variation diagram of Anderson and Anderson (1970).

Remarks. Contrary to Townrow (1957) I believe that this species should be maintained as separate from *D. odontopteroides* because it has a different stratigraphic range and is not always associated with the same reproductive organs. *Dicroidium lancifolium* is found in older Triassic rocks such as the upper Beaufort Beds of South Africa (Du Toit, 1927) and the upper Narrabeen Group of New South Wales (Walkom, 1925c) as well as Middle to Late Triassic rocks. However *D. odontopteroides* and its presumed reproductive structures, *Pteruchus johnstonii* (Feistmantel) Townrow 1962 and *Pilophorosperma* spp. Thomas 1933, first appear

in Middle Triassic rocks such as the middle Molteno Beds (Stage C) of South Africa and the Wianamatta Group of New South Wales.

Occurrence. *Dicroidium lancifolium* is very widely distributed in middle Triassic rocks of Gondwanaland. The oldest reliable records are probably those from the upper Beaufort Beds of South Africa (Du Toit, 1927) and the upper Narrabeen Group, Sydney Basin, New South Wales (Walkom, 1925c). In Queensland it persists to the top of the Ipswich Coal Measures but has not been found in the overlying Bundamba Group (Jones and De Jersey, 1947). In South Africa it ranges as high as the middle Molteno Beds (Stage D of Du Toit, 1927, and cycle 4 of Anderson, 1974). In Argentina it is found as high as the lower plant bearing level of the Ischigualasto Formation of the Ischigualasto-Villa Union Basin and the Cacheuta Formation of the Cacheuta Basin (Frenguelli, 1948). Specimens from Punta Puquen in Chile appear to underly a Norian marine fauna (Azcárate and Fasola, 1970). At La Ternera in Chile (Solms-Laubach, 1899) and Paso Flores in Argentina (Frenguelli, 1948) it occurs in fossil floras apparently underlying Liassic marine rocks. A supposed pinna apex in the Liassic flora of Piedra Pintada (Frenguelli, 1937) cannot be accepted as convincing evidence of *D. lancifolium.* Arber (1917, pl. 5, fig. 2, New Zealand Geological Survey number B62·7) figured a specimen of *D. lancifolium* from the Middle Jurassic (Speden, 1958) of Owaka Creek, New Zealand. I have examined this specimen. The " fork " in this case is sympodial and formed by the accidental juxtaposition of two robust *Cladophlebis* pinnae whose rachis have quite dissimilar textures. The range of *D. lancifolium* can thus be taken as late Scythian to Norian, as suggested by Stipanicic and Bonetti (1969, p. 1097).

Comparable Basin Creek Formation material. UNEF14608 from UNEL1489.

Dicroidium odontopteroides (Morris) Gothan 1912 (*s.s.* Anderson and Anderson 1970) var. *remotum* (Szajnocha) Retallack comb. nov.

Figs 6G–6H

*1889 *Neuropteris remota* ? ; Szajnocha, p. 226, pl. 2, fig. 3.
1944e *Dicroidium remotum* ; Frenguelli, p. 449, pls 1–3.
1948 *Dicroidium remotum* ; Frenguelli, pp. 234, 291.
1968a *Dicroidium remotum* ; Archangelsky, p. 80.
p1975 *Dicroidium odontopteroides* ; Flint and Gould, pl. 3, fig. 11 only.
1975 *Dicroidium remotum* ; Boureau and Doubinger, p. 668.

Varietal type. The specimen from Cacheuta in Argentina figured by Szajnocha (1889, pl. 2, fig. 3a).

Description. Some fragments (UNEF14699–700) from UNEL1463 are very similar to the forking specimen (fig. 6G) from UNEL1564.

Comparison. This variety is a new combination of *Dicroidium remotum* Frenguelli 1944e. This has relatively more elongate, rounded, basally constricted pinnules than is usual for *D. odontopteroides* (*sensu* Anderson and Anderson, 1970). In addition, the pinnules inside the rachis fork are at a more acute angle to the rachis and those below the fork are almost triangular cordate. The pinnules of *D. odontopteroides* var. *remotum* are not as long and narrow as those of the holotype of *D. odontopteroides* (Townrow, 1957) or those of *D. lancifolium* (*sensu* Anderson and Anderson, 1970). *Dicroidium odontopteroides* var. *remotum* is separated from *Johnstonia* (*sensu* Frenguelli, 1943) by the more common forms of *D. odontopteroides* and *D. obtusifolium* (Johnston) Townrow 1966a with short pinnules.

Occurrence. This variety is best known from the lower portions of Argentine Triassic sequences, the Las Cabras Formation of the Cacheuta Basin and the Cortaderita Formation of the Barreal-Hilario Basin (Frenguelli, 1948).

Dicroidium odontopteroides s.s. is very widely distributed in Middle to Late Triassic rocks of Gondwanaland (Townrow, 1967a; Frenguelli, 1943). The upper limit in South Australia and Tasmania is probably close to the Rhaeto-Liassic boundary (Townrow, 1966a). However, at this level *D. odontopteroides* has short pinnules of a type intergrading into *D. obtusifolium* quite unlike *D. odontopteroides* var. *remotum*. In Queensland *D. odontopteroides* persists into the Raceview Formation of the Bundamba Group (Jones and De Jersey, 1947) and in South Africa it persists to the top of the Molteno Beds (Stage E of Du Toit, 1927, and cycle +5 of Anderson, 1974).

Balme and Helby (1973) record *D. odontopteroides* in the Tuggerah Formation of the Sydney Basin. However I cannot locate their specimen and am convinced that the earliest records of this species in this region are the specimens of Feistmantel (1878, 1890) from the Wianamatta Group. The most securely dated early occurrence of *D. odontopteroides* is a range of specimens I am currently studying for the New Zealand Geological Survey. These were found at Mount Potts, New Zealand, underlying Kaihikuan (=Ladinian) marine rocks.

Comparable Basin Creek Formation material. UNEF14609 from UNEL1489 is an identical frond to Fig. 6G; UNEF13455 from UNEL1495 is a similar but smaller frond (Flint and Gould, 1975, pl. 3, fig. 11).

Dicroidium superbum (Shirley) Townrow 1957

Figs 8A–8B

?1889 *Thinnfeldia trilobita* (?); Feistmantel, p. 65, pl. 2, figs 2, 2a, 2b.
v1898 *Sphenopteris superba*; Shirley, p. 18, pls 4, 8.
v1917a *Sphenopteris superba*; Walkom, p. 27, pl. 8, fig. 3.
?1924 (?) *Sphenopteris superba*; Walkom, p. 86.
?1927 *Thinnfeldia feistmanteli* var. *trilobita*; Du Toit, p. 22.
  1947 *Sphenopteris superba*; Jones and De Jersey, p. 31, pl. 5, fig. 2C.
v1965 *Dicroidium superbum*; Hill, Playford and Woods, pl. T4, fig. 6.
 p1970 *Dicroidium* tripinnate sp. A; Anderson and Anderson, 1970, chart 9, excluding examples with linear segments.
 p1970 *Dicroidium* tripinnate sp. B; Anderson and Anderson, 1970, chart 9, excluding examples with linear segments.

Description. Only two fragments (Figs 8A, 8B), probably from the same frond were found at UNEL1564. The broad pinnules have clear venation and generally three marginal lobes. The primary and secondary rachis are conspicuously grooved.

Comparison. The material is most similar to that of Hill *et al.* (1965, pl. T4, fig. 6). The lobation of the pinnules in *Dicroidium superbum* is much more marked than in *D. zuberi* (Szajnocha) Archangelsky 1968c, which may show incipient lobing of the pinnules (Feistmantel, 1890, pls 23, 24; Frenguelli, 1944a, figs 1–4). The pinnules of *D. superbum* are not as elongate as in the tripinnatified fronds variously called *Thinnfeldia sphenopteroides* Seward 1908, *Zuberia barrealensis* Frenguelli 1944a and *Thinnfeldia* sp. Arnold 1947 (fig. 117).

Remarks. After examining Shirley's (1898) material (including the holotype) I conclude that these are somewhat torn remains of leaves with formerly broader, lobed pinnules. For this reason I exclude from *D. superbum* specimens with narrow coriaceous pinnules and acute pinna apical points such as those ascribed to this species by Townrow (1957) and Anderson and Anderson (1970, chart 9, in part).

Occurrence. *Dicroidium superbum* is most common in the Esk Trough, but is also found at some levels in the Ipswich Coal Measures of Queensland (Jones and De Jersey, 1947). It also occurs in the lower Molteno Beds (Stage C of Du Toit, 1927, and cycle 2 of Anderson, 1974) in South Africa.

Comparable Basin Creek Formation material. A pinna fragment (UNEF14610) from UNEL1469.

Dicroidium zuberi (Szajnocha) Archangelsky 1968c

Fig. 7

Description. Several specimens (Figs 7A, 7B, 7C) of intermediate size for this species were found at UNEL1564. They have subrhombic to rounded pinnules. The basiscopic pinnule of the pinnae overlaps the rachis by less than half its length. Some fragments from UNEL1563 (Figs 7D, 7E, 7F) are similar to the more complete examples from UNEL1564.

Comparison. There is considerable variation within bipinnate *Dicroidium* leaves. This material ranges between *Zuberia zuberi* (of Frenguelli, 1944a) and *Dicroidium sahnii* (of Seward, 1933 ; Rao and Lele, 1962). This variation is not broad enough to include the larger interpinnuled *Zuberia feistmantelii* (of Frenguelli, 1944c) or the smaller semi-pinnatifid *Dicroidium* int. sp. B (of Anderson and Anderson, 1970). Some specimens of the Jurassic *Pachypteris crassa* (Walkom, 1921 ; Townrow, 1965) are similar but definitely unforked (Australian Museum specimen number AMF2664).

Remarks. I agree with Bonetti (1966) and Archangelsky (1968c) that most of the distinctions made within bipinnate *Dicroidium* leaves by Frenguelli (1943, 1944a) are not clear enough to be recognised at a species level. Our material is not sufficiently distinctive to fall into any of Frenguelli's (1943, 1944a) categories as a variety of *D. zuberi.*

Occurrence. Frenguelli (1944a, 1948) has pointed out that flora dominated by *D. zuberi* are generally lowest in the Argentine Triassic successions, although *D. zuberi* does persist less prominently at higher levels. Frenguelli (1944a) figures abundant material from the Las Cabras Formation of the Cacheuta Basin and the Cortaderita Formation of the Barreal-Hilario Basin. Fragments of this species have been found as high as the (?) Norian, in the Ischigualasto Formation of the Ischigualasto-Villa Union Basin (Archangelsky, 1968c) in Argentina and at Punta Puquen in Chile (Azcárate and Fasola, 1970). In India it occurs in the Parsora Beds (Seward, 1933). In South Africa it occurs in the upper Beaufort Beds and the lower and middle Molteno Beds (Stages B, C, D of Du Toit, 1927, and cycle 2 of Anderson, 1974).

In the Sydney Basin *D. zuberi* (Walkom, 1925c, 1932 ; Jacob and Jacob, 1950 ; Townrow, 1957) dominates Scytho-Anisian fossil flora found from the base of the Bald Hill Claystone to the Brookvale shale lens of the Hawkesbury Sandstone. Similar *D. zuberi* dominated fossil floras are found in the Camden Head Claystone of the Lorne Basin New South Wales (Pratt and Herbert, 1973), the Erskine Sandstone of the Canning Basin, Western Australia (Antevs, 1913 ; Townrow, 1957) and the *Cylostrobus* macroflora of Tasmania (Banks and Clarke, 1973). By the level of the Wianamatta Group of the Sydney Basin, *D. zuberi* is rarer, smaller and subordinate to *D. odontopteroides* (*sensu* Anderson and Anderson, 1970). *Dicroidium zuberi* also persists in the *D. odontopteroides* dominated fossil flora of the Esk Trough (Walkom, 1924, 1928) and Ipswich Coal Measures (Jones and De Jersey, 1947) in Queensland, the Feldspathic Sandstone Series in Tasmania (Walkom, 1925a, 1925b) and the Leigh Creek Coal Measures in South Australia (Chapman and Cookson, 1926 ; Etheridge, 1902 ; Pledge, 1974). It has not been found in the Raceview Formation of the Bundamba Group (Jones and De Jersey, 1947).

The *D. zuberi* dominated fossil flora of the upper Narrabeen Group of New South Wales and the upper Beaufort Beds of South Africa are probably as old as Scythian. *Dicroidium zuberi* probably persisted until the Norian in the Ischigualasto Formation and Punta Puquen of South America. It could range as high as the Rhaetian at Leigh Creek in South Australia. However this palynological age of Playford and Dettmann (1965) has been seriously questioned by Anderson and Anderson (1970, chart 14).
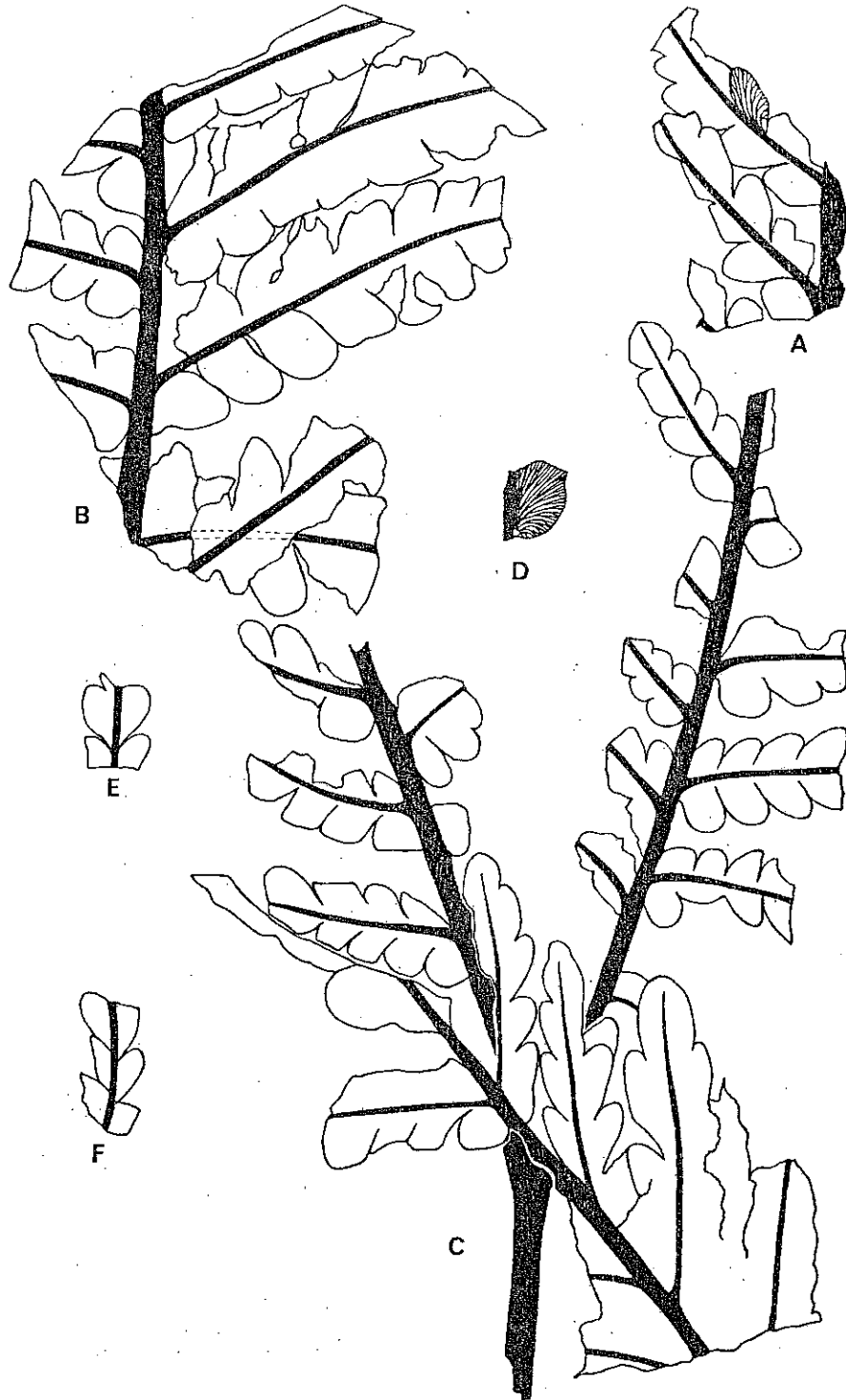
Fig. 7. A–F. *Dicroidium zuberi*. A. UNEF14657 ; B. UNEF14655 ; C. UNEF14656 ;
D. UNEF14709 ; E. UNEF14701 ; F. UNEF14702.   A–C. Frond fragments from UNEL-
1564 ; D–F.   Comparable pinnule and pinna fragments from UNEL1563.   All natural size.

Comparable Basin Creek Formation material. Two specimens figured as *Hoegia papillata* by Flint and Gould (1975, pl. 2, figs 4, 5) and UNEF13326 from UNEL 1489 and UNEF13472 from UNEL1495.

Genus PTERUCHUS Thomas emend. Townrow 1961 : 289

Pteruchus dubius (Thomas) Townrow 1961

Fig. 8D

Description. One rock specimen (UNEF14695) from UNEL1561 bears two impressions of microsporangial aggregates. One aggregate consists of 50 pollen sacs in a group 4·4 mm wide. The arrangement of the pollen sacs indicates this is about half the width of the microsporophyll. The individual pollen sacs show clear cellular striation and a prominent peg-like internal mould of the rounded apical end of the dehiscence slit. The second aggregate (Fig. 8D) shows about 30 pollen sacs arranged with bilateral symmetry on a lamina about 8·8 mm wide.

Comparison. The aggregates are probably fragments of long *Pteruchus* heads. They are most similar to the South American *Pterorrachis barrealensis* (Frenguelli, 1942b, 1944a), which is the supposed pollen organ of *Dicroidium zuberi* (Szajnocha) Archangelsky 1968c. Townrow (1961) regarded *Pterorrachis barrealensis* as a junior synonym of *Pteruchus dubius* although the South American microsporophylls have longer heads than the Molteno material on which *P. dubius* is based.

Occurrence. *Pteruchus dubius* is known from the middle Molteno Beds (Stage D of Du Toit, 1927, and cycle 2 of Anderson, 1974 ; Townrow, 1961 ; Thomas, 1933) of South Africa and the Ipswich Coal Measures (Hill *et al.*, pl. T6, fig. 3) of Queensland. *Pterorrachis barrealensis* is known from the Barreal and Cortaderita Formation of the Barreal-Hilario Basin in Argentina (Frenguelli, 1944a ; Stipanicic and Bonetti, 1969).

Comparable Basin Creek Formation material. A large slab (UNEF13395) bearing *Cladophlebis* fronds from UNEL1489 also contains a similar short fragment of a microsporangiate head.

Pteruchus johnstonii (Feistmantel) Townrow 1962

Fig. 8C

Description. Only one specimen was found in part and counterpart (UNEF 14661, UNEF14690) at UNEL1564. The four fleshy subrectangular micro-sporangiate heads bear numerous pendant cigar-shaped dehisced pollen sacs.

Comparison. I agree with Townrow (1961) that *Pteruchus* should not include specimens with spirally inserted pollen sacs, such as *Pteruchus indicus* Pant and Basu 1973, *P. nipurensis* Srivastava 1974 and *P. edwardsi* Thomas 1933. These species are otherwise quite similar to *P. johnstonii* and should perhaps be placed in a separate genus. Townrow (1962) regards *Sphenolepis rhaetica* Geinitz as a *nomen vanum* and with it disappears any record of South American forms which are comparable with *P. johnstonii* (Archangelsky, 1968a, table 3 ; Stipanicic and Bonetti, 1969, fig. 1a ; Jain and Delevoryas, 1967, p. 572). Townrow (1961) gives a detailed comparison of the species of *Pteruchus*.

Remarks. This is the supposed microsporophyll of *Dicroidium odontopteroides* and *D. lancifolium* (Townrow, 1961).

Occurrence. Townrow (1961) relocated the holotype of the species from the Feldspathic Sandstone Series, of Lords Hill, Hobart, Tasmania. It also occurs in the Ipswich Coal Measures of Queensland and the middle Molteno Beds (Stage D of Du Toit, 1927, and cycle 2 of Anderson, 1974) of South Africa (Townrow, 1961).

Comparable Basin Creek Formation material. An almost identical specimen (UNEF14612/3, part/counterpart) from UNEL1489.
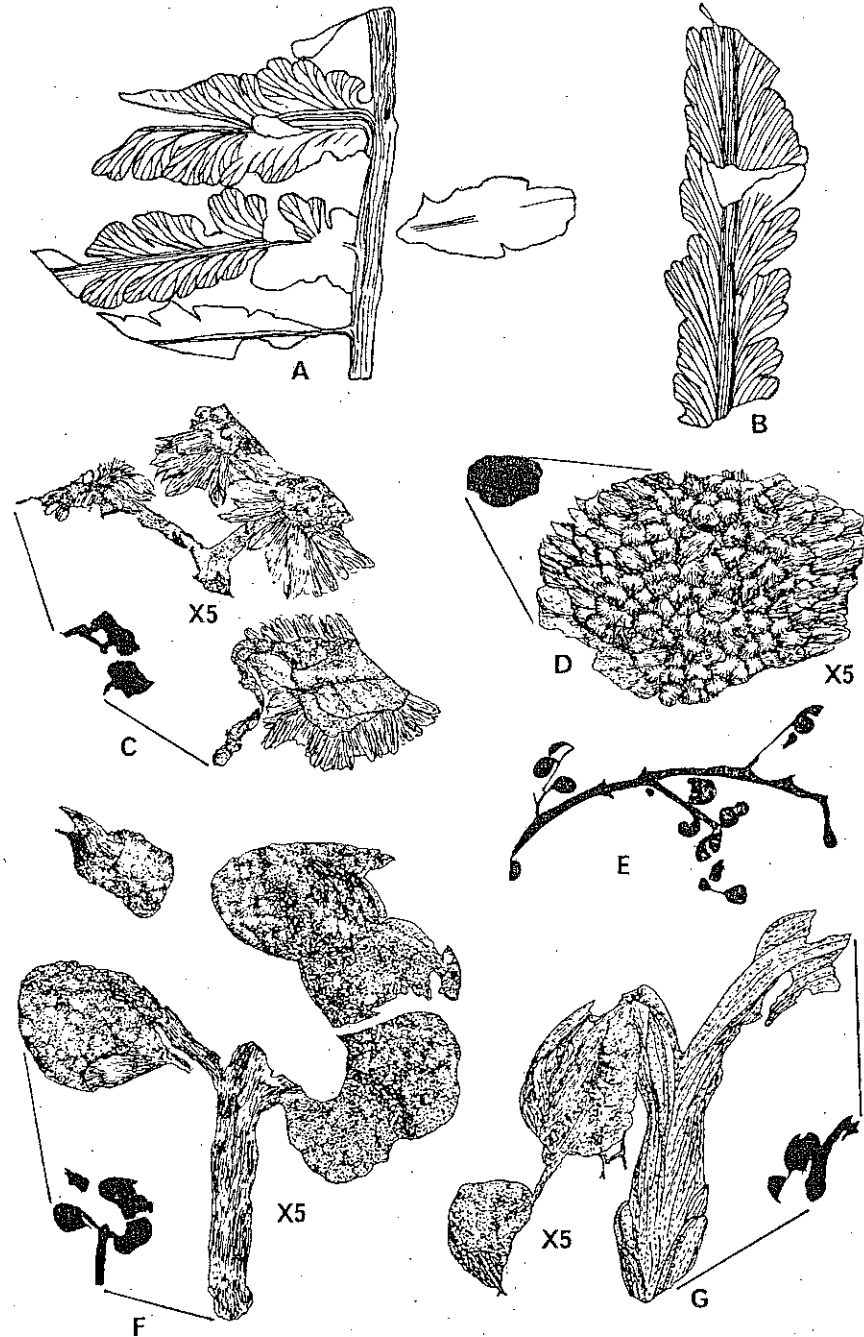
Fig. 8.   A–B. *Dicroidium superbum.*   C. *Pteruchus johnstonii.*   D. *P. dubius.*   E–G.
Pilophorosperma sp. cf. *P. costulatum.*   A. UNEF14674, natural size; B. UNEF14675,
natural size; C. UNEF14661, ×5; D. UNEF14695, ×5; E. UNEF14689; natural size;
F. UNEF14685, ×5;   G. UNEF14686, ×5.   A–C and E–G from UNEL1564;   D from
UNEL1561.   Silhouettes natural size.

Genus PILOPHOROSPERMA Thomas 1933

Pilophorosperma sp. cf. *P. costulatum* Thomas 1933

Figs 8E–8G

Description. Three specimens in part and counterpart were collected from UNEL1564. UNEF14684/5 (Fig. 8F) shows a group of cupules around a short section of rachis. Two show a single, ribbed seed with a bifid micropyle protruding some distance from the more or less even lower margin of the fleshy verrucose cupule. UNEF14686/7 (Fig. 8G) is similar, showing also " bracts " on the rachis and more distinctly ribbed seeds. UNEF14688/9 (Fig. 8E) is a very poorly preserved, pinnately arranged group of cupules on a muddy solution plane of the rock.

Comparison. In addition to microscopic characters (Thomas, 1933), *Umkomasia* differs from *Philophorosperma* in its larger size and deeply cleft cupule. Within *Pilophorosperma* the variable presence, size, prominence and ornament of the seed is probably dependent on its growth stage. The fleshy, verrucose, smooth-margined cupules and ribbed prominent seeds in the Cloughers Creek material are most like *Pilophorosperma costulatum* Thomas 1933 (fig. 22). However there seem to be few megascopic reasons for separating this species from *Pilophorosperma granulatum*, *P. gracile*, *P. geminatum*, *P. paucipartitum*, *P. burnerense*, *P. natalense*, *P.* sp. type A, *P.* sp. type B and *P.* sp. type C. The distinctly lobed cupular margins of *P. crassum* and *Spermatocodon sewardii* distinguish them from this group of forms and this material.

Remarks. It appears that Thomas (1933) has created an unnecessary number of *Pilophorosperma* species, as Townrow (1961) has shown for the equivalent microsporophylls. *Pilophorosperma* spp. are the most abundant corystosperm megasporophylls at the " Waterfall " locality of the Molteno Beds in South Africa. Following Townrow's (1961) arguments for the microsporophylls, *Pilophorosperma* spp. are probably the megasporophylls of *Dicroidium odontopteroides* and *D. lancifolium* (both *sensu* Anderson and Anderson, 1970).

Occurrence. *Pilophorosperma* is best known from the middle Molteno Beds (Stage D of Du Toit, 1927, and cycle 2 of Anderson, 1974) of South Africa (Thomas, 1933).

Comparable Basin Creek Formation material. Two very similar specimens (UNEF14711, UNEF14715) from UNEL1489.

Family PELTASPERMACEAE

Genus LEPIDOPTERIS Schimper emend. Townrow 1956 ; 4

Lepidopteris madagascariensis Carpentier 1935

Fig. 9

Description. A range of specimens (UNEF14671–3, UNEF14677–9) was collected at UNEL1564 and one (UNEF14697) at UNEL1561. The material from UNEL1564 varies (Fig. 9) from small unipinnate fronds (Fig. 9C) to bipinnatifid (Fig. 9C) and bipinnate (Figs 9A, 9B) fronds. All have rachis pinnules (*Zwischerfiedern*) and rounded pinnule apices. The rachis generally shows sparsely distributed blisters and a finer punctation, and often an indistinct mibrib (Fig. 9D).

Comparison. *Lepidopteris madagascariensis* is very difficult to distinguish from *L. stormbergensis.* Townrow (1966b) found a whole range of intergrading forms in the Brookvale shale lens of the Hawkesbury Sandstone, New South Wales. The variation in the Cloughers Creek Formation material (Fig. 9) is very similar to that of *L. stormbergensis* (Townrow, 1960, fig. 5). The unipinnate form (Fig. 9C) from the Cloughers Creek Formation is very similar to specimens of *L. stormbergensis* figured by Townrow (1960, figs 5B, 5E) and Du Toit (1927, pl. 22, fig. 1). However I follow Townrow (1966b, p. 210) in placing the Cloughers
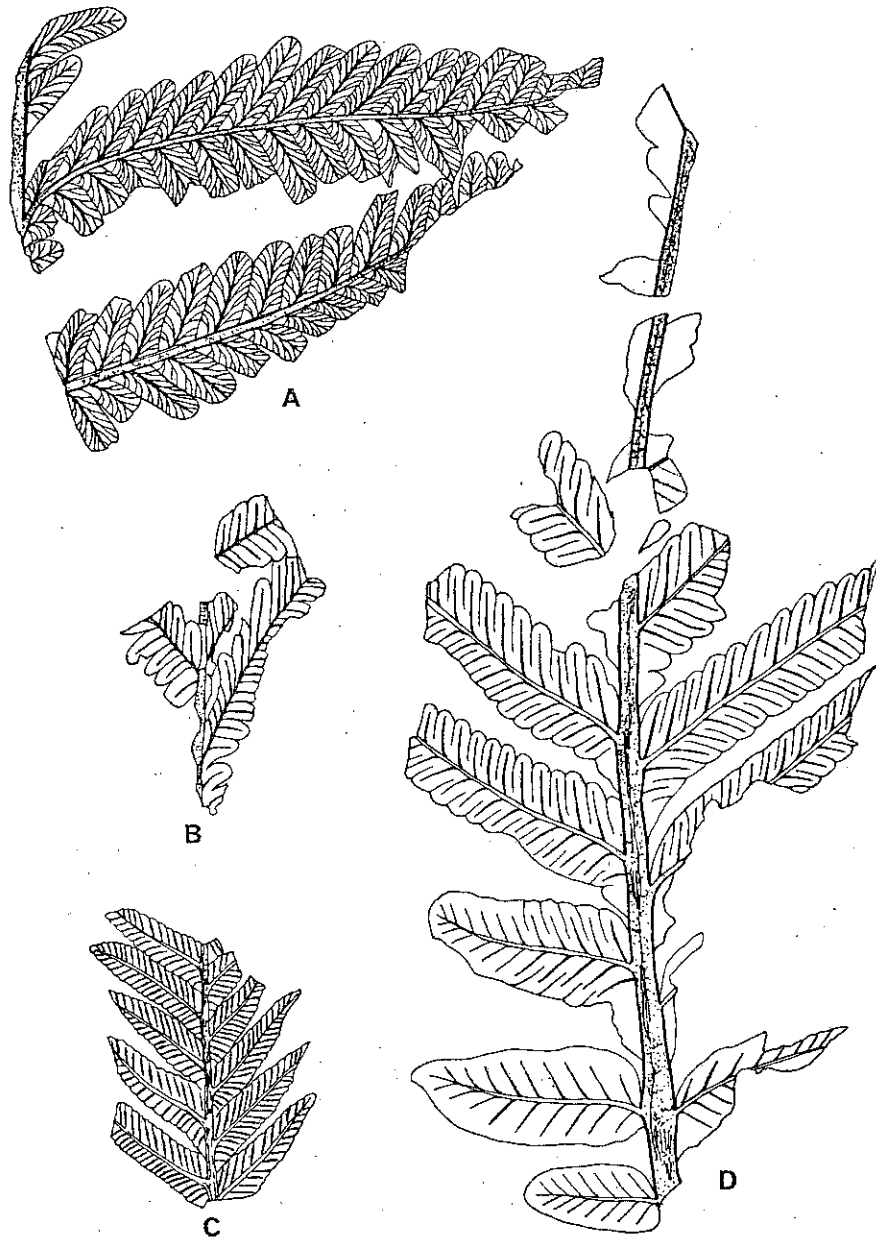
Fig. 9. A–D. *Lepidopteris madagscariensis*, showing intraspecific variation. A. bipinnate UNEF14678 ; B. bipinnate UNEF14672 ; C. pinnatifid UNEF14671 ; D. bipinnatifid UNEF14677. All from UNEL1564. All natural size.

Creek material in *L. madagascariensis* because of its thick leaf substance and mostly obtuse pinnules. *Lepidopteris indica* (Srivastava, 1974) is larger, with broader rounded pinnules and a more distinctly grooved rachis than both *L. madagascariensis* and *L. stormbergensis*.

Occurrence. According to Townrow (1966b) *L. madagascariensis* occurs in the upper Beaufort Beds (Stage B of Du Toit, 1927) in South Africa, bed 3 of the Sakamena Group in Madagascar, throughout the Narrabeen Group of the Sydney Basin in New South Wales and in the Esk Trough in Queensland. Flint and Gould (1975) also record it from the Nymboida Coal Measures in New South Wales. Townrow (1960, 1966b) had difficulty identifying specimens from the Brookvale shale lens of the Hawkesbury Sandstone in the Sydney Basin, New South Wales, and in the Esk Trough of Queensland. At Brookvale he decided that both *L. madagascariensis* and *L. stormbergensis* were present with intergrading forms. Townrow (1966b) finally identified the Esk specimens as *L. madagascariensis* (figured by Hill *et al.*, 1965, pl. T6, figs. 1, 2). *Lepidopteris stormbergensis* is best known from the lower and middle Molteno Beds (Stages C and D) in South Africa (Du Toit, 1927 ; Townrow, 1960).

Baldoni (1972) identified *L. stormbergensis* from the Cacheuta and Potrerillos Formations of the Cacheuta Basin in Argentina, apparently unaware of the work of Townrow (1966b). All the megascopic and cuticular features of these specimens, excepting the elongated cells at the margin, agree with *L. madagascariensis* rather than *L. stormbergensis*. Furthermore, these leaves are associated with peltasperm fructifications unlike those known for *L. stormbergensis* (Townrow 1960). These are the microsporophylls *Fanerotheca dichotoma* Frenguelli 1944c and *F. exstans* Frenguelli 1944c *pro parte* (those specimens not included in *Antevsia exstans* by Townrow, 1960, p. 350). The megasporophyll " *Umkomasia* " *cacheutensis* Frenguelli 1942c is more likely a *Peltaspermum* with laterally attached heads bearing six seeds and with no marginal lobes.

Comparable Basin Creek Formation material. Flint and Gould (1975, pl. 2, figs 1, 2) figure similar bipinnate specimens, and UNEF14616 is a similar unipinnate specimen, all from UNEL1489.

DIVISION CYCADOPHYTA

FORM GENERA OF UNCERTAIN POSITION

Genus TAENIOPTERIS Brongniart emend.   Harris 1932 ; 33

Taeniopteris carruthersii Tenison Woods 1883

Fig. 10G

1872 *Taeniopteris Daintreei* ; Carruthers, p. 355, pl. 27, fig. 6.
1878 *Taeniopteris Daintreei* ; Feistmantel, pl. 14, fig. 4.
*1883 *Taeniopteris Carruthersi* ; Tenison Woods, p. 117.
1886 *Taeniopteris Carruthersi* ; Johnston, p. 375.
1890 *Taeniopteris Carruthersi* ; Feistmantel, p. 115, pl. 28, fig. 7.
1892 *Taeniopteris Carruthersi* ; Etheridge, in Jack and Etheridge, p. 374.
1898 *Taeniopteris Carruthersi* ; Dun, p. 393.
p1903 *Taeniopteris carruthersi* ; Seward, p. 59, pl. 8, fig. 6 only.
1908 *Taeniopteris Carruthersi* ; Seward, p. 99, fig. 6.
1917a *Taeniopteris Carruthersi* ; Walkom, p. 37, fig. 10.
1924 *Taeniopteris Carruthersi* ; Walkom, p. 85, fig. 3.
1925b *Taeniopteris Carruthersi* ; Walkom, p. 64.
p1927 *Taeniopteris carruthersi* ; Du Toit, p. 347, fig. 9. (excluding narrow
    leaves).
1947 *Taeniopteris Carruthersi* ; Jones and De Jersey, p. 46.
1958 *Taeniopteris carruthersi* ; De Jersey, p. 85.
1965 *Taeniopteris* aff. *lentriculiforme* ; Hill, Playford and Woods, pl. T8, fig. 4.
p1975 *Taeniopteris lentriculiforme* ; Flint and Gould, pl. 3, fig. 8 only.

Description. Several leaves were found on one rock fragment (Fig. 10G) from UNEL1564. These are elongate lanceolate and have a rounded apex. The secondary veins arise steeply from a robust deeply striated midrib and turn sharply to run perpendicular to the margin for most of their course. They dichotomise once or twice at varying distances from the midrib. The half width of the lower apical fragment (Fig. 10G) is 12·6 mm.

Comparison. I regard narrower leaves of this type (about 1 cm wide; Seward, 1903, pl. 8, fig. 5; Du Toit, 1927, fig. 9; Flint and Gould, 1975, pl. 3, fig. 9) as *Taeniopteris daintreei* (*sensu* Frenguelli, 1944b, pp. 387–388). *Taeniopteris lentriculiforme* (Walkom, 1917a) is a relatively shorter, more lanceolate leaf, with a more abruptly tapering biconcave lower margin. Its lateral veins are rarely forked and then only close to the midrib. *Taeniopteris fluctuans* (Etheridge, 1895, p. 139, pl. 5, figs 1–3) is very similar to *T. carruthersii* but for its strong transverse wrinkling.

Occurrence. This species has been reliably recorded from the Cortaderita Formation of the Barreal-Hilario Basin in Argentina (Stipanicic and Bonetti, 1969), the Esk Trough (Walkom, 1924) and Ipswich Coal Measures (Jones and De Jersey, 1947) in Queensland, the Feldspathic Sandstone Series in Tasmania (Walkom, 1925b), the Nymboida Coal Measures in New South Wales (Flint and Gould, 1975) and the lower and middle Molteno Beds (Stages C and D) in South Africa (Du Toit, 1927).

Comparable Basin Creek Formation material. UNEF13454 (Flint and Gould, 1975, pl. 3, fig. 8) from UNEL1495, and UNEF13440 and UNEF14614 from UNEL1489.

DIVISION GINKGOPHYTA
ORDER GINKGOALES

Genus PHOENICOPSIS Heer emend. Florin, 1936; 45

Phoenicopsis elongatus (Morris) Seward 1919

Fig. 10A

Description. This species is well represented at UNEL1564 (UNEF14649–52). These are narrow lanceolate leaves with a rounded apex and a broad abscission scar rather than a well-formed petiole. The veins are well-spaced, parallel and unforked except at the base of the leaf. The leaves are mostly about 15 mm wide. An exceptionally long narrow leaf (Fig. 10A) is 9·8 mm wide and more than 110·4 mm long.

Comparison. *Phoenicopsis elongatus* is distinctly lanceolate unlike other species of the genus (Seward, 1919).

Remarks. In both the Cloughers Creek and Basin Creek Formations *P. elongatus* lacks a well-defined petiole and appears to grade into *Sphenobaiera argentinae* (Kurtz) Frenguelli 1946. This suggests ginkgoalean rather than cycadophyte or podocarp affinities. Frenguelli (1937) placed *Phoenicopsis elongatus* within the genus *Podozamites*. However his specimen of a leaf group shows no clear evidence of a central axis.

Occurrence. This species is locally abundant in Middle and Late Triassic rocks of Gondwanaland. In Australia it is common in the Esk Trough (Walkom, 1924; Hill et al., 1965) and Ipswich Coal Measures (Walkom, 1917b; Jones and De Jersey, 1947) in Queensland, the Nymboida Coal Measures in New South Wales (Flint and Gould, 1975) and the Feldspathic Sandstone Series (Walkom, 1925b) and/or uppermost megafossil flora in Tasmania (Banks and Clarke, 1973). It also occurs in the Molteno Beds (Stages C and D of Du Toit, 1927, and cycles 2 to ±5 of Anderson, 1974) in South Africa. In Argentina it occurs at Paso Flores (Frenguelli, 1937), in the El Tranquilo Basin (Stipanicic and Bonetti, 1969), the Tronquimalal Formation in the Chihuiu-Tronquimalal Basin (Menendez, 1951), the Potrerillos and Cacheuta Formations in the Cacheuta
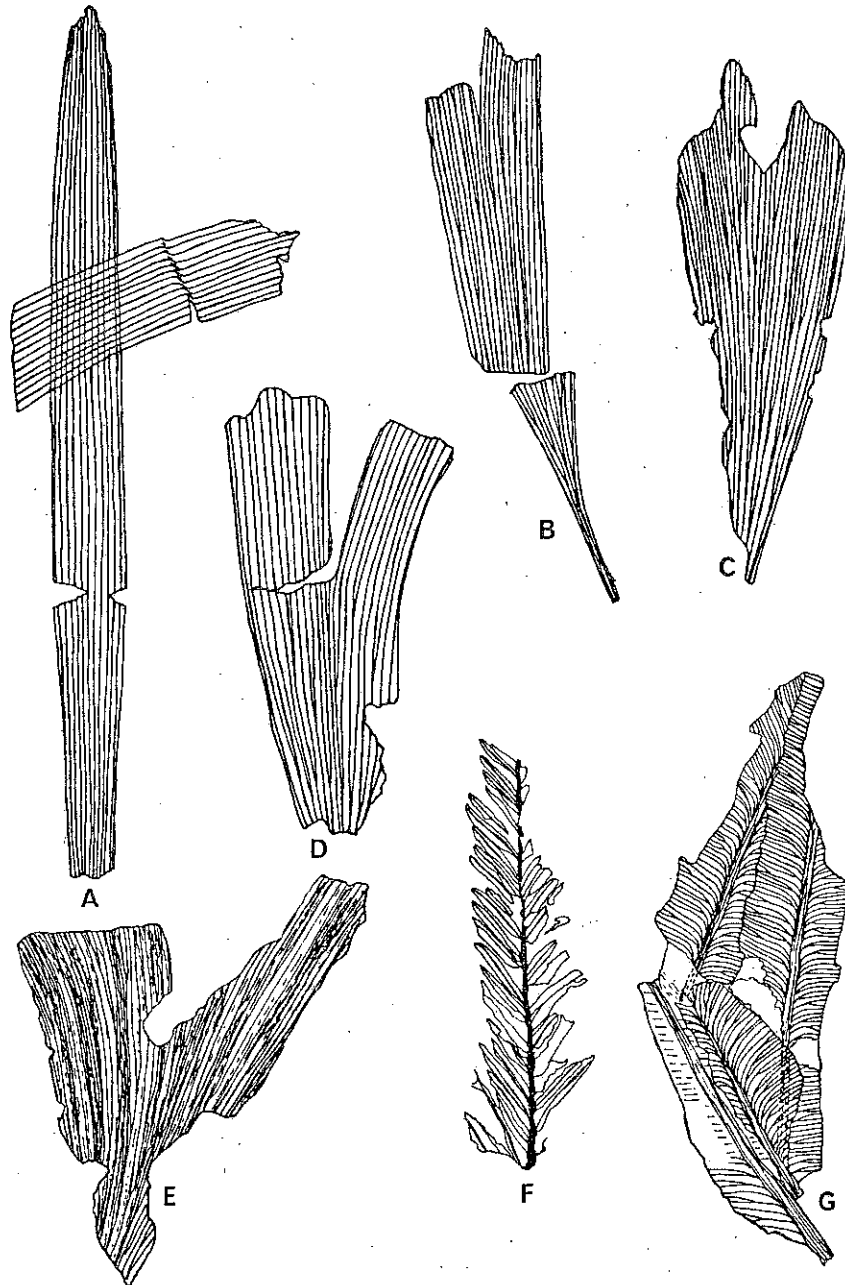
Fig. 10. A. *Phoenicopsis elongatus*. B–D. *Sphenobaiera argentinae*. E. *S. storm-bergensis*. F. *Rissikia media*. G. *Taeniopteris carruthersii*. A. Complete unusually long leaf and normal width leaf UNEF14650 ; B. UNEF14642 ; C. UNEF14644 ; D. UNEF-14646 ; E. Showing strongly developed woody interveinal striae UNEF14648 ; F. Foliar spur UNEF14683 ; G. Natural group UNEF14670. All from UNEL1564. All natural size.

Basin (Frenguelli, 1948), the Cortaderita Formation of the Barreal-Hilario Basin (Frenguelli, 1948), the Los Rastros Formation in the Ischigualasto-Villa Union Basin (Stipanicic and Bonetti, 1969) and the Challao-San Isidro Basin (Frenguelli, 1948). Douglas (1969) believes that supposed remains of *P. elongatus* from the Early Cretaceous of Victoria (Medwell, 1954, pl. 3, figs 9, 10) are equisetalean fragments.

Comparable Basin Creek Formation material. UNEF13465 (Flint and Gould, 1975, pl. 2, fig. 6) from UNEL1495 and UNEF13326 from UNEL1489.

Genus SPHENOBAIERA Florin 1936

Sphenobaiera argentinae (Kurtz) Frenguelli 1946

Figs 10B–10D

Description. Several specimens from UNEL1564 vary from narrow scarcely-divided leaves (Fig. 10B) to more widely divided (Fig. 10C) and broader fan-shaped leaves (Fig. 10D). They have a narrow almost petiolate leaf base. The veins dichotomise at various levels. Commonly there are clear interveinal woody striae.

Comparison. These leaves differ from *Phoenicopsis elongatus* in their divided apex and veins dichotomising at various levels in the leaf. *Sphenobaiera argentinae* is larger and more deeply divided than is usual for *Ginkgoidium* (Seward, 1919; Frenguelli, 1946). The variation in shape (Figs 10B, 10C, 10D), the interveinal striae and close relationship with associated *Phoenicopsis elongatus* are most similar to the South American material (Frenguelli, 1946).

Occurrence. This species is best known from the Potrerillos and Cacheuta Formations of the Cacheuta Basin in Argentina (Frenguelli, 1946; Jain and Delevoryas, 1967). Archangelsky (1968a) and Anderson and Anderson (1970) also record it from Paso Flores, the Cortaderita Formation in the Barreal-Hilario Basin and in the Chihuiu-Tronquimalal Basin in Argentina. It may also occur in the Feldspathic Sandstone Series at Lords Hill, Hobart, Tasmania (as *Salisburia hobartensis* in Johnston, 1887, 1888).

Comparable Basin Creek Formation material. UNEF14610, UNEF14611 and Australian Museum specimen number AMF48873 all from UNEL1489.

Sphenobaiera stormbergensis (Seward) Frenguelli 1948

Fig. 10E

*1903 *Baiera stormbergensis*; Seward, p. 64, pl. 8, fig. 3.
p1917b *Ginkgo magnifolia*; Walkom, p. 9, pl. 4, figs 3, 4.
p1927 *Ginkoites magnifolius*; Du Toit, p. 25, fig. 17, pls 10, 11, fig. 1.
   1928 *Ginkgoites* cf. *magnifolius*; Walkom, p. 466, pl. 27, fig. 3.
   1936 *Ginkgoites magnifolius*; Florin, p. 44.
   1947 *Ginkgoites magnifolius*; Jones and De Jersey, p. 59, pl. 10, figs 2, 3.
   1948 Sphenobaiera, Stormbergensis; Frenguelli, p. 247.
   1968a Sphenobaiera stormbergensis; Archangelsky, p. 82.
   1969 Sphenobaiera stormbergensis; Stipanicic and Bonetti, pp. 1095, 1099.
   1975 *Ginkgoites* cf. *magnifolius*; Flint and Gould, p. 71.

Holotype. The specimen figured by Seward (1903, pl. 8, fig. 3) from the middle Molteno Beds (Stage D) of Konings Kroon, Elliot, South Africa (Du Toit, 1927, p. 371).

Description, Only one specimen (Fig. 10E) was found at UNEL1564. This is a broad leaf in which the venation is obscured by woody striae giving the leaf a pleated appearance.

Comparison. The strong pleating of the leaf is most similar to the specimen figured by Du Toit (1927, pl. 30). *Sphenobaiera argentinae* is smaller, narrower, only once divided and never shows a comparable development of woody inter-veinal striae. *Sphenobaiera stormbergensis* has been synonymised with "*Ginkgo*

Huttoni magnifolia " of Ward (1905) from the Jurassic of Oregon and Alaska. The American Jurassic species is distinctly smaller, usually only divided into four segments and the lowest segments form a right angle to a long well-diferentiated petiole (Ward, 1905, pl. 32, fig. 2).

Remarks.   The three species *Phoenicopsis elongatus*, *Sphenobaiera argentinae* and *S. stormbergensis* form an intergrading series of increasing size, dissection and development of woody interveinal striae.   They may have been one species in life.

Occurrence.   This species is known from the upper Beaufort Beds (Stage B) and the middle Molteno Beds (Stage D of Du Toit, 1927, and cycle 2 of Anderson, 1974) in South Africa, the Esk Trough and Ipswich Coal Measures in Queensland (Walkom, 1917b, 1928 ; Jones and De Jersey, 1947), the Red Cliff Coal Measures in New South Wales (Flint and Gould, 1975) and the Cortaderita Formation of the Barreal-Hilario Basin in Argentina (Stipanicic and Bonetti, 1969 ; Archangelsky, 1968a).

Comparable Basin Creek Formation material.   Robust pleated leaves UNEF13333 from UNEL1489 and UNEF13471 from UNEL1495.

DIVISION CONIFEROPHYTA

ORDER CONIFERALES

Family PODOCARPACEAE

Genus RISSIKIA Townrow 1967b

Rissikia media (Tenison Woods) Townrow 1967b

Figs 10F ; 11A

Description.   A foliar spur (Fig. 10F) from UNEL1564 shows spirally arranged, narrow, elongate lanceolate leaves with strong midribs.   The leaves are up to 9·6 mm long, 1·6 mm wide and about 3 mm apart.   They are contracted at the base and arranged at a relatively open angle to the axis.

A seed cone (Fig. 11A) from UNEL1563 was collected in part and counterpart (UNEF14707/8).   The three obtusely pointed lobes of the cone scale at the top of the specimen each bear two ovules.   A trifid bract scale may be seen immediately left of the X5 indication on Fig. 11A.   The ovules are not all exactly the same size (Townrow, 1967b, p. 111).   To the lower left of the cone is a fragment of a foliage leaf.

Comparison.   The specimens are identical to those of Townrow (1967b, 1969). Similar Gondwanaland conifer remains are compared in detail by Townrow (1967b, p. 123).

Occurrence.   This species is best known from the middle Molteno Beds (Stage D of Du Toit, 1927, and cycle 2 of Anderson, 1974) in South Africa.   The type specimen of Tenison Woods (1883) is localised as " Ipswich " and has a specimen of *Dicroidium odontopteroides* on the same slab.   However nothing like it was found in the Ipswich Coal Measures by Jones and De Jersey (1947).   *Rissikia media* has been found in the neighbouring Esk Trough in Queensland (as *Elatocladus* sp. in Hill *et al.*, 1965, pl. T8, fig. 7) and rocks of the same age in New South Wales ; the Nymboida Coal Measures (Flint and Gould, 1975) and the Gunnee Beds near Delungra (Gould and Retallack in Bourke *et al.*, in press). Townrow (1967a) also records it from Antarctica.   I am reluctant to accept that the foliar spurs from bed 3 of the Sakamena Group in Madagascar, synonymised by Townrow (1967b) are valid records of *R. media*.   These have thicker axes than *R. media* and crowded flexuous leaves curving sharply into the axis.   *Voltziopsis* fructifications are associated with the Madagascar leaves, but no *Rissikia* cones have been found.

Comparable Basin Creek Formation material. Foliar spurs figured by Flint and Gould (1975, pl. 2, fig. 6a) from UNEL1495 and UNEF13334 from UNEL1489.

UNCLASSIFIED PLANT REMAINS
Fructification type A
Fig. 11C

Description. This is a lax cone with stalked seed-like organs borne on thick woody cone scales. The best specimen (Fig. 11C, part and counterpart UNEF-14690/1) from UNEL1564 shows three apparently-inverted sets of possibly paired ovules on a slender branched stalk which rises almost perpendicularly from the cone scale. The cone scale is very thick and heavily carbonised. It arises almost perpendicularly to the axis and then curves sharply upwards. UNEF14692/3 is a very poorly preserved leached fragment in a coarser matrix from UNEL1564. UNEF14606 from UNEL1563 is a group of three stalked seedlike bodies overlying a flat portion of cone scale.

Comparison. This cone has some features of the Voltziaceae, but does not agree with any known genus of that family (Archangelsky, 1968b). *Strobilites laxus* Seward 1908 is larger and lacks seeds, although it has similar curved thick cone scales. *Beaniopsis* is also superficially similar but has only two distinctly angled seeds per scale which are back to back and directed in opposite directions (Ganju, 1947). In *Stachyotaxus* the seeds are fused with the cone scale (Seward, 1919). A specimen of "seeds of possible Ginkgoalean affinity" (Jones and De Jersey, 1947, p. 63) is somewhat similar but the associated sterile bracts are linear.

Remarks. The coalification of the remains in a coarse matrix and leaching of the rock do not allow a closer analysis.

Fructification type B
Fig. 11B

Description. This is a natural oblique section through a cone found as part and counterpart (Fig. 11B, UNEF14703/4) at UNEL1564. The bract scales are elongate triangular with a sagittate, almost sheathing base. The bract substance is very thick and coriaceous. The midrib is prominently rounded but the probably once-forking lateral veins are very difficult to trace. Below and to the left of the most obvious bract scale is a natural longitudinal section of the thick woody cone scale, bearing several seeds on its adaxial surface, and of the underlying thinner bract scale. The seeds are small, tear-shaped and strongly convex with micropyles directed upwards. They appear to have a fleshy sarcotesta elongated above the micropyle. The woody sclerotesta shows up as three rounded lobes separated by narrow furrows on one flattened side. The cone was relatively lax after fall as it has picked up extraneous plant fibres in transport. A further specimen of the leaf-like bract scale (UNEF14705 from UNEL1563) shows its acute apex.

Comparison. The venation of the bract scale suggests a relation with *Blechnoxylon* (Etheridge, 1899) or *Glossopteris* of the type attached to a thick caudex (Etheridge, 1894) rather than slender axes (Pant and Singh, 1974). This cone scale is superficially similar to *Dictyopteridium, Scutum* (Surange and Chandra, 1975) and *Austroglossa* (Holmes, 1974), but in these the bract scale covers a complete strobilus adnate to a foliage leaf. The ribbed seeds are superficially similar to some pteridosperm seeds (Taylor, 1966). The structure is similar to *Palissya* (Frenguelli, 1949). However in the Cloughers Creek cone the bract scale is not fused to the cone scale and the arrangement of the seeds cannot be exactly determined.

Remarks. This fructification is probably a new type of gymnosperm possibly related to the Glossopteridae or primitive conifers.
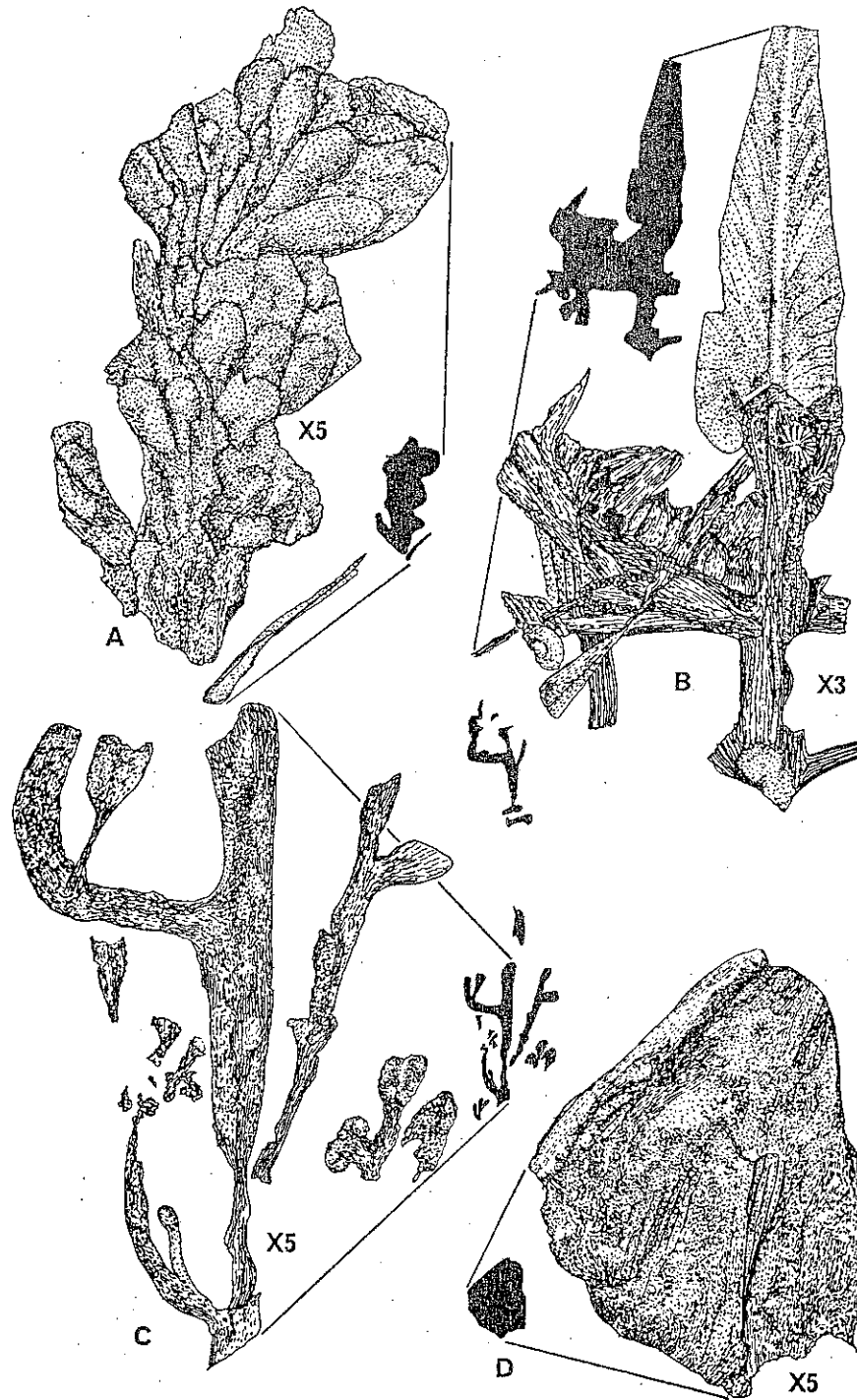
Fig. 11. A. *Rissikia media*. B. Fructification type B. C. Fructification type B. C. Fructification type A. D. Fructification type C. A. Seed cone UNEF14707,×5; B. (?) seed cone UNEF14704,×3; D. (?) seed cone UNEF14690,×5; D. Large seed UNEF14696,×5. A, B and D from UNEL1563; C from UNEL1564. Silhouettes natural size.

Fructification type C
Fig. 11D
Description.   Fig. 11D depicts a large seed from UNEL1563.
Comparison.   The size, shape and longitudinal rib of this seed are similar to seeds commonly associated with *Dicroidium zuberi* (Szajnocha) Archangelsky 1968c (Frenguelli, 1944a, pl. 12, figs 1, 2).
Occurrence.   Frenguelli's (1944a) specimen was collected from the Cortaderita Formation of the Barreal-Hilario Basin in Argentina.
Comparable Basin Creek Formation material.   UNEF14712/3 (part and counterpart) from UNEL1489.

Woody many-branched roots.
Description.   One specimen (UNEF14694) was collected from an underclay (UNEL1562).
Comparison.   Roots of this type are most similar to specimens described by Frenguelli (1942a) as " *Czekanowskia* " rigalii.
Occurrence.   " *Czekanowskia* " rigalii occurs in the Cacheuta Basin (Archangelsky, 1968a), the Challao-San Isidro Basin and the Los Rastros Formation of the Ischigualasto-Villa Union Basin (Frenguelli, 1948) in Argentina.
Comparable Basin Creek Formation material.   UNEF14710 from UNEL1489 is identical with the Cloughers Creek Formation specimen ; UNEF14717 from UNEL1489 is very similar to more typical Argentine specimens of " *Czekanowskia* " rigalii.

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