TRIASSIC PLANT MEGAFOSSILS FROM THE SPRINGFIELD BASIN, SOUTH AUSTRALIA

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TRIASSIC PLANT MEGAFOSSILS FROM THE SPRINGFIELD BASIN, SOUTH AUSTRALIA

A thesis submitted to the University of Adelaide
for the degree of Master of Science.

by

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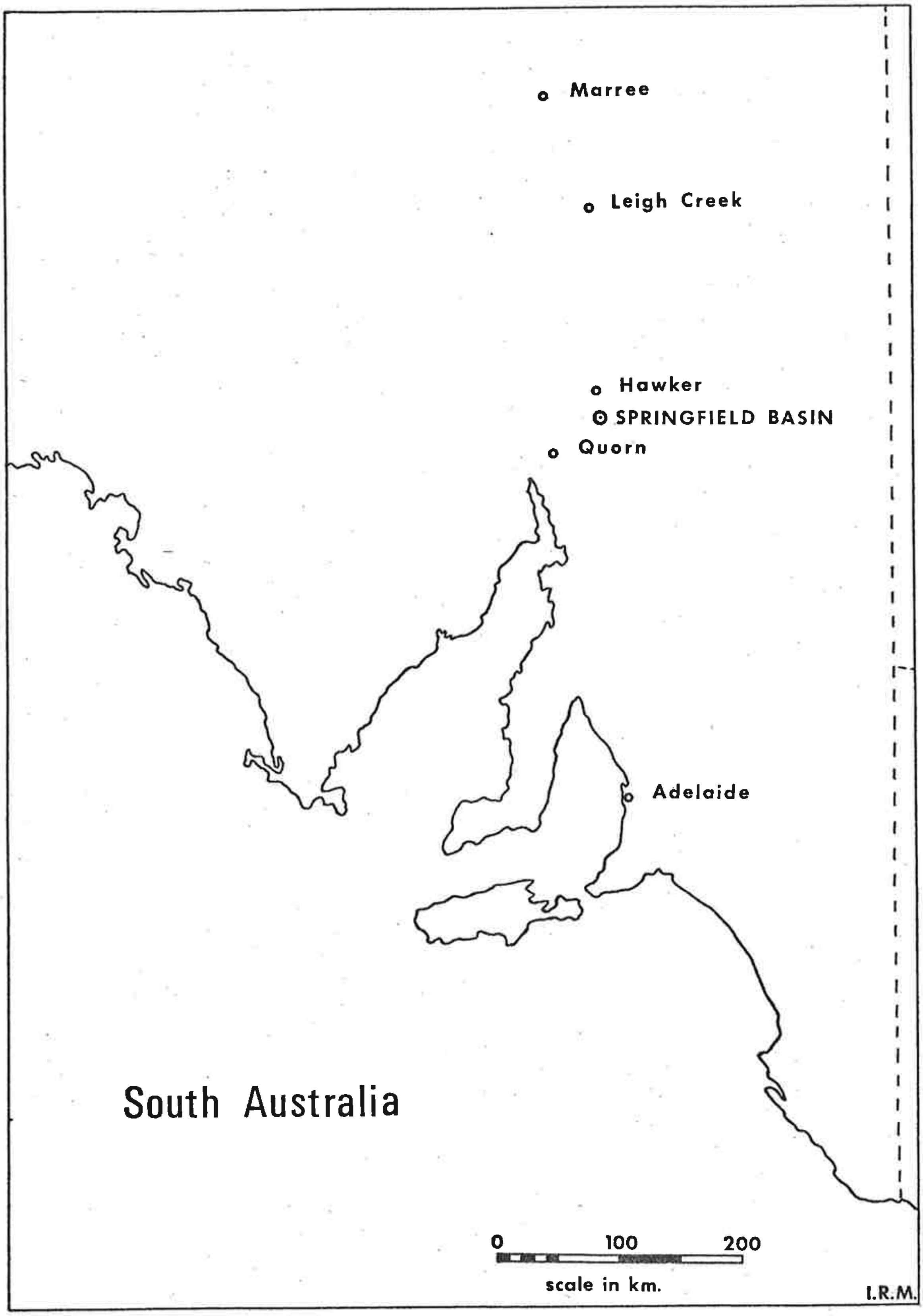
DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any University and to the best of my knowledge and belief it contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

IAN R. MOSEL.



Locality Map

SUMMARY

Plant megafossils were found on a mesa in the Springfield Basin, South Australia and aspects of the stratigraphy of the mesa complementary to those discussed by Johnson (1960) were examined. Little useful information about the stratigraphic sequence of plant megafossils was obtained.

The present study deals with the taxonomy of plant megafossils held in the collections of the Botany Department, University of Adelaide and the South Australian Museum. Difficulties were experienced due to the extremely fragmentary nature of many of the fossils and the complete lack of preserved cuticle material. Classification of the material resulted in the following determinations of taxa: *Neocalamites carrerei* (Zeiller) Halle, *Dicroidium odontopteroides* (Morris) Gothan, *Dicroidium zuberi* (Szajnocha) Archangelsky, *Dicroidium coriaceum* (Johnston) Townrow, *Dicroidium dubium* (Feistmantel) Bonetti, *Dicroidium acutum* (Walkom) Jacob and Jacob, *Xylopteris elongata* (Carruthers) Frenguelli, *Xylopteris spinifolia* (Tenison-Woods) Frenguelli, *?Umkomasia macleani* Thomas, *Taeniopteris spatulata* Oldham and Morris (non McClelland 1850), *Taeniopteris springfieldensis* sp. nov., *Yabeilla brackebuschiana* (Kurtz) Oishi, *Podozamites lanceolatus* (Lindley and Hutton), *Ginkgo digitata* (Brongniart) Heer, *Ginkgoites antarcticus* (Saporta) Seward and two specimens, *insertae sedis*.

Other Gondwanaland floras were compared with the Springfield Basin flora and a Middle to Upper Triassic age for the flora proposed.

INTRODUCTION

In 1957 a group of geology students from Adelaide University, mapping under the supervision of Dr. A. W. Kleeman, found fossilized leaf impressions in rocks from an area approximately 25km north-east of Quorn in the mid-north of South Australia. The fossils were found in partially silicified argillites at the top of a small mesa (Plate 1.) situated on the "Springfield" grazing property of Mr. J. H. Hilder. Kleeman recognized that these leaf impressions had Triassic affinities, and the South Australian Department of Mines became interested in the area as a potential source of coal, the flora being recognised as similar to that associated with the Leigh Creek deposits.

W. Johnson of the South Australian Mines Department conducted a reconnaissance of the area in November 1957 and found outcrops of carboniferous material which showed the existence of a sedimentary basin about 5km long and 2km wide. Following the reconnaissance a more detailed geological study organised by the South Australian Mines Department was reported upon by Johnson (1960).

After making extensive collections from the mesa in the Springfield Basin, Amtsberg (1969) published an account of the plant megafossils from these sediments and some specimens from the Leigh Creek coal measures. However Amtsberg's preliminary study of the fossils from Springfield Basin lacked a critical analysis of the taxonomic status of many of the plant fossil specimens. This present study revises Amtsberg's taxonomic treatment of his earlier collections and includes an analysis of specimens collected subsequently by him and by others.

CHAPTER 1.

OLDER MESOZOIC PLANT REMAINS IN SOUTH AUSTRALIA

The presence of Lower Mesozoic sediments in South Australia has been established since plant fossil-bearing shale was discovered in 1888 during excavation of a Government Dam in the vicinity of Leigh Creek, approximately 580km north of Adelaide. Specimens were examined by Etheridge Jnr. and his first figures and a report were published in the South Australian Parliamentary Papers in 1891. The possible significance of this discovery was realized when ultimately economic deposits of sub-bitumous coal were found in the vicinity of Leigh Creek.

The "Sweet" collection of plant fossils from Leigh Creek was described by Etheridge Jnr. (1895) and later revised by Chapman and Cookson (1926). Plant fossils determined by Chapman and Cookson and listed in this report, included equisetaleans, ferns, seed ferns, ginkgoaleans and conifers.

Following the discovery of the Springfield Basin, a second mesozoic basin was found at East Boolcunda 6km south-west of Springfield Basin in 1958. Drilling was carried out in these basins by the South Australian Department of Mines in the hope of finding economic deposits of coal, and palynological studies of these sediments were undertaken during this time.

Balme (1961) reported on the results of some of these investigations and other information is contained in unpublished reports held by the South Australian Department of Mines. Balme (1974, personal communication) now considers that his reported determination of fossil material should be revised in the light of recent knowledge. Palynological studies of South Australian Mesozoic plant megaspores have also been carried out on Leigh Creek material by Glaessner and Parkin (1958), Dettman (1961) and Playford and Dettman (1965).

The sedimentary history of the Leigh Creek and the Springfield and Boolcunda Basins remains very fragmentary.

CHAPTER 2

METHODS USED IN INVESTIGATIONS

1. Fossil Material

1.1 Collections Studied.

1.11 The Amtsberg Collection of the South Australian Museum.

This collection made by Mr. H. Amtsberg over several years was donated to the Museum in 1974.

1.12 Collection of the Botany Department, University of Adelaide.

This collection consists of material collected by Mr. W. Harvey in 1970 and the author's collection made during the period from 1972 to 1974.

1.2 Collection Methods.

The top of the mesa (pl.2,fig.1.) at Springfield Basin from which the megafossils were collected has the general appearance of a pile of rubble with the average size of rocks being about the dimensions of half a house brick. Between and beneath the surface layer of rocks there is a little soil supporting a few low shrubby plants. The solid rock of the top stratum lying 50-80cm beneath the surface is completely cracked into football sized pieces of rock. These larger pieces of rock were removed with difficulty with pick and shovel. Several sites on top of the mesa were sampled but most were taken from diggings near the N-W corner of the mesa.Many of Mr. Amtsberg's specimens were found amongst the smaller rocks of the top layer. These rocks with exposed impressions were subject to weathering and the fine details of the fossils were often not visible.

1.3 Exposing the Fossils.

The cap of the mesa consists of very hard porcelainised argillite. When struck, the rock breaks with a blocky to conchoidal fracture and it is only by chance that an exposed section of a broken rock occurs along the plane of sedimentation. An attempt was made to further expose some partially obscured leaf impressions by sawing and grinding away rock with abrasive tips of a dental drill. This was successful with a few specimens where only a small amount of rock needed to be removed. Other attempts were frustrated by the very rapid wearing away of the abrasive material by the extreme hardness of the rock. These difficulties plus the relatively low frequency of fossils in the strata resulted in only a small total number of specimens (about 200), being available for study, and many of these were very fragmentary. No efficient method was found for exposing fossils in these rocks.

1.4 Examination of Material.

All the fossils examined were impressions. No carbonised material or cuticles were found although pieces of fossil material were digested in Schultz's macerating fluid which was used to remove the rock matrix, leaving any cutinized material present undigested. Several cellulose acetate peels were taken of some specimens in case small pieces of cuticle remained undetected. However, microscopic examination of these peels also failed to disclose any cuticle remains.

Many of the impressions had stained the matrix rock and gross morphological features could easily be seen. However, stereomicroscopic examination of many of these often failed to reveal detail of features such as venation. The venation of many of the leaf impressions could however, quite clearly be seen either by direct viewing under incident light with hand lens or stero-microscopic where veins were differentially stained in comparison to other parts of the leaf, or by oblique lighting so as to create shadowing of vein impressions. Coating of leaf impressions with ammonium chloride was also carried out in an unsucessful attempt to improve observation of venation patterns.

Some of the impressions were obscured by a white powdery material which could be removed by application of dilute hydrochloric acid. This calcareous material only occurred on rock surfaces where some weathering had occurred. Opaque or transparent crystalline material also sometimes covered freshly-exposed leaf impressions and often obscured features of the fossil. This siliceous material could only be removed by breaking it away from the rock with a sharp needle. Often good detail could be observed after removal of this material from the leaf impression.

Lele (1961) reported success in observing cell detail of the epidermis of *Dicroidium* from India where cuticles of the leaves were not present. Black, or nearly black, non-carboniferous material associated with the impression was found by Lele to reveal some cell detail, including stomatal features, when viewed with a compound microscope using incident light illumination. This technique was tried with several leaves, particularly those which were most darkly stained, using a compound microscope with condenser and stage removed. Whilst the leaf impressions could be clearly observed no cell detail could be detected. It was unfortunate that no cell detail of the leaf epidermis could be found.

Latex rubber moulds were made of seeds and seed-bearing structures. The moulds were made by applying successive layers of liquid latex with a small brush on to the rock with a period for drying allowed between each application. When a sufficient thickness of rubber had been built up, the moulds were stripped off the rock. Rubber moulds of impressions of structures such as seeds and fruits gave a clearer impression of the actual appearance of these three dimensional structures, but no additional information was gained by using this technique.

1.5 Photography

Photographs of all specimens were taken using a Leitz "Reprovit" apparatus and a Leica 35mm camera. Oblique lighting was used for shadowing of three-dimensional features such as the impressions of veins and stem ridges.

1.6 Diagrams.

Line diagrams were produced by tracing features on photographs of specimens with drawing ink and then bleaching the photograph. The bleaching process was performed in the following way:

Solution A:	5.5% (by weight) solution of Potassium permanganate in distilled water.
Solution B:	.02N Sulphuric Acid.

A mixture of Solution A, Solution B and distilled water was made up in the ratio 1:4:20 and the photographic paper immersed until bleached (approximately one minute). The paper was then fixed for 5 minutes in "Hypam" fixer and then washed. This method was adapted from Isham (in Kummel and Raup, 1965, p464-465).

2. Field Techniques.

Mapping.

Detailed mapping of the Springfield Basin was carried out and reported by Johnson (1960); however, only a very general description of the fossil bearing mesa was given. A reconnaissance of this structure indicated that distinctive strata existed and that quite variable environmental conditions must have existed during the period in which the sediments of the mesa were deposited.

Exposed rock in a gully on the eastern side of the mesa (Plate 2, fig.2.) made it possible to obtain a more detailed picture of the sedimentary history of this part of the basin. Levels were taken and samples of rocks at various depths below the top of the mesa were collected and examined.

An attempt was made to obtain a complete picture of the sediments of the mesa by measuring the dip and strike of the strata. Although this could be done at certain points such as in the gully and at one or two outcrops, the mass of scree covering the bulk of the mesa prevented a complete picture from being elucidated. The little evidence which was obtained indicated that if further pursued, this exercise would have given only trivial data.

CHAPTER 3.

GEOLOGY AND GEOMORPHOLOGY.

The geology, geomorphology, probable depositional history, and consequent stratigraphic sequence of the Springfield Basin has been described by Johnson (1960) following extensive systematic drilling of the basin. Except for a few fragments of leaves in drill cores the only known plant macro-fossils in the basin are located on or near the top of the mesa which has been able to largely withstand the effects of weathering due to a resistant cap formation. Johnson and Bucknell (1959) have explained the extreme hardness of this argillite cap as being possibly due to baking of the rock surface by the heat of previous subterranean coal fires below the mesa. The presence of pseudo-igneous rocks in the immediate vicinity of the mesa is evidence supporting this hypothesis.

Examination of the strata of the mesa indicates that the mesa is variable in its composition. The stratigraphic sequence (see below) compiled from data obtained during this investigation shows that plant macro-fossils occur in only a relatively few strata near the top of the mesa. The various rock types present in the sequence suggest considerable changes in the local environmental conditions which prevailed during the time in which the sediments of the basin (to 360m. depth) were deposited.

Johnson (1960), in speculating on the geomorphological processess and palaeo-climatic conditions prevailing during the sedimentary history of the basin, concluded that the climate appeared to have varied considerably during the formation of the deposits. Arid conditions were probably interrupted by intermittent, torrential rain during the early period followed by tropical or sub-tropical conditions with marked seasonal rains, and finally by a period when the rainfall was abundant and non-seasonal. The presence of the fresh-water bivalve mollusc *Unio,* in the uppermost strata of the mesa indicates that non-stagnant, fresh-water lakes occurred in the region at the time when these deposits were formed. The presence of plant fossils with xeromorphic features, such as *Xylopteris*, which form part of the Springfield Basin flora, is often given as evidence that arid conditions prevailed at the time when these plants became fossilized. Such speculation is not strongly supported by the morphology of other species present in the Springfield Basin flora. Other leaf forms in the flora are largely mesomorphic although the leaves of the *Dicroidium* group of plants could be considered on account of their hard, leathery structure, to have been well adapted to conditions of lower rainfall.

Rock Strata of the Mesa.

The mesa is composed of strata consisting of several rock types, however the very narrow zone of plant remains in the strata provided little scope for a stratigraphic sequence of fossils to be studied. The only significant qualitative distinction between strata of the fossil bearing zone was demonstrated by the high density of *Neocalamites* in the stratum immediately beneath the fine-grained argillites of the mesa cap.

Rock Strata of Mesa

Distance below surface of Mesa	Description of Strata
3 - 5m.	Chocolate to light/pale grey, slightly to somewhat silificied fine siltstones and mudstones (argillites) with irregular, blocky to angular fracture. Plant impressions, freshwater mussel (*Unio Sp.*) impressions.
6 - 7m.	Off-white, porous, very calcareous fine sandstone/sandy lime stone. Plant impressions very common, particularly *Neocalamites*.
11 - 12m.	Light pink, very fine grained and well sorted, somewhat porous non-calcareous sandstone with carbonate skin on the weathered surface. Leaf impressions less common.
12 - 14m.	Pale grey to white, thinly and very evenly laminated, somewhat porous very fine grained and well sorted sandstone.

(Rock types were determined with assistance from the South Australian Mines Department).

CHAPTER 4

PLANT TAXONOMY

Order EQUISETALES

Genus *Neocalamites* Halle, 1908.

Diagnosis.

Halle (1908)."Stem articulated, hollow, with smooth outer surface, internally grooved. Leaves in whorls, numerous, long, slender, stem-like, once-nerved, entirely free of each other. Leaves signifcantly fewer in number than the grooves of the stems, half as many or less".

Remarks.

Halle (1908) instituted this genus for a group of Mesozoic equisetalian stems with free, linear leaves previously classified with *Schizoneura*. *Schizoneura* is now reserved for stems with linear leaves fused into groups. Other similar genera which may be confused with *Neocalamites* are *Phyllotheca* and *Annulariopsis* but these can be distinguished mainly on the basis of leaf characteristics, *Phyllotheca* having leaves that are fused at the base but free above, and thin stems, and *Annulariopsis* with leaves of the *Neocalamites* type but of unequal length. Harris (1931a) commented that *Neocalamites, Schizoneura,* and *Phyllotheca* are genera that cannot be successfully delineated from one another because there are species between each pair of genera which are intermediates.

The genus *Neocalamites* has been recorded from a wide range of lower Mesozoic deposits including Gondwanaland sediments.

Determination of the Springfield Basin equisetalian material is based on a very small sample of well preserved specimens. Only one specimen, P17382, has structures which are unequivocally leaves.

Neocalamites carrerei (Zeiller) Halle

(Plate 3, figs. 1-8; plate 4, figs. 1,5,6; text-fig. 3.4).

1903 *Schizoneura carrerei* Zeiller, p. 137, pl. xxxvi, figs. 1,2; pl. xxxviii, figs. 1-8.

1908 *Schizoneura carrerei* (Zeiller): Seward, p. 85, pl. 11, fig. 1.

1908 *Neocalamites carrerei* (Zeiller) Halle, p. 6.

1915 *Neocalamites cf. carrerei* Walkom, figs. 1,4. pl. 1.

1927 *Neocalamites carrerei* (Zeiller): DuToit, p. 315, pl. xvi, figs. 2,3.

1939 *Neocalamites carrerei* (Zeiller): Kawasaki, p. 6-8, pl. 1, figs. 2,3.

1946 *Neocalamites carrerei* (Zeiller): Harris, p. 9-14, pl. 1, fig. 8. text-fig. 2.

1947 *Neocalamites carrerei* (Zeiller): Jones and de Jersey, text-fig. 2.

1962 *Neocalamites carrerei* (Zeiller): Konno, pl. 9, figs. 1-3.

1967 *Neocalamites carrerei* (Zeiller): Jain and Delevoryas, pl. 86, figs. 406.

1971 *Neocalamites carrerei* (Zeiller): De Cabrera, figs. 1-5, 7.

Description of specimens from Springfield Basin.

Specimen P17382 (Plate 3, fig. 3; text-fig. 3.4) is the only specimen which clearly shows the presence of leaves attached to the stem. The stem is approximately 30mm. in length consisting of three internodes each about 10mm. long and 3-4mm. wide. The fossil is a pith cast but details of surface features of the nodes and internodes cannot be determined because of poor preservation. No complete leaf is visible but some evidence of leaf form can be determined. The leaves are all under 1mm. wide (0.7-0.9mm.) and the longest fragment is 14mm. long. The margins are parallel and there is a distinct midrib. Few of the leaves can be seen to join the nodes, but this specimen suggests that the number at each node is quite small, certainly less than 20.

The pith cast, P14146 (Plate 3, fig. 7) clearly shows impressions of the nodes. The number of scars at the nodes indicates that the number of leaves per node in this speciment was 12-16.

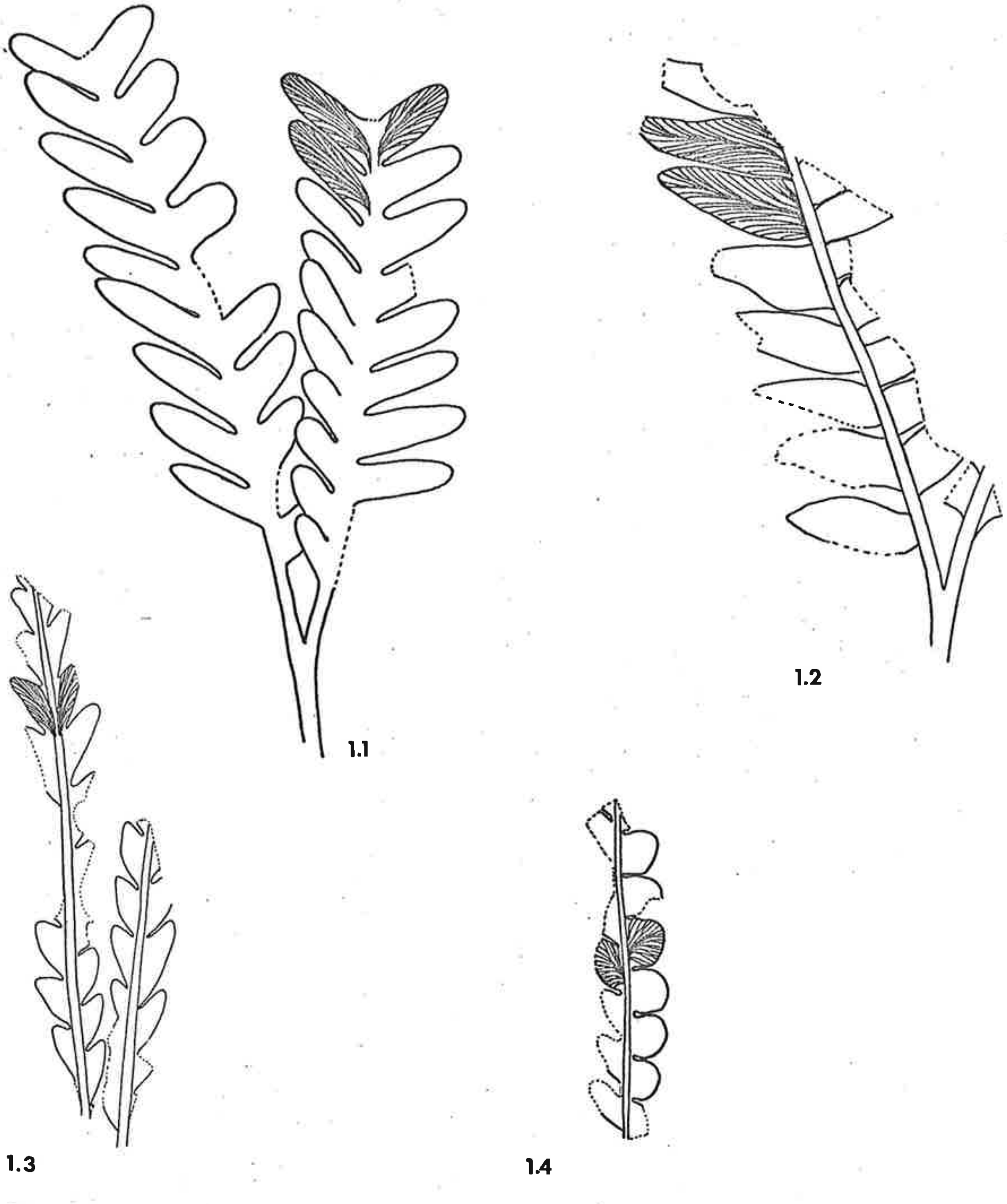
P17395 (Plate 4, fig. 5) is a pith cast with two nodes, one complete internode and two partial internodes. The specimen is longitudinally ridged and grooved with 10 ridges and grooves per 5mm. Compared to other specimens the internode is long relative to the width of the impression (33m. long, 7mm. wide).

P17383 (Plate 3, fig. 8) is a pith cast 65mm. long and 7mm. wide consisting of four internodes which show the characteristic ridging. No leaves or leaf scars can be seen.

Speciment S0273 (Plate 3, fig. 6) consists of a pith cast which became detached from the matrix revealing an impression of the outer surface of the stem. The pith cast which is 60mm. long and 15mm. wide, is finely ridged and grooved longitudinally, and 15 ridges can be counted per 5mm. The fine sculpturing of the pith cast is superimposed on a faint outline of the surface features of the stem which can be clearly seen in the cast. The impression of the outer surface of the stem shows a series of longitudinal ridges. The ridges are rounded whilst the grooves between are acute in cross-section. There appear to be 14 ridges in this stem. There is no clear indication of nodes in this specimen. Associated with the densely concentrated pith casts of *Neocalamites* in the upper strata of the Springfield Basin Mesa are impressions of thin, linear structures which may be leaves of the same plant, however they are all considerably fragmentary and distorted, show no fine detail and are not attached to the stems.

Specimen P14120 (Plate 3, fig. 2) is similar to S0273 except that the stem is slightly broader (18mm). The outer surface of the stem again appears to have had 14 ridges. However, in this case the ridges are narrow and acute whilst the grooves are shallow, broad and rounded in section.

Specimen P14119 (Plate 3, fig. 4) is an impression of the outer surface of a stem approximately 20mm. wide in its flattened state. There appear to be 5 longitudinal ridges across this region which would mean that the intact stem had 10 ridges round the circumference. The form of the ridging in this specimen suggests that the cross-section outline of the stem was a near regular polygon. Nodal regions are indicated by the presence of rather scattered patches of scars separated by internodes 15-20mm. long. Four nodes are visible in this section. The scars are lenticular shaped impressions approximately 1mm. wide and 3mm. long, their long axes being parallel with the long axis of the stem. There is no regular pattern of distribution of these scars except that at one node there seem to be two rows. However this is not uniform across the full width of the stem as one or two scars are displaced significantly from the regular patterns. The density of scars suggest that there may have been approximately 20 leaves around the circumference of the stem at each node. The shape of the leaf scar indicates that the base of the leaves were laterally flattened.



Text-fig.1. 1.1, *Dicroidium odontopteroides*, specimen S0101b (X 1.5); 1.2, *D. odontopteroides*, S0088 (X 1.5); 1.3, *D. odontopteroides*, S0085 (X 1.5); 1.4, *D. odontopteroides*, S0082 (X 1.5).

Order CAYTONIALES

Family Corystospermaceae

Genus *Dicroidium* Gothan, 1912.

Gothan (1912) established the genus *Dicroidium* for "*Thinnfeldia*-like" plants originating in regions which at one time supported a *Glossopteris* flora i.e., Gondwanaland. Gothan described *Dicroidium* as having "frond constantly once forked, each fork usually once pinnate, seldom twice pinnate. Venation odontopteroid seldom alethopteroid. Epidermis (cuticle) thin, cell outline way, stomata thin without "wallzellen" (i.e. with irregular subsidiary cells)."

Dicroidium odontopteroides (Morris) Gothan

(Plate 7, fig.6; plate 8, figs.1-7; plate 9, figs.1-7; text-figs. 1.1, 1.2, 1.3, 1.4)

1845 *Pecopteris odontopteroides* Morris, p.249, pl. VI, figs. 2,3,4.

1878 *Thinnfeldia odontopteroides* (Morris) Feistmantel, pp. 79-81, pl. 13, fig. 5; pl. 15, figs. 307.

1903 *Thinnfeldia odontopteroides* (Morris): Seward, pp. 52-57, pl. 7, figs. 1,8a; pl. 8, fig. 7; pl. 9, figs. 7,8; pl. 11, fig. 2.

1912 *Dicroidium odontopteroides* (Morris) Gothan, pp. 71-78, pl. 15, fig. 4; pl. a6, fig. 5.

1917 *Thinnfeldia odontopteroides* (Morris): Walkom, pp. 19,20, pl. 3, fig. 1.

1917 *Thinnfeldia lancifolia* (Morris var.): Walkom, pp.21-23, pl. 4, fig. 1; pl. 7, fig. 2; text-fig. 6.

1937 *Dicroidium odontopteroides* (Morris): Frenguelli, pp. 80-83, pl. 2, fig. 5,; pl. 3, figs. 6,7.

1957 *Dicroidium odontopteroides* (Morris): Townrow, pp. 33-39, pl. 11 (B.C); pl. 111 (A); text-figs. 2, B-E, 3, A-K; 4, C-J; 5, A-F; 6, A-M.

1967 *Dicroidium odontopteroides* (Morris): Jain and Delevoryas, p. 571, pl. 89, fig. 6; pl. 90, figs. 1-3.

1969 *Dicroidium odontopteroides* (Morris): Amtsberg, pl. 1, fig. 8; pl. 3, figs. 16,17.

Diagnosis.

Morris (1845). "Frond pinnatifidly bipinnate or flabellate? Pinnae linear elongate, acuminate; pinnulae opposite,

> approximately ovate, adnate, ovate obtuse, entire; veins nearly obliterated."

Townrow (1957) emended this diagnosis as the circumscription for this species (see later general discussion of *Dicroidium*) to read in part:

> "Leaf (7) -10-(13)cm. long. Pinnae typically 9mm. long and 6mm. wide, not contracted basally, apex blunt. Venation of three veins arising from a common point of origin each branched at least twice."

Townrow's emended diagnosis also includes characteristics of the cuticle which are irrelevant in this discussion because cuticle material of Springfield Basin fossils is not available..

Specimens which have been assigned to this species show very considerable variation of form. The fragmentary nature of some of the specimens from Springfield Basin together with the lack of cuticle material makes the systematic treatment of this group difficult. Fortunately the venation of the leaves can be clearly seen in most cases.

Description of Springfield Basin material.

Specimen S0101 (pl. 9, fig. 2; text-fig. 1.1) has pinnae very similar to Morris' type specimen. Length of rachis 52mm. comprising of unbranched stalk (pedicel) 10mm. and the two rami of the forked section 42mm. and 34mm. respectively. Pinnae ovate to linear, 6-8mm. long, 2-2.5mm. broad, emerging from rachis at an angle of from 45° - 60°, somewhat decurrent at the base, apices rounded to acute, not overlapping. Venation sphenopteroid [1], veins emerging from single point on basiscopic side of base of pinnae. Rachis stout. The pinnae of specimen S0089 (pl.9, fig.1) are shorter (6mm. and less) and broader (about 3mm.) than those of specimen S0101 , overlap each other, but do not appear to be decurrent. Venation is similarly sphenopteroid. The forked frond of spec. S0085(pl.8,fig.1)has pinnae of variable shape and dimensions. Near the fork of the rachis the pinnae are small, 5mm. long, 3mm. broad,

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[1] Forms of venation according to Emberger (1968), p. 270, fig. 318.

and ovoid with an acute apex which is recurved towards the basiscopic edge of the pinnae. Towards the apices of the frond the pinnae are more elongate, 8-9mm. long, 3mm. broad, and at this point are almost alternate whereas near the base of the frond they are almost opposite. The venation is not clear but appears to be sphenopteroid.

Specimen S0082 (pl.8, fig.6; text-fig. 1.4) is a fragment of a forked frond with pinnae alternate, almost semi-circular, 4mm. long, 4mm. broad, apex rounded, slightly decurrent. Venation apparently odontopteroid i.e, veins appear to arise from 2 or 3 separate points at base of some pinnae. Many specimens have pinnae which appear to have this type of venation. The veins join very close to the rachis, but this conjunction is difficult to observe. S0082 is an extreme form of *D. odontopteroides*; however there are intermediate morphological forms which appear to link it with the type.

The pinnae of specimen S0099a (pl.8, fig.5) attached to the pedicel of this frond are very short, 1.5mm long, 6mm. broad, and almost triangular in planar outline. The pinnae are slightly decurrent, sub-opposite and the venation is sphenopteroid.

Specimens S0163 (pl.9, fig.7) and S0119 (pl.8, fig.2) show the leaf apices of leaves which are probably fully developed. Most specimens of *D. odontopteroides* have apices terminating with a pair of mature pinnae of similar size to those nearer the fork of the rachis.

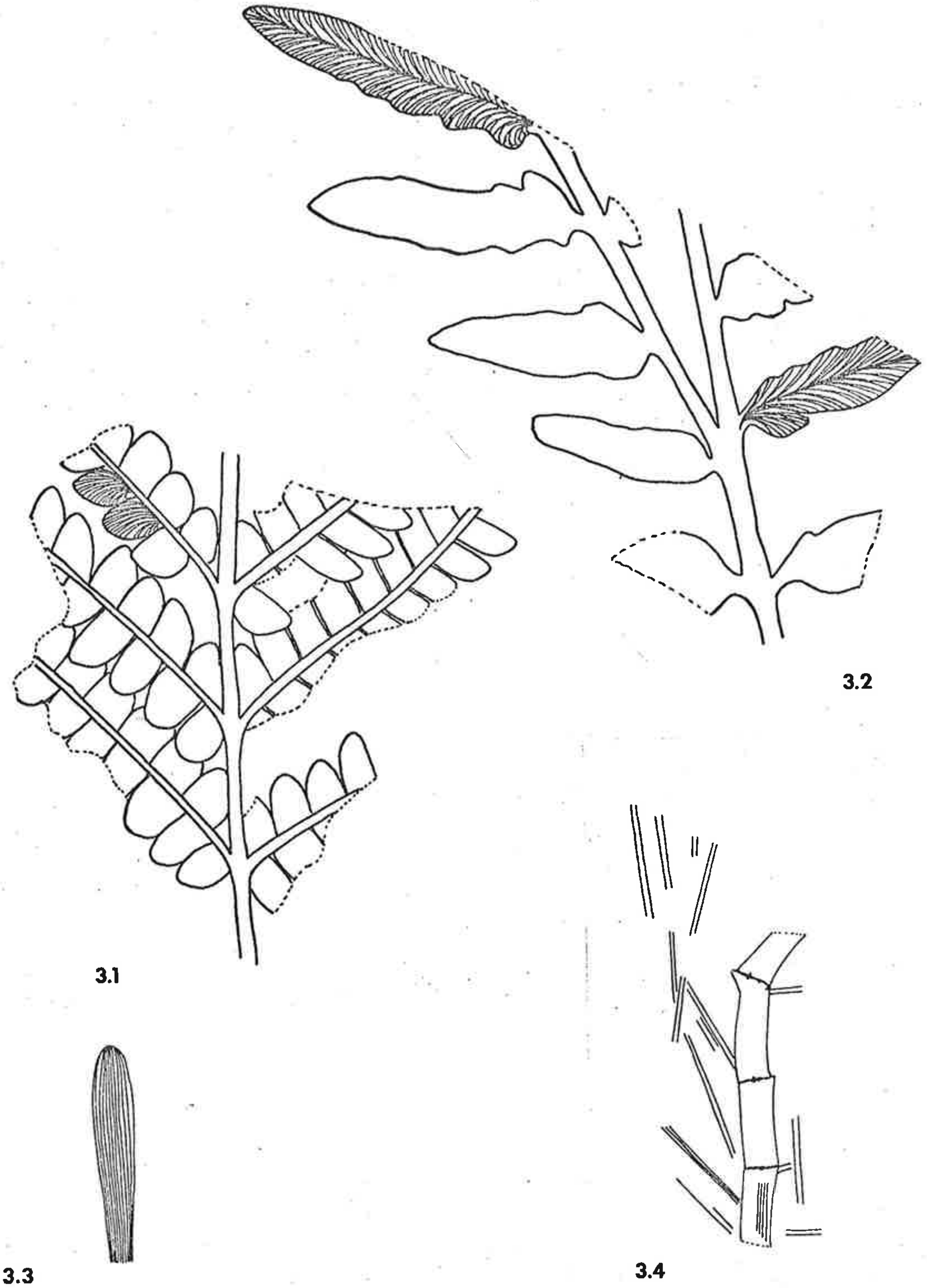
Specimen S0088 (text-fig. 1.2) is a fragment of a forked frond and has unusually large pinnae for *D. odontopteroides*. The pinnae are approximately 20mm. long and 6.7mm. broad, lanceolate, sub-opposite, not overlapping and not apparently decurrent. The pinnae have a prominent midrib which extends from the base to a point 2/3 to 3/4 of the way to the apex where it branches into several veins which lead to the distal margins. The characteristics of this frond, and also of P14127 described by Amtsburg (1969) as *D. acuta*, are characteristic of specimens often classified as *D. lancifolium* (Morris) Gothan by a number of authors.

Specimen P14147 (pl.9, fig.6) is another which has quite large lanceolate pinnae.

Discussion.

Townrow (1957) considered *D. odontopteroides* and *D. lancifolium* to be synonymous on the basis of the fact that cuticles of both forms cannot be distinguished and there is a complete intergraded series from the typical form of *D. odontopteroides* with its sphenopteroid or odontopteroid venation to the lanceolate pinnae of *D. lancifolium* with its distinct midrib. Townrow included the lanceolate forms in *D. odontopteroides* but considered this as provisional until a complete study of *Dicroidium* and its allies could be carried out. Anderson and Anderson (1970) in a preliminary account of this genus separated *D. lancifolium* from *D. odontopteroides* on macroscopic grounds basing their findings on a large number of specimens from the Molteno Beds of The Karroo System of South Africa. Although they have taken intermediate forms into consideration in this study a more complete analysis of the group is necessary before it can be accepted that the Springfield Basin specimens under discussion here represent more than one species. Close examination of the relatively small number of Springfield Basin specimens in this study referred to *D. odontopteroides* does not provide evidence for regarding *D. lancifolium* as distinct from *D. odontopteroides*.

D. obtusifolium (Johnston) Townrow may also be easily confused with *D. odontopteroides* because of similarities in the form of the pinnae, and it is likely that the two are synonomous. Johnston (1885) remarked that the two species could be distinguished by the shorter and more rounded pinnae and thicker cuticle of *D. obtusifolium*. Townrow (1966) pointed out that the main difference between *D. odontopteroides* and *D. obtusifolium* is in the leaf thickness, that of *D. odontopteroides* being thin in comparison to *D. obtusifolium*. Townrow claims that in practice, 9 out of 10 leaves in a population are "definitely identifiable". It must be concluded that on the basis of present evidence there is little justification for maintaining *D. obtusifolium* as a species distinct from



Text-fig. 3. 3.1, *Dicroidium zuberi*, P14124 (X 1.5); 3.2, *D. dubium*, P17386 (X 1.5); 3.3, *Podozamites lanceolatus*, P14132B (i); 3.4, *Neocalamites carrerei*, P17382 (X 2).

D. odontopteroides. It is certain that all of the specimens from Springfield Basin which might fit the diagnosis for *D. obtusifolium* equally well fit that of *D. odontopteroides*.

Dicroidium zuberi (Szajnocha) Archangelsky

(Plate 11, figs. 1-4, plate 12, fig. 1; text-fig. 3.1)

1878 *Thinnfeldia odontopteroides* (non-Morris sp.) Feistmantel, pp. 87-98, pl. 9, fig. 1.

1888 *Cardiopteris zuberi* Szajnocha, p. 233, pl. 2, fig. 1.

1895 *Thinnfeldia feistmanteli* Johnston, p. 57, figs. 2,? 16.

1912 *Dicroidium feistmanteli* (Johnston) Gothan, pp.11-13, pl. 16, fig. 1. (after Feistmantel 1878).

1917 *Thinnfeldia feistmanteli* (Johnston): Walkom, pp. 17-19, pl. 2, figs. 1,2.

1926 *Thinnfeldia feistmanteli* (Johnston): Chapman and Cookson, pp. 167-168, pl. xx, fig. 9; pl. xxi, fig. 10.

1943a *Zuberia feistmanteli* (Johnston) Frenguelli, p. 300, 309, fig. 25.

1943a *Zuberia zuberi*: (Szajnocha) Frenguelli, p. 300.

1944 *Zuberia zuberi*: (Szajnocha) Frenguelli, p. 9, pl. iv-xi; pl. xii, figs. 1,2.

1957 *Dicroidium feistmanteli* (Johnston) Townrow, pp.39-41, text-figs. 2, f; 5, G-J; 7, A,B; 9, A-F.

1957 *Hoegia papillata* Townrow, P. 49, pl. 2, D; text-figs. 8, B-D; 10, C,D.

1967 *Dicroidium feistmanteli* (Johnston): Jain and Delevoryas, p. 571, pl. 90, figs. 5,6.

1968 *Dicroidium zuberi* (Szajnocha) Archangelsky, p. 502,504, pl. 98, figs. 1,2; text-figs. 1a,2d,e.

1969 *Dicroidium feistmanteli* (Johnston): Amtsberg, p. 82, pl. 2, figs. 9-11.

1970 *Dicroidium zuberi* (Szajnocha): Anderson and Anderson, figs. 0-R160, 0-R175, N-L. SW 262.

Diagnosis.

Szajnocha (1888) "Frond pinnate. Pinnae large, broad, almost linear. Rachis very strong and broad, occasionally with weak longitudinal furrows. Pinnules very large,

> rounded, four sided, almost rhomboid, apex acute on acroscopic side, rounded on basiscopic side. Pinnules opposite, separate, decurrent at base on basiscopic side. Pinnules, thick and leathery. Veins many, groups of veins originating at base of pinnule from rachis. Strong main veins not formed."

Description of Springfield Basin material.

Bipinnate forms of *Dicroidium* are not common at Springfield Basin and no fossils of this type were found during this present study. There are however five specimens in the Amtsberg collection of the South Australian Museum which can be referred to *D. zuberi*. All but one of these, P17387, were referred to by Amtsberg (1969) as *D. feistmanteli*. All of the specimens are fragments and none exhibit the forked rachis which is characteristic of the genus *Dicroidium*. Specimen P14125 (pl. 12, fig. 1) is very poorly preserved and details of the pinnules are largely obscured. It is a larger specimen that the others. Specimens P14126 (pl. 11, fig.3), P14124 (pl. 11, fig.2; text-fig 3.1), P14152 (pl. 11, fig. 1) and P17387 (pl. 11, fig. 4) are all similar in having a stout rachis, opposite pinnae and rhomboidal, overlapping pinnules with odontopteroid venation.

Discussion.

The first published account of a bipinnate *Dicroidium* type leaf was that of Szajnocha (1888) from the Cacheuta Basin, Argentina. Szajnocha referred this leaf to Schimper's genus *Cardiopteris*. The figure (Szajnocha, 1888; Plate 2, fig. 1) of *Cardiopteris zuberi* Szajnocha is a poor one and shows only small parts of two pinnae each with several pinnules; however the detail is sufficient to allow it to be compared with the Springfield Basin material. The first figures of binpinnate forms from Australia were those of Johnston (1895) from Tasmania. Johnston's species *Thinnfeldia feistmanteli* was later placed in the genus *Dicroidium* by Gothan (1912) but it was not until Frenguelli systematically studied the "*Thinnfeldia* series" of Argentina and elsewhere in the 1940's that the relationship between

Szajnocha's species and that of Johnston was elucidated.

Frenguelli transferred both these species to his new genus *Zuberia* maintaining a distinction between the species. *Zuberia zuberi* (Szajnocha) Frenguelli was distinguished from *Z. feistmanteli* (Johnston) Frenguelli on the basis of the form of the pinnule and other frond characteristics; *Z. feistmanteli* being distinguished by having entire margins, less crowded veins and fewer stomata.

The generic status of these leaves with a bipinnate form has been reviewed several times since the work of Frenguelli, particularly in the light of cuticle studies by Jacob and Jacob (1950). Recent review of the genus include those of Townrow (1957), Archangelsky (1968) and Anderson and Anderson (1970). Townrow (1957), in reviewing leaf forms morphologically similar to those of *Dicroidium feistmanteli*, established the genus *Hoegia* for a number of Australian specimens previously referred to Johnston's species and based the distinction mainly on the form of the epidermis. Archangelsky (1968) referred leaves from Ischigualasta, Argentina, to Szajnocha's species and placed them in the genus *Dicroidium*. He concluded that Townrow's species *Hoegia papillata* was synonomous with *D. zuberi* and expressed the opinion that Townrow's only other species of *Hoegia* *H. antevsiana*, might be regarded as a variation of *D. zuberi* on the basis of similar stomatal structure and epidermal cell size.

Anderson and Anderson (1970) likewise referred Townrow's *Hoegia* species to *Dicroidium* but have provisionally maintained a distinction between *D. antevsiana* and *D. zuberi* on the basis of the shape of the pinnules. *D. feistmanteli* of Walkom (1924) is referred to *D. antevsiana* whilst *D. feistmanteli* of most other authors is referred to *D. zuberi*.

Since the Springfield Basin specimens do not have preserved cuticles associated with them, an opinion on their taxonomic status must be regarded as provisional. However the overall morphological features, including the venation, of these leaves are discernable and a tentative classification can be made. All of the bipinnate fronds from the

Springfield Basin are morphologically similar and can be referred to the same species. Although Archangelsky (1968) maintained the distinction between *D. zuberi* and *D. feistmanteli* on similar grounds to those of Frenguelli, this distinction cannot be sustained on the basis of other authors' figures referred to *D. feistmanteli* or *D. zuberi* (see synonomy). For this reason these two species are regarded as synonomous and those specimens from the Springfield Basin are therefore placed in the species *Dicroidium zuberi* (Szajnocha) Archangelsky.

Dicroidium coriaceum (Johnston) Townrow

(Plate 10, figs. 104; text-fig. 2.3)

1887	*Rhacophyllum coriaceum* Johnston, p. 170.
1888	*Rhacophyllum coriaceum* Johnston, pl. 26, fig. 9.
1925	*Johnstonia coriacea* (Johnston) Walkom, pp. 79-81, figs. 6,7.
1927	*Johnstonia coriacea* (Johnston): DuToit, text-figs, 12D, 13B.
1943a	*Johnstonia coriacea* (Johnston): Frenguelli, pp. 310-317. text-fig. 28a, (b?).
1947	*Johnstonia coriacea* (Johnston): Jones and DeJersey, pp. 19-20, text-fig. 11.
1957	*Dicroidium coriaceum* (Johnston) Townrow, p. 45. (Not figs. 7,C,D).
1967	*Dicroidium coriaceum* (Johnston): Jain and Delevoryas, pp. 571, 572, pl. 91, figs. 1,2.
1968	*Dicroidium coriaceum* (Johnston): Archangelsky, pp. 506, 507, pl. 97, figs. 2,5; pl. 98, figs. 3; text-figs. 1B, 26.
1970	*Dicroidium coriaceum* (Johnston): Anderson and Anderson, Figs. N-UU. 963, N-U.U. 965.

Diagnosis.

Johnston (1887). "Entire or slightly lobed pinnae. Prominent mid-vein, secondary veins usually once-forked, arising at an acute angle from mid-rib."

Several specimens of this species have been found at Springfield Basin and all agree with the diagnosis given.

Discussion and description of Springfield Basin specimens

As with other *Dicroidium* species there are difficulties in circumscribing the limits of this taxon. There are certainly intermediate forms between *D. coriaceum* and other species such as *D. odontopteroides* and *D. dentata*. Several authors have included lobed forms into *D. coriaceum* Walkom (1917), text-fig. 8; Jones and DeJersey (1914) text-fig. 11; Frenguelli (1943a), text-fig. 29a, b; Townrow (1957), text-fig. 2, G-H, 7, C-D, 9, G-J).

The entire or slightly lobed specimens from Springfield Basin are clearly distinct from other specimens of *Dicroidium* collected and distinct from the lobed frond described in the literature.

Anderson and Anderson (1970) proposed an intermediate species, *Dicroidium* (intermediate species A) which links *D. coriaceum* with *D. dentata*, *D. odontopteroides* and *D. obtusifolium*. The creation of such a taxon adds to the confusion about the limits of these species and therefore should be avoided until more certain evidence is available.

The specimens from Springfield are all fragments of fronds. Three of them clearly show the forked nature of the frond.

The apices of only two pinnae are distinct, P17393 (pl. 10, fig. 4; text-fig. 2.3) and P17388 (pl. 10, fig. 3) and these are round to slightly acute. The pinnae of all except P17993 (pl. 10, fig. 2) are entire save for some irregularly wavy edges in a few specimens. P17993 has slightly lobed edges and would clearly fit the definition *Dicroidium* (intermediate species A) of Anderson and Anderson (1970). The mid-rib of all specimens is prominent and impression of the secondary veins can be seen, though not clearly, in all specimens. The secondary veins generally emerge from the mid-rib at an acute angle, curve somewhat and usually bifurcate before reaching the margin of the leaf. In the small specimen P17393, the secondary veins are almost at right angles to the margin.

Dicroidium dubium (Feistmantel) Bonetti

(Plate 7, figs. 7,8; text-fig. 3.2)

1890 *Thinnfeldia (Gleichenia) dubia* Feistmantel, pl. 26, fig. 3.

1921 *Thinnfeldia talbragarensis* (Feistmantel): Walkom, pl. 1, figs. 1,2; Pl. 11, figs. 7-9.

1928 *Thinnfeldia talbragarensis* (Feistmantel): Walkom, pl. xxvii, fig. 1.

1944 *Dicroidiopsis dubia* (Feistmantel) Frenguelli, pl. 1, fig. 1,2.

1947 *Sphenopteris bergina* Jones & DeJersey, Pl. 4, fig. 2; pl. 5, fig. 5; text-fig. 20.

1966 *Dicroidium dubium* (Feistmantel) Bonetti, p. 394.

1970 *Dicroidium dubia* (Feistmantel): Anderson and Anderson, figs. N-L S.W. 1064, N-L. S.W. 112.

Description of Springfield Basin material.

Two specimens from Springfield Basin are referred to this species. As with other species of *Dicroidium* discussed here there are considerable difficulties in deciding about the determination.

Feistmantel (1878, 1890) figured a specimen from the Wianamatta Beds of New South Wales and was apparently undecided about its taxonomic position because he described it as *Gleichenia dubia* Feistmantel but figured it as *Thinnfeldia (Gleinchenia) dubia* Feistmantel. The form of this specimen is close to, but not the same as that of specimens described below.

The pinnae of P17386 (pl. 7, fig. 7; text-fig. 3.2) are more constricted at the base and are not lobed in the same way. Feistmantel's figure (Plate XXVI, fig. 3) shows pinnae with shorter and more acute lobes or pinnules most of which are lobed along the whole length of the pinnae whereas the pinnae of P17386 are lobed only near the base. The pinnae of P17390 (pl. 7, fig. 8) are smaller and probably represent part of a frond near its apex. The bases of the pinnae are similar to Feistmantel's figure but the lobing is not as pronounced and there are fewer lobes per pinna. The venation is alethopteroid (see Emberger, 1968). The mid vein is not prominent and extends almost to the tip of the pinna before it divides into secondary veins leading to the margins. Secondary veins arising from the mid-vein emerge at an acute angle, arch and bifurcate towards the margins of the pinnae.

Discussion.

The variable form of this species allows only a tentative identification. Some of the synonyms are only doubtfully included e.g. *Sphenopteris bergina* Jones and DeJersey whilst others e.g. *Thinnfeldia talbragarensis* Walkom are clearly synonomous. Jacob and Jacob's (1950) illustration (fig. 13) of *Dicroidium sp.* cf. *D. talbragarensis* (Walkom) differs quite markedly from the form showin in Walkom's species. The figure of Jacob and Jacob is not sufficiently accurate to allow a positive determination of it to be made. Bonetti (1966) combined Frenguelli's genus *Dicroidiopsis* into *Dicroidium* on the basis of the close similarity of forms placed in these genera. It seems reasonable to conclude that the Springfield Basin specimens most closely fit Feistmantel's diagnosis and are hence placed in his species. Specimens of *Dicroidium* which have been figured from elsewhere, (such as Anderson and Anderson (1970)) show that there are many intermediate forms between the pinnate and bipinnate types, and the the name *D. dubium* is applied to one group of such forms. The accurate delineation of taxa for these forms must await a comprehensive study of a large number of specimens from many localities.

Dicroidium acutum (Walkom) Jacob and Jacob

(Plate 7, fig.5)

1898 *Thinnfeldia indica* var. *falcata* Shirley, p. 21, t7, fig. 2.

1917 *Thinnfeldia acuta* Walkom, p. 23; p.13, fig. 4.

1943a *Diplasiophyllum acutum* (Walkom) Frenguelli, pl. 1, fig. 1.

1950 *Dicroidium acuta* (Walkom) Jacob and Jacob, fig. 4.

1970 *Dicroidium lancifolia* (Walkom) Anderson and Anderson, figs. N-L SW. 500, N-L. S.W. 828.

Description of Springfield Basin material.

Only one specimen from Springfield Basin is referred to *Dicroidium acutum* and this specimen, S0091 (pl. 7, fig. 5) is a very small fragment which consists of an impression of one whole pinna and the base of several others. The leaf is typical of the *Dicroidium* form. The shape is oblong-lanceolate with a very acute apex. The midrib persists almost to the tip of the pinna and the secondary veins are bifurcated. The base of each pinna is broad with no indication of a constriction near the rachis. It is not possible to determine whether the pinnae are decurrent.

Discussion.

It is not clear whether this specimen rightly belongs to *Dicroidium acutum, Dicroidium lancifolium* or *Dicroidium odontopteroides*. The relationship between *D. lancifolium* and *D. odontopteroides* has been discussed previously (p. 20) and it was concluded that there was no real justification for maintaining *D. lancifolium* as a distinct species. A problem arises however when dealing with *Dicroidium* specimens with pinnae as extremely linear as this one from Springfield Basin. There is a graded series of pinna forms from the small-leafed *D. odontopteroides* to the linear leaf of *D. acutum* and it is somewhat arbitrary to limit the circumscription of any single species to one variable characteristic such as leaf size. Frenguelli (1943a) discussed the linear pinnae of fronds of the "*Thinnfeldia* series" and drew conclusions which seem only to have further confused the situation. He regarded DuToit's specimens identified as *Thinnfeldia acuta* as distinct from *T. acuta* Walkom, and established the genus *Dicroidiopsis* for DuToit's plants and the genus *Diplasiophyllum* for those of Walkom. He regarded *Dicroidium lancifolium* (Morris) Gothan as a separate species distinguishable from other species on the basis of the size and shape of the pinna, the form of its tip and venation. There are few clearly observable morphological differences in the above forms upon which to base sound taxonomic decisions at the species level.

It is therefore clear that the species of these fronds must be determined somewhat arbitary. Due consideration must be given to such factors as the degree and discreteness of the morphological variation and the usefulness of the system of classification for purposes of stratigraphic correlation and understanding of possible evolutionary relationships of the plants. With these principles in mind the name *D. acutum* should be reserved for fronds where the pinnae are lanceolate, entire, greater than 2cm. long with a pointed tip and a prominent midrib.

Discussion: GENUS *DICROIDIUM*.

The group of leaf species included under the generic name *Dicroidium* is taxonomically difficult and has been the subject of many controversies since the study of Gondwanaland floras attracted attention about the middle of the 19th century.

The most heated controversy centred around the relationship between the forms of the Gondwanaland floras and the genus *Thinnfeldia* known from the mesozoic in the Northern Hemisphere. Although Gothan (1912) and Antevs (1914) gave reasons for the separation of *Dicroidium* and *Thinnfeldia*, basing their conclusions on morphological differences between *Thinnfeldia* and the Gondwanaland leaves, palaeontologists did not agree with these conclusions.

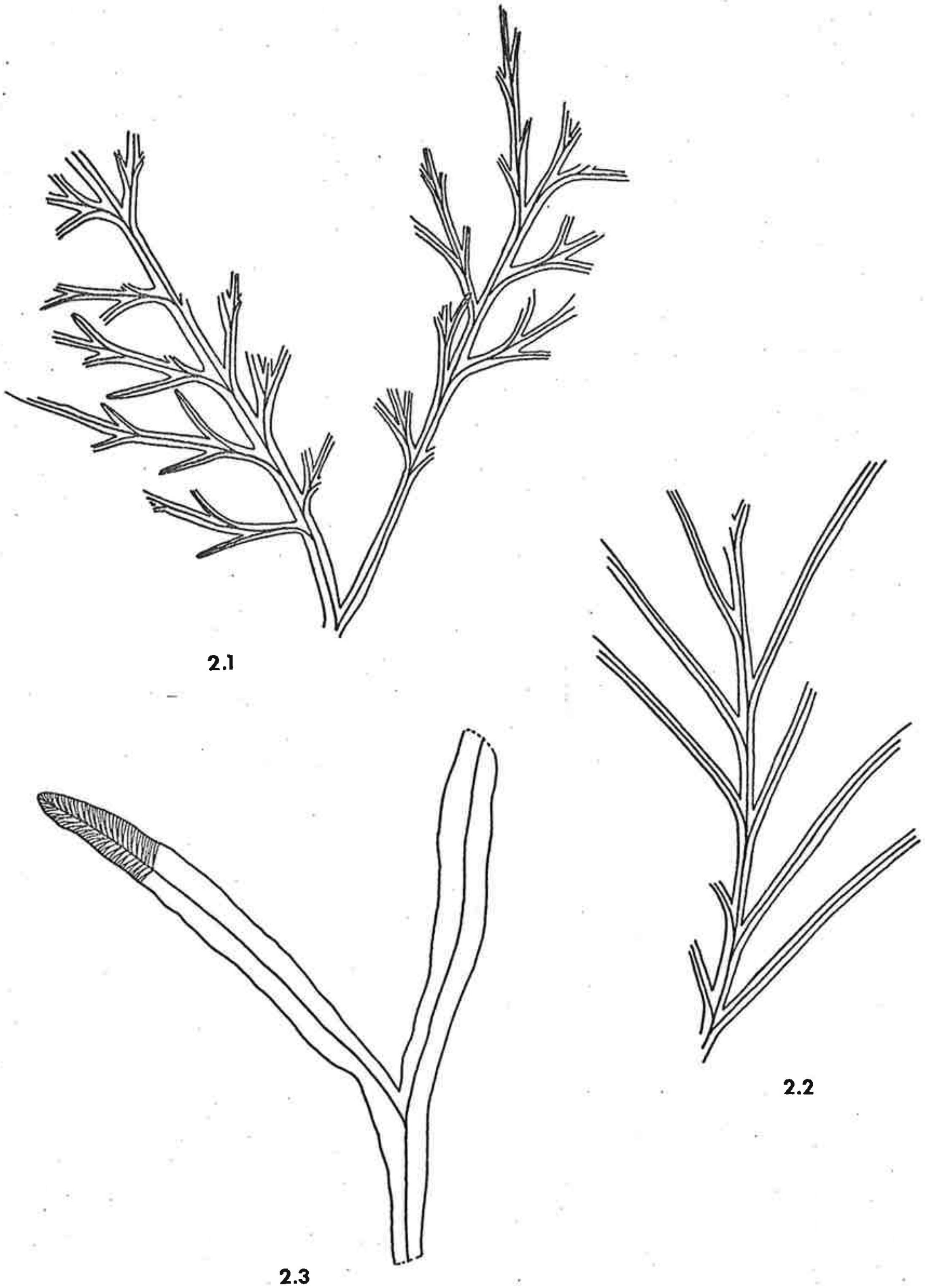
Walkom (1917) rejected *Dicroidium* in his many studies of Australian Mesozoic floras as did DuToit (1927) for the flora of the Molteno Beds of South Africa and Jones and DeJersey (1947) in their study of the Ipswich flora of Queensland.

DuToit and Jones and DeJersey commented on the distinctiveness of the southern "*Thinnfeldias*" and the likelihood of many of them being properly referred to the genus *Dicroidium*.

The present situation with regard to *Dicroidium* follows the work of Frenguelli (1941-1946 (1943a especially)), Jacob and Jacob (1950) and Townrow (1957).

Although these and other workers consolidated earlier work and agreed that the Gondwanaland pteridosperms were distinct from those of the northern hemisphere mesozoic there has been and still is considerable confusion about the group at the generic level. This confusion is illustrated by the number of synonomous epiphets quoted for most of the species discussed above. Townrow (1957) analysed a number of forms making considerable use of cuticle studies. He concluded that many of the genera proposed for "*Dicroidium*-like" fronds had been based on slight grounds e.g. *Dicroidiopsis* Frenguelli (1943a), *Diplasiophyllum* Frenguelli (1943a), *Zuberia* Frenguelli (1943a) and *Johnstonia* Walkom (1925). On the other hand Townrow also proposed a new genus *Hoegia* for large fronds from the Australian triassic which had previously been classified as *Dicroidium feistmanteli* mainly on the basis of differences in the cuticle structure. Cuticle studies on *Dicroidium* and its relatives by a number of workers (Harris (1932), Jacob and Jacob (1950), Jones and DeJersey (1947) and Townrow (1957)) have often given results that are less than conclusive about supposedly different leaves. It seems that cuticle studies, whilst of great importance in the classification of many fossil plant groups, should be used cautiously and due consideration given to other characteristics.

Anderson and Anderson (1970) have proposed that virtually all the Gondwanaland *Dicroidium*-like forms including *Xylopteris* be included in the genus *Dicroidium*. Although they do not discuss reasons for this opinion, a series of figures show intermediate forms which link *Xylopteris* with *Dicroidium* (see later discussion under genus *Xylopteris*).



Text-fig. 2. 2.1, *Xylopteris spinifolia*, P14130 (X 1.5), 2.2, *X. elongata*, P14129 (X 1.5), 2.3, *Dicroidium coriaceum*, P17393 (X 1.5).

Genus *Xylopteris* Frenguelli 1943.

Diagnosis

Frenguelli (1943a). "Frond leathery, rigid, dichotomously divided, rachis woody, irregularly striated with small wart-like eruptions in regular transverse series across axis, pedicel naked or with pinnae foliage, ramuli paired pinnatisect or dichotomously pinnate; pinnae opposite or sub-opposite, closely packed to wide apart, narrow linear and entire or partly obtuse lobulate, apex obtuse or abruptly lanceolate, veins imbedded, mostly uninerved, perhaps bearing lateral veins arising obliquely from midrib". (Trans. I.R.M.)

Remarks.

Frenguelli (1943a) established the genus *Xylopteris* for a diverse group of dichotomously branched fronds from the mesozoic of Australia, South Africa and South America which had previously been placed in the genus *Stenopteris* Saporta by Seward (1903). Seward pointed out that there were significant differences between the Gondwanaland forms and *Stenopteris*, in particular the woody xerophytic nature of the southern forms and the nature of the median nerve, but considered these differences to be insurfficient to assign them to a separate genus. Seward's proposal was maintained by others including Walkom (1917) and DuToit (1927). Thomas (1933) pointed out the similarity of the southern forms assigned to *Stenopteris* to formsassigned to the genus *Dicroidium*. Thomas noted that both groups had a forked rachis and a similar cuticle structure, and there were transitional forms which linked them together. All of these characteristics were distinct from the characteristics of *Stenopteris* from mesozoic of the northern hemisphere. Jones and deJersey (1947) also noted the similarity of the group of leaves they placed in *Stenopteris* to the genus *Dicroidium* but they did not regard cuticle studies as definitive or the forked rachis as sufficient grounds to separate the genus. Jones and deJersey were not at this time apparently aware of Frenguelli's pioneering work (1943,1943a,1944-1946) with Gonwanaland pteridosperms.

Observations of a wide range of material, particularly forms from the Rhaetic of Cacheuta, Argentine convinced Frenguelli (1943a) that the Gonwanaland forms were distinct enough from *Stenopteris* to be separated from that genus. Frenguelli noted that not only is separation of the southern and northern forms warranted on anatomical grounds but is indispensible "both because of their palaeogeographical distribution and because of significant differences in their geological age".

Xylopteris elongata (Carruthers) Frenguelli

(Plate 13, fig. 1, 3-5, 7; plate 14, figs. 2-7; text-fig. 2.2)

1872 *Sphenopteris elongata* Carruthers, p. 355, pl.27, fig.1.

1883 *Sphenopteris elongata* (Carruthers): Tenison-Woods, p. 92.

1878 *Sphenopteris elongata* (Carruthers): Feistmantel, p.108.

1888 *Sphenopteris elongata* (Carruthers): Szajnocha, pl.2, fig.2.

1890 *Sphenopteris elongata* (Carruthers): Feistmantel, pp.90,91.

1892 *Trichomanites elongata* (Carruthers) Etheridge, p. 367.

1903 *Stenopteris elongata* (Carruthers) Seward, p.70, pl.7, fig.2; pl.11, fig. 3.

1917 *Stenopteris elongata* (Carruthers): Walkom, p.40, pl.1, fig. 1.

1927 *Stenopteris elongata* (Carruthers): DuToit, pp.362,363 (Pinnate forms).

1933 *Stenopteris densifolia* (Carruthers): Thomas, fig. 51.

1943 *Xylopteris elongata* (Carruthers) Frenguelli, pp.320,321, figs. 30,31.

1947 *Stenopteris elongata* (Carruthers): Jones and DeJersey, pp.25-28. pl. 2, fig. 5a, pl.3, fig.1.

1962 *Xylopteris elongata* (Carruthers): Townrow, pp.1230127, text-fig. 1, A-F.

1967 *Xylopteris rigida* (Carruthers): Jain and Delvoryas, p. 573, pl. 91. figs. 307.

1968 *Dicroidium elongatum* (Carruthers) Archangelsky, p. 504, 506, pl. 97. figs. 1,3; pl. 98, fig. 4; text-figs. 1b,2a.

1970 *Dicroidium elongatum* (Carruthers): Anderson and Anderson, Chart 9, figs. N-U.U. 928, C-K.K.1. 58, C-Dtll 246, N-U.U. 229.

Diagnosis.

Carruthers (1872). "Frond dichotomously divided, each division irregularly pinnate; pinnae simple, bifurcate, or irregularly pinnate; segments narrow, linear, slightly tapering upwards to the somewhat blunt apex; the single midrib sending out simple branches which run along the middle of each segment."

Description of Springfield Basin material.

Several specimens from the Springfield Basin have been assigned to this species. All of these agree with Carruthers' diagnosis except that none have "bifurcate pinnae". There is a suggestion of multiple bifurcation of the rachis in speciment P14131 (pl. 14, fig. 2) but a detailed examination shows it to be similar to forms assigned to *Xylopteris elongata*. The specimens of *X. elongata* from the Springfield Basin exhibit a wide variation in form.

Each leaf has a forked rachis with the exception of specimen P14129 (pl.13, fig.3; text-fig. 2.2) which is a fragment, and all are once pinnate. Jones and deJersey (1947) included forms in this species which exhibit a small basal lobulation of the pinnae (as distinct from definite pinnules), but none of the Springfield Basin specimens show this characteristic. The most common form is that shown in specimens S0148 (pl.13, fig.4) and S0192 (pl.13, fig. 7). These impressions show leaves with a rather broad rachis, approximately 1.4mm. wide, pinnae about 1mm. wide and 20 to 30mm. long. The pinnae are set close together, approximately 2mm. apart, and arise at an angle of 30°-45° to the rachis. The most extreme departure from this typical form is seen in specimen P14131 (pl.14, fig. 2) which has a much narrower, more rounded rachis and long (50-55mm.), narrow (0.5-0.75mm.), needle-like, sub-opposite pinnae. The pinnae are sparse with adjacent pairs 10-20mm. apart.

Other specimens appear to be of *X. elongata* with unusually fine or delicate characteristics. S0170 (pl.13, fig. 5) and P17384 (pl.13, fig. 1) have very narrow (0.5mm.), tapering pinnae with adjacent opposite pairs set 4-5mm. apart. On the other hand, specimens P14128 (pl.14, fig.4) and P14129 (pl.13, fig. 3) have a much more robust appearance. The rachis is stout and the pinnae comparatively broad (about 1.5mm.) and estimated to be 50mm. in length although no complete pinna can be seen. The median nerve of these robust leaves has left an easily observable, deep impression.

Discussion.

Carruthers' interpretation of this species has been the cause of considerable confusion. Jones and deJersey (1947) discussed this confusion and commented that the problem could not be resolved until Carruthers' material was re-examined. Townrow (1960) examined the type material of *X. elongata* (Carruthers) Frenguelli and concluded that Carruthers misinterpreted the material and that his figure was a composite one which was misleading. The description of the lectotype and lectoparatype selected by Townrow (1960) from Carruthers' material contradicts the evidence that the leaf was only once forked and once pinnate according to Carruthers' diagnosis of the species.

The Springfield Basin *X. elongata* material is, as indicated above, a morphologically diverse group of leaves. P14131 is a distinctive specimen having an extreme form compared to that of the type. An analogous situation exists with the species *Stenopteris densifolia* DuToit (1927) which Frenguelli (1943a) considered to be a distinct species, although for pinnate forms only, and not for some bipinnate leaves originally assigned by DuToit to *S. densifolia*. *Xylopteris densifolia* (DuToit)

Frenguelli is identical with *X. elongata* except for the high density of pinnae. Jones and deJersey (1947) pointed out that intermediate forms of *S. elongata* rendered *S. densifolia* a dubious species although they did not include *S. densifolia* as a synonym of *S. elongata*. Although there are no clearly identifiable intermediate forms linking the more typical forms of *X. elongata* to the form seen in specimen P14131, this specimen should not be considered as a likely new species of *Xylopteris* until more similar specimens are found and it is considered unlikely that intermediate forms existed.

Xylopteris spinifolia (Tenison-Woods) Frenguelli
(Plate 13, figs. 2, 6; plate 14, figs.1,3; text-fig. 2.1).

1883 *Trichomanides spinifolium* Tenison-Woods, p.95, p.13, fig.7.

1890 *Trichomanides spinifolium* (Tenison-Woods): Feistmantel p.95.

1892 *Trichomanides spinifolium* (Tenison-Woods): Etheridge, p.367, pl.18, fig.8.

1898 *Trichomanides elongata* var *spinifolia* (Tenison-Woods): Shirley, p.19, pl.5, fig. 2.

1898 *Trichomanides elongata* (Tenison-Woods): Shirley, pl.10, fig. 3.

1903 *Stenopteris elongata* (Tenison-Woods) Seward, p.70, pl.7. fig.3,3a.

1917 *Stenopteris elongata* (Tenison-Woods): Walkom, p.40, pl.1, fig.1. p.16, figs. 1,2,3.

1927 *Stenopteris elongata* (Tenison-Woods): DuToit, p.362, pl.19, fig.1. text-fig. 12E.

1943a *Xylopteris spinifolia* (Tenison-Woods) Frenguelli, p.325, fig. 32.

1947 *Stenopteris spinifolium* (Tenison-Woods): Jones and deJersey, p.28, 29; pl.11, fig.6; pl.222, figs. 204; text-figs. 17,18.

Diagnosis.

Tenison-Woods (1883). "Evidently somewhat stiff, spreading, dichotomously dividing bipinnate, pinnae opposite or nearly so, long, linear and, together with the rachis, membranaceously winged; pinnules nearly opposite or alternate, very

short and quite acute the apical one long
and linear, veins thick, simple, free."

Description of Springfield Basin Material.

Several specimens from the Springfield Basin can be referred to this species. They exhibit considerable variation in form. All show the typically forked rachis, linear pinnae and pinnules, although the form and arrangement of pinnules is variable. Specimen P17389 (not figured) has pinnae with one or two pairs of opposite pinnules at their base. The apical pinnule is neither as long nor as linear as that occurring in some specimens included in this species. An impression of the median veins of the pinnae can be clearly seen as can single veining in each of the pinnules. The origin of the veins of the basal pair of pinnules is unusual in that the vein of the basiscopic member of the pair appears to arise directly from the rachis, below the point at which the nerve of the pinna originates. The nerve of the acroscopic basal pinnule arises from near the base of the central nerve of the pinna. This type of venation is similar to the sphenopteroid type observed in the genus *Dicroidium*. Specimen S0223 (pl. 14, fig. 1) has longer, more linear and fewer pinnules, with only a single pair at the base of the pinna. Only about half the pinnae, those nearest the bifuraction of the rachis, have pinnules; the rest are simple. This frond has a much more open appearance than P17389 (pl.13, fig.2) and has a more rigid, xermorphic structure. The venation of this frond is not easily observable but is similar to that described for P14389. Specimen S0235 (pl.14, fig.3) is unusual in that veins can be seen bifurcating into several of the pinnules. This feature was commented on by DuToit (1927) when describing bipinnate forms. Specimen P14130 (pl.13, fig.6; text-fig. 2.1) has the most open appearance of all the *X. spinifolia* material from Springfield Basin. The pinnae are paired and quite widely spaced on the rachis. Each pinna has two pairs of narrow, linear pinnules which are themselves widely spaced. The pinnules of the basal pair are longer than those of the distal pair. Median veins can be clearly seen along the main axis of the pinnae and in the pinnules. In this specimen the veins of the pinnules all arise from the main vein of the pinna.

Discussion.

All of the specimens fit the description given in detail by Jones and deJersey (1947); however the variation is considerable, with the differences most marked between the open, linear types and the form represented by specimen P17389 described above. This is a further illustration of the great morphological plasticity of the *Dicroidium-Xylopteris* group. The various forms are found together as fossils and it is likely that they were contemporaries and lived in the same geographical area.

The taxonomic position of *Xylopteris* must be regarded as provisional. The problem of circumscribing species of this genus has been indicated previously and results from the continuously variable nature of many of the morphological characteristics of the group. Anderson and Anderson (1970) showed this in their comprehensive chart illustrating the forms from the Molteno Beds of South Africa. Jones and deJersey (1947) recognised three species (*S. elongata* - simple pinnae, *S. spinifolia* - bipinnate, *S. tripinnata* - tripinnate), from Ipswich, Queensland, based on the complexity of the frond, and they have provided good evidence of the discrete nature of these forms as populations by means of a chart which shows the occurrence (or non-occurrence) of these species in different stages of the Ipswich Series. Jones and deJersey found that the earliest occurrence of this plant was in the older Kholo Stage and through the other stages became a less evident member of the Ipswich flora. *S. spinifolia* appeared during the Tivoli Stage and *S. tripinnata* during the Blackstone Stage. The evolution of *Xylopteris* towards more complex forms is clearly demonstrated and the case for regarding these three forms as distinct species is well supported. Frenguelli (1943a) noted that *X. spinifolia* and *X. elongata* occurred with different frequency in different strata but made no comment about their evolution.

There is little taxonomically useful published material concerning the cuticle structure of the various species. Jones and deJersey (1947) claim that their studies gave results which showed that intraspecific variation of stomatal characteristics of Ipswich species was often greater than differences between characteristics of Ipswich leaves referred to *Stenopteris* and leaves of the northern hemisphere referred to this species. Cuticle studies have certainly shown the close relationship between *Xylopteris* and *Dicroidium*, and some authors now regard these as congeneric.

Archangelsky (1968) placed *X. elongata* in *Dicroidium* without explanation, and Anderson and Anderson (1970) refered all species of *Xylopteris* to *Dicroidium*, also without comment, although their chart shows how they picture the relationship between the various forms of *Dicroidium* and the forms here described as *Xylopteris*. Anderson and Anderson's figures show that there are some forms intermediate between *Dicroidium* and *Xylopteris* but this would be true of perhaps the majority of plant groups at the generic level. Evidence for transferring *Xylopteris* into *Dicroidium* is not compelling and it seems likely that *Xylopteris* is a distinct entity which is easily identified. At present *Xylopteris* is retained until the results of further studies are available.

CORYSTOSPERM REPRODUCTIVE STRUCTURES

Taxonomists have recognized a group of Gondwanaland plant structures as male and female pteridosperm reproductive organs and have classified these into the genera *Umkomasia, Pilophorosperma, Spermatocodon,* and *Pteruchus*.

Several specimens of corystosperm seed-bearing organs are amongst the Springfield Basin material. These fructifications are of the *Umkomasia* type found in the Molteno Beds of South Africa and described by Thomas (1933). Compared with Thomas's material, however, the Springfield Basin specimens are poorly preserved.

Thomas (1933) gave the following description of female fructifications of the *Umkomasia- Pilophorosperma-Spermatocodon* type:

> "Unisexual inflorescence, 20-60mm. in length, consisting of a main axis with lateral branches produced in the axils of bracts and pedicelate cupules; cupules recurved, campanulate or bivalved, containing one seed; seeds avoid or elliptical with a curved bifid micropyle projecting from the cupule."

The specimens from the Springfield Basin clearly fit this general description; however the criteria used by Thomas to define these genera are difficult to apply to these South Australian fossils. The genera *Umkomasia, Pilophorosperma,* and *Spermatocodon* are basically distinguishable on the form and character of the cupule, although Thomas also asserts that the study of the cuticle structure of the axis and cupules supports the division. According to Thomas, *Umkomasia* has a two-lobed cupule without a lining of hairs while *Spermatocodon* has a campanulate cupule without hairs and *Pilophorosperma* has a hood-like cupule thickly lined with hairs on its inner surface.

Although there are no organic remains in the Springfield Basin material, and therefore cuticle characteristic cannot be determined, the general morphological features of these fossils most closely resemble Thomas's figures of *Umkomasia* rather than those of the other two genera. They are therefore tentatively assigned to this genus.

GENUS *UMKOMASIA* Thomas 1933.

Diagnosis.

Thomas (1933). "Inflorescence branching in one plane, with pedicelate cupules enclosing seeds; cupules deeply divided into two lobes by clefts in the plane of branching; inside cupules without hair or hair bases."

? *Umkomasia macleani* Thomas

(Plate 15, figs. 1-4, pl.16, figs. 1-4; text-fig. 5.4)

Diagnosis.

Thomas (1933). "Main axis elongated, with distant alternate branches, lateral branches with two opposite small saccate bracteoles, dichotomously forked at the apex into two pedicels bearing cupules and producing one or two stalked cupules just below; pedicels short and strong; cupules ellipsoidal, bivalved with a well marked fissure extending up to the pedicel and another on the opposite side of the cupule; margin of cupule entire; surface of cupule much wrinkled, smooth between the ridges; seeds with long tapering micropyle; cuticle of the axis stout, differing noticeably on the two sides; axis and cupules glabrous."

Description of Springfield Basin material.

All of the specimens exhibit some basic similarities but most are quite fragmentary and poorly preserved. There are two or three classes recognised of possible taxonomic significance.

The class in which the five specimens, S0253, P17979, P17980 and P17981 are included are all of lateral branches with 3-6 cupules. The main axis is not observable on any of these specimens. The cupules are elliptical in shape, 3-5mm. long and 3-4mm. wide and approximately as thick as they are wide. Most of the specimens appear to have a single cupule at the apex of the lateral branch and one or two opposite pairs of cupules along the axis, but specimen S0253 (pl.15, fig. 3; text-fig. 5.4) agrees with Thomas's diagnosis in appearing to have a dichotomously branched pair of cupules at the apex. The characteristics of the cupules agree with the diagnosis for this species in so far as they can be interpreted from the poor material. The clefts between the lobes of the cupule can be seen in specimens P17979 (pl.15, fig.4) and P17981 (pl.16, fig.4) and the wrinkled nature of this structure is seen in specimen S0253. No micropyle can be seen.

Specimen P17992 (pl.15, fig.2) shows the main axis of the inflorescence and three or four lateral branches. The details of the cupules cannot be discerned but they are considerably smaller than those described above, except for the basal pair in specimen S0253. It is possible that only the basal part of the lateral branches of specimen P17992 are represented in this fossil.

Specimens P17991 (pl.15, fig.1) and P14133a, (pl.16, fig.1) have much larger cupules. P14133a is a single detached cupule or seed which is described by Amstberg (1969) as a gymnospermous seed. Specimen P17991 is a single pair of large cupules. Only the lateral features of these cupules can be seen. They are elliptical in outline, 15mm. long and 10mm. wide. They appear to be more laterally flattened than the small cupules of the other observed specimens, but this may be due to changes during the fossilizing process. The cupules are attached to the axis by short, stout pedicels. The surface of each cupule is wrinkled. There is insufficient detail seen in these larger specimens to confidentaly regard them as a distinct species, but it is possible that better preserved and less fragmentary specimens would provide sufficient information to describe them as specifically distinct.

Discussion.

The presence of the *Umkomasia* (female) and *Pteruchus* (male) fructification in association with *Dicroidium* and *Xylopteris* has been discussed by Townrow (1962) and there is strong evidence that they are distinct organs from the same plants. Evidence of this relationship relates to the similarity of the cuticles of the various organs and the close physical proximity of these organs in mesozoic Gonwanaland sediments.

Surprisingly perhaps, very few *Umkomasia*-like specimens have been figured from Australian sediments. Walkom (1917) figured 4 specimens from Queensland and Chapman and Cookson (1926) figured a specimen from Leigh Creek in South Australia, ((?) *Sphaereda physaliformis*, pl. XXIV, fig. 22) which appears similar to theSpringfield Basin specimens.

Order PTERIDOSPERMALES.

Genus *TAENIOPTERIS* Brongniart, 1828.

Brongniart (1928) established the genus *Taeniopteris* for "simple linear or broadly linear leaves with a prominent midrib and secondary veins which arise from the midrib either at right angles or obliquely, and which are simple or dichotomously branched".

The early workers who dealt with Australian taeniopterids generally followed the classification scheme of Schimper (1869-74) which involved the following generic names: *Taeniopteris* Brongniart, *Macrotaeniopteris* (Schimper) Feistmantel, *Oleandridium* Schimper, *Angiopteridium* Schimper, and *Marratiopsis* Schimper.

Walkom (1917) suggested that the implied relationship to extant genera of ferns shown in the names of the latter four genera was not evident in any of the Australian leaves, described in the literature. He also commented that the name *Macrotaeniopteris* was not descriptive and suggested that the name *Taeniopteris* should be used for taeniopteroid leaves of Australian origin.

In a review of taeniopteroid leaves from the mesozoic of various parts of the world Harris (1932) devised a classification scheme which is now followed to a large extent. Harris's scheme involves several genera which are keyed out in the following way:

1. Species lacking cuticles, known to be sterile leaves of ferns - *Marratiopsis, Danaeopsis.*
2. Species with definite cuticles (seed plants)-
   (a) With Bennettitalean type of stoma:- *Taeniozamites* Harris (1932).

   (b) With Cycadean type of stoma, small leaves attached to the side of the rachis - *Doratophyllum* Harris (1932). Small leaves with lamina attached to top of rachis - *Nilssonia.* Large leaves - *Macrotaeniopteris.*
3. Species in which the cuticle is absent or unknown, or, if present, is not well enough preserved to show the structure of the stomata - *Taeniopteris.*

In addition to these the genus *Yabeiella* Oishi (1931) has now to be added in 3. above, for taeniopteroid leaves with anatomosing secondary veins and distinct marginal veins.

Taeniopteris spatulata Oldham and Morris (non McClelland 1850)
(Plate 5, figs, 3,4, 6-11, plate 7, figs. 1,2; text-fig. 4.3).

1863 *Stangerites spathulata* Oldham and Morris, p.34, pl. vi, figs. 1-6.

1892 *Taeniopteris (?Angiopteridium) daintreei:* Etheridge Jr., p. 371.

1898 *Taeniopteris (?Angiopteridium) Spatulata* (Oldham and Morris): Shirley, 7:23.

1898 *Angiopteridium daintreei:* (Oldham and Morris): Dunstan, Pub. 131: t.5.

1898 *Angiopteridium spathulatum* (Oldham and Morris): Dun, 7: 390.

1902 *Taeniopteris spatulata* (Oldham and Morris): Shirley, 18:12.

1917 *Taeniopteris spatulata* (Oldham and Morris): Walkom, p.30 pl.5, fig. 2(b).

1917 *Taeniopteris spatulata* var. major (Oldham and Morris):Walkom, p.32 pl.8, fig.2.

1969 *Taeniopteris spatulata* (Oldham and Morris): Amtsberg, p.84, pl.4, figs. 27-30.

Diagnosis.

Seward (1904) (as *Taeniopteris daintreei* McCoy, regarded as synonomous with *T. spatulata)*.

"Frond simple, linear, long and narrow reaching a length of more than 7cm. and varying in breadth from 1.5mm. to slightly more than 1cm. The apex is either gradually tapered to an acuminate tip or bluntly rounded; towards the petiole the lamina becomes gradually narrower. Midrib stout and prominent giving off numerous secondary veins, usually at right angles; these veins are frequently forked close to the midrib, or the branching may occur at varying distances between the midrib and the edge of the leaf. The veins are delicate and numerous, approximately fifteen veins per 5mm. of lamina. Towards the apex of the fronds the secondary veins become oblique, branching at a wide angle from the midrib".

Description of Springfield Basin material.

There are several fragments referrable to *Taeniopteris* from Springfield Basin. None of the specimens are complete and none show the apex of the leaf. They range in width from 5-13mm. with the majority 8-10mm. wide. The midribs are prominent in all specimens ranging in size generally from 1-1.5mm. The lateral veins generally arise at near right angles to the midribs; however, in some specimens they arise at a smaller angle and then arch over to meet the margin at approximately 90°. Most of the lateral veins are bifurcate. The bifurcation most commonly occurs at or very near the midrib, thought it may also occur nearer the margin. Most of the specimens have a unique pattern of bifurcation of secondary veins as seen in specimen P14142 (pl.7, fig.1) which has a high proportion of secondary veins which are not bifurcated; bifurcations in most cases occurring near one third the distance towards the margin from the midrib. Specimen S0244 (pl.5, fig.3) has virtually all veins bifurcated, the majority near the midrib. Specimen S0169 (pl.5, fig.6) has most veins forked but the position of the forking is very variable - most commonly within 1mm. of the midrib but often further towards the margin. Specimen P14145 (pl.5, fig.4; text-fig. 4.3) has a few lateral veins which join at a point near the margin and continue as a single vein, or, alternatively, bifurcate again before reaching the margin. Lele (1955) described this occurrence in Indian specimens of *T. spatulata* from Parsora commenting that it is also known in *T. spatulata*. Rao (1943) also mentioned *T. spatulata* with rarely anastomosing secondary veins. This feature is discussed further, under the genus *Yabeiella*. The density of lateral veins measured at the margin is somewhat variable averaging 15 per 5mm. and within the range of 11-18 per 5mm. The margin of the leaves are approximately straight and parallel. None are lobed.

Discussion.

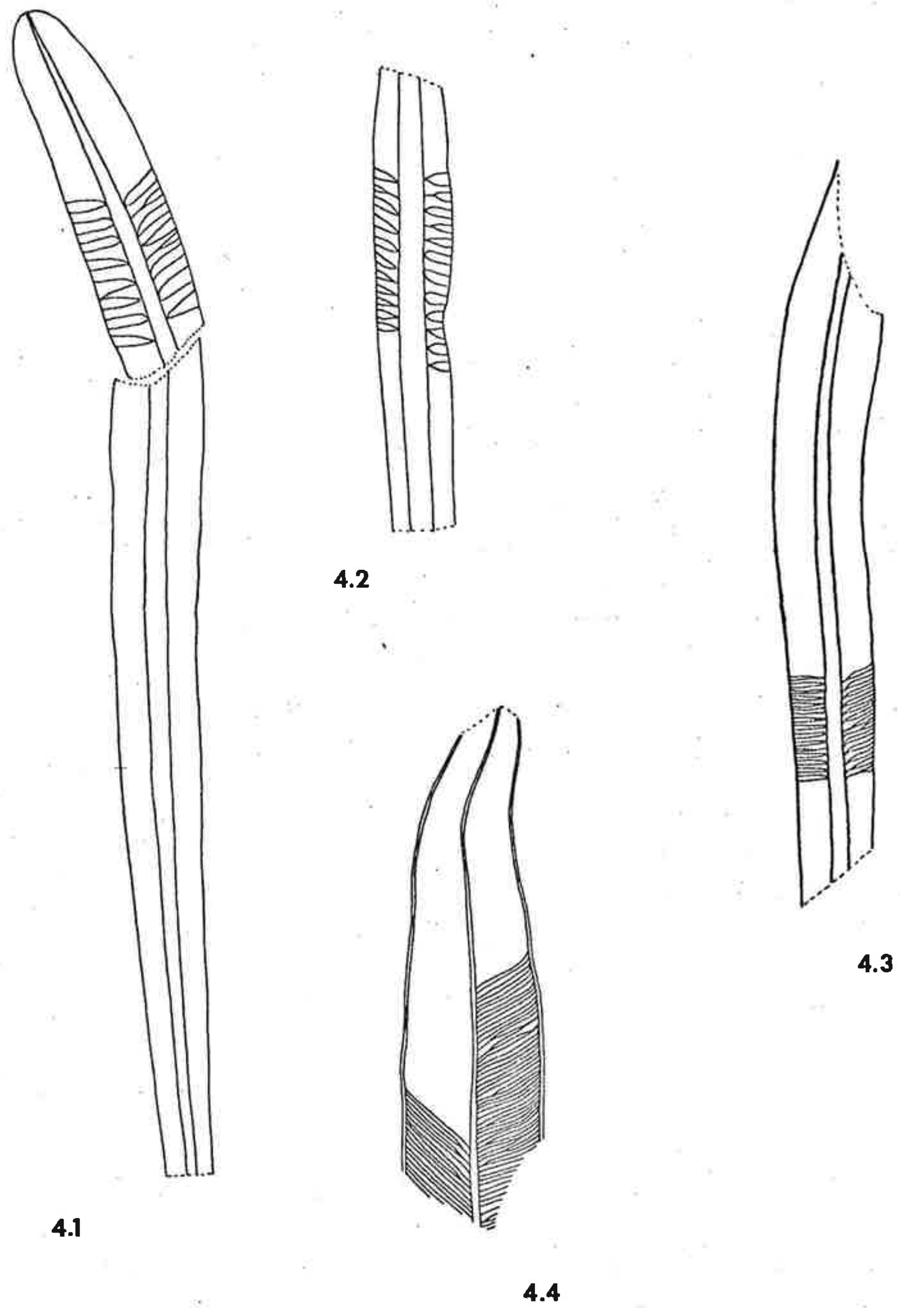
Material from the Rajmahal Hills of India was described and figured as *Taeniopteris spatulata* by McClelland (1850) as "Frond linear, two or three inches long, narrow at the base, becoming broader towards the apex, or subspathulate", but his figure showed a specimen with trifurcated secondary veins which, if correct, should not have been referred to *Taeniopteris* as defined by Brongniart. It is most likely that McClelland's specimen was incorrectly figured because none of the subsequent specimens referred by him to this species had trifurcated secondary veins. Unfortunately his type material has been lost. Oldham and Morris (1863) referred a number of specimens from the Rajmahal Hills to *Stangerites (?Taeniopteris) spatulata* McClelland. Halle (in Sahni 1948) suggested that the name *Taeniopteris spatulata* sensu Oldham and Morris 1863 (non McClelland 1850) be applied to specimens equivalent to the forms from the Rajmahal Hills described by Oldham and Morris (1863).

The taxonomic position of Australian forms referrable to the genus *Taeniopteris* has been the subject of much discussion and controversy still exists.

Walkom (1917) regarded *T. spatulata* as synonomous with *T. daintreei* McCoy. Walkom recognised a difference between the Victorian forms described by McCoy and others and the Queensland forms but did not regard this difference as sufficient to maintain them as separate species.

Etheridge (1902) explained that the difference between *T. spatulata and T. daintreei* was: "the veins in the former (*T. daintreei)* seem to be still straighter and are thicker than in *T. spatulata"*, however, he continues, "it will not, however, surprise me if these species have to be united; if not, most of the Queensland fronds will have to be referred to *Angiopteridium spathulatum* McClelland".

Medwell (1954) discussed the controversy at some length and concluded that *T. spatulata and T. daintreei* were synonomous and referred the Victorian leaves of her study to *T. spatulata*. She also concluded that the Victorian flora, of which *T. spatulata* was a part, was Lower Jurassic in age. Douglas (1969) disagreed with Medwell on her determination of *T. spatulata* as synonomous with *T. daintreei* and placed the Victorian specimens in this latter species. Unfortunately he did not give reasons



Text-Fig. 4. 4.1, *Taeniopteris springfieldensis,* S0238b (X 1.5); 4.2, *T. springfieldensis,* P17385 (X 1.5); 4.3, *T. spatulata,* P14145 (X 1.5); 4.4, *Yabeiella brackebuschiana,* P14141A (X 2).

for his conclusions. He also disagreed with Medwell about the geological age of the flora which included *T. daintreei* and gave good evidence that this flora inidicated a Lower Cretaceous age for the greatest part of Victorian mesozoic sediments.

There is great need for a thorough revision of Australian taeniopteroid leaves based on large numbers of specimens from all regions where they occur. Unfortunately the descriptions and figures in the majority of papers concerning this group lack clarity and give little indication of the variation in form of leaves within any designated taxon. The situation presently is that two taxa, *T. spatulata* and *T. daintreei*, are recognised which are possible conspecific and which are certainly very similar morphologically. Also, if Douglas is correct, these taxa are of a significantly different geological age.

Some of Walkom's material of *T. spatulata* was inspected and also some of the Victorian material described by Douglas as *T. daintreei*. A comparison was made between these relatively few specimens with material from Springfield Basin referrable to *Taeniopteris*. It must be concluded on the basis of this examination that there are insufficient grounds for separating the two species. Small differences in the variation of individual specimens occurs, such as the size of leaf and density of venation, but no consistent pattern of differences between the Springfield Basin, Queensland and Victorian specimens was detected.

Taeniopteris springfieldensis sp. nov.

(Plate 5, figs.1-4; text-fig. 4.1, 4.2)

Diagnosis.

Leaf elongate, spatulate; length variable 100-150mm. width less than 10mm; tapers gradually towards petiole; margin entire; apex rounded or broadly acute. Midrib prominent, stout, 1-2mm. in diameter; longitudinally ridged. Secondary veins slightly sinuous, arising at an angle of 80-90° to midrib; 8-10 per 5mm. at margin; often forked at or near midrib, occasionally secondary veins join near margin.

Holotype.

Speciment S0238a (pl.6, figs. 3,4; text-fig. 4.1) located in the palaeo-botanical collection of University of Adelaide.

This species is close to *Taeniopteris spatulata* but is distinguished by the shape of the lamina which is more linear with a broader midrib in relation to leaf-width and by the secondary venation which is sparse (about 8 per 5mm. at the margin) and is irregularly sinuous. The occasional anastomosis of secondary veins, whilst not common, is not unknown in *Taeniopteris*. In this feature there is an obvious link with genus *Yabeiella* where the anastomosing of secondary veins has led to the evolution of a marginal vein.

Only one other specimen from the Springfield Basin can be referred to *T. springfieldensis*, P17385 (pl.6, figs. 1,2; text-fig. 4.2), although this specimen is poorly preserved and the lamina near the petiole is similar to that of *T. spatulata*. *T. springfieldensis* is a rare species at Springfield Basin and must, on the basis of the small sample be regarded as provisional. It is possible that intermediate forms link this species with other taeniopteroids, in particular *T. spatulata*.

Discussion.

Genus *Taeniopteris*. Taxa of taeniopteroid leaves have, in many cases been regarded as conspecific with the result that many of the early controversies about taxonomy of the group no longer occur. Nevertheless it is a difficult group taxonomically with many taxa distinguished on small morphological differences and for this reason must be regarded as of limited use as an indicator for stratigraphic correlation purposes. The systematics of the group must still be regarded as problematical. Originally *Taeniopteris* and its allies *(Angiopteridium, Marratiopsis, Oleandridium)* were regarded as ferns, but it was early realized that such a classification could not be supported. The leaves appeared too leathery in texture to be fern fronds and no fertile leaves were ever found.

Later, *Taeniopteris* was placed with the cycads, but there was little evidence for doing so. Rao (1943) investigated silicified leaves from Bihar, India which he referred to *Taeniopteris spatulata* and concluded, on the basis of stomatal type, that the leaves were of a Bennettitalean type. Sahni (1948) investigated these leaves further and showed that the vascular bundles of the midrib were almost exactly like those of a modern cycad. Sahni further sought to establish a relationship between these leaves and the stems, *Nipanioxylon* Srivastava, which were found in close association in the Bihar sediments. Although there was no anatomical contact between the leaves and the stem Sahni believed that the leaves, which he called *Nipaniophyllum raoi*, and the stems were part of the same plant. Seed bearing and microsporangiate organs have been described which are associated with *Nipanioxylon* and related stem *Pentoxylon* Srivastava. The seed bearing organs *Carnoconites*, described by Srivastava (1946) and the microsporangiate organs *Sahnia*, described by Vishnu-Mittre (1953) are united in the family Pentoxylae which can be regarded as gymnospermous but of uncertain affinities.

Douglas (1969) compared *Taeniopteris daintreei* with *Nipaniophyllum* leaves and concluded that they could be distinguished on the basis of the form of stomata and the thickness of cuticle. There is no evidence that Australian taeniopteroid leaves are associated with stems and reproductive organs as in the case of *Nipaniophyllum* but the close similarity of the leaf forms suggests that it would be reasonable to conclude that *Taeniopteris* is related to the Pentoxylae.

It must be regarded as a dubious taxonomic practice to remove a leaf from *Taeniopteris spatulata* and place it in another genus on the grounds of its inferred relationship with another organ as Sahni (1948) did.

Genus *YABEIELLA* Oishi 1931.

Oishi (1931). "Leaf taeniopteroid, midnerve strong, generally with minute pitting, lateral nerves simple or forked and occasionally two adjacent ones joining or connected with cross bars; at their outer extremities lateral nerves joining to form a distinct marginal nerve. Fructification unknown".

Oishi (1931) regarded the taeniopteroid leaf form with anastomosing secondary veins and a marginal nerve as distinct from that of *Taeniopteris*. The genus *Yabeiella* was based on material from the Rhaetic of Argentina, Ipswich in Queensland and the Upper Karroo Beds of South Africa. The type species is *Yabeiella mareyesiaca* (Geinitz) 1876, p.9, pl.ii, figs.1-3.

Yabeiella brackebuschiana (Kurtz) Oishi.

(plate 7, figs, 3,4; text-fig. 4.4).

1921 *Oleandridium brackebuschianum* Kurtz, pl. 18, fig. 307; pl. 21, figs. 147-150, 302, 304,-6. (also unnamed figs. in same plate 145, 310, 312).

1927 *Taeniopteris c.f., brackebuschiana* (Kurtz) DuToit, p.354, text-fig. 2.

1931 *Yabeiella brackebuschiana* (Kurtz) Oishi, p.263,pl.26, figs.3,5,6.

1967 *Yabeiella brackebuschiana* (Kurtz): Jain and Delevoryas, p.575, pl. 93, figs. 1-5.

Description of Springfield Basin material.

There is a single specimen consisting of part and counterpart impressions, P14141 A and B (pl.7, figs. 3,4; text-fig.4.4), of the upper part of one leaf. The fragment is 45mm. long and 12mm. broad at the widest part. The margins are entire. The apex is acute. (The apex of the specimen is somewhat damaged but its shape can be inferred with reasonable accuracy) The midrib is prominent and longitudinally striated. Lateral veins are mostly simple but some are forked, arising at an angle of 50°-65° from the midrib, occasionally adjacent veins joining, approximately 22 per cm.

at the margin. A marginal vein, very close to the margin of the leaf is present.

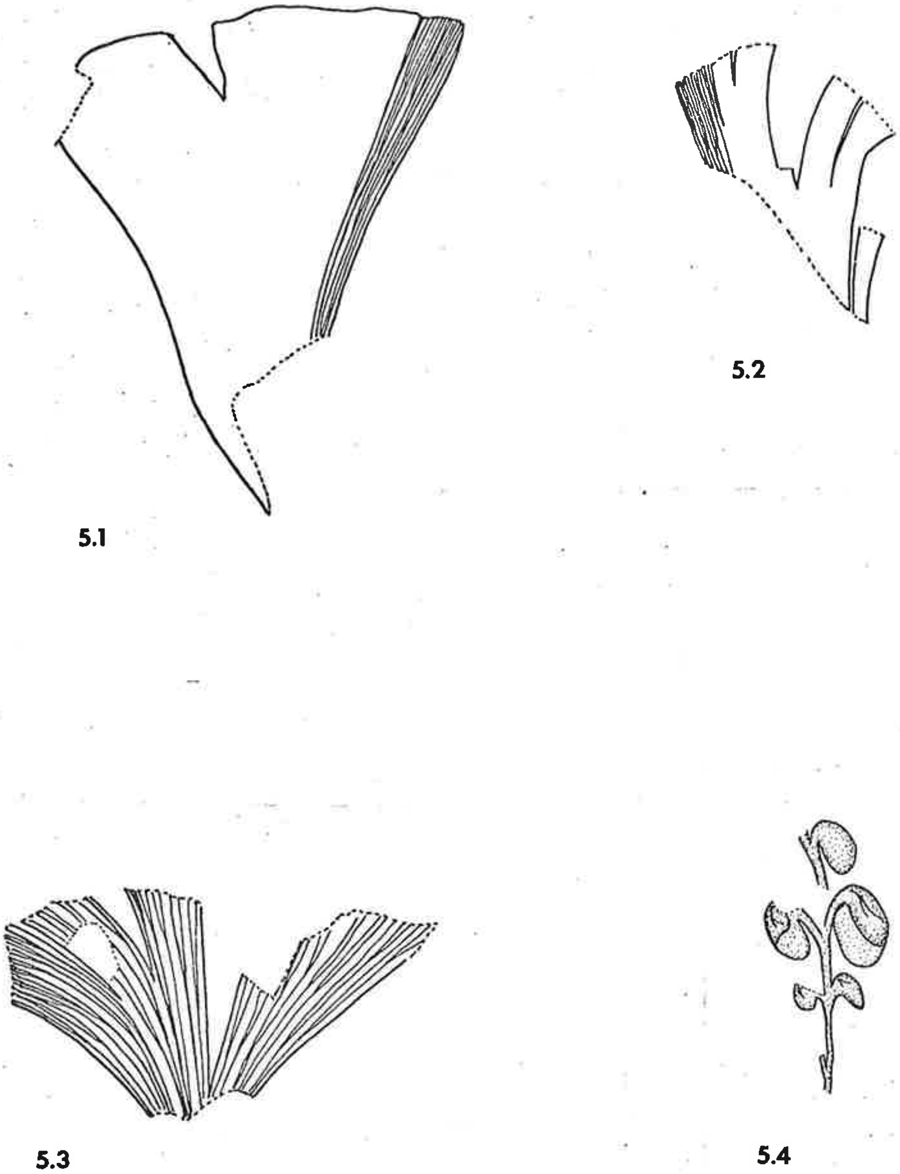
Amtsberg (1969) incorrectly referred specimen P14141 to the species *Taeniopteris dunstani* Walkom (1917). Oishi (1931) established that *T. dunstani* was synonomous with *Yabeiella mareyesiaca* (Geinitz) Oishi from which this species differs in being a narrower leaf with an acute or sometime acuminate apex. The lateral veins of *Y. brackebuschiana* are more dense (i.e. number per cm.) than in *Y. mareyesiaca* and arise from the midrib at a much more acute angle (50°) - 55° (-65°) compared with 70° for *Y. mareyesiaca*.

Jones and deJersey (1947) described and figured specimens from the Ipswich series, Queensland, which they referred to *Y. brackebuschiana*. None of those represented by Jones and deJersey's figures can however be referred to *Y. brackebuschiana*. Some appear to be *Y. wielandi* Oishi, which Jain and Delevoryas regarded as synonomous with *Y. brackebuschiana,* while others are *Y. spatulata* Oishi.

Discussion.

The position of *Yabeiella* in relation to other taeniopteroid leaves is of interest. It has been pointed out that lateral veins in *T. spatulata* join together very occasionally in a similar way to those in *Yabeiella*. It could reasonably be argued that *Taeniopteris* leaves showing anastomoses represent an intermediate form, and that the *Yabeiella* leaves with marginal veins could have evolved from a *Taeniopteris*-like ancestor. However this conjecture would imply a close phylogenetic relationship between *Yabeiella and Taeniopteris* to which other evidence gives little support. As described above, Sahni (1948) found strong circumstantial evidence that the leaf *Nipaniophyllum raoi (=Taeniopteris spatulata)* was associated with the seed bearing organ *Carnoconites*. Wieland (1929) believed that *Fraxinopsis* should be regarded as gymnospermous, though of uncertain position.

Thus there is little evidence from seed-form to closely link *Taeniopteris* *with Yabeiella* if the above evidence of the fertile structure is accepted.



Text-fig. 5. 5.1, *Ginkgoites antarcticus*, P14118 (X 1.5); 5.2, *Ginkgo digitata*, P17394 (X 1); 5.3, *Ginkgo digitata*, *P14117 (X 1.5)*, *5.4*, *?Umkomasia macleani*, *S0253* (X.2).

Order CYCADALES

Genus *PODOZAMITES* Braun, 1843.

The presence of this genus in Australian fossil floras should be regarded as only tentative. *Podozamites* is generally regarded as a coniferous leaf (or foliage shoot) and has been recorded in the Mesozoic floras from many areas of the northern hemisphere. Whilst it has also been regarded as occuring in Gondwanaland sediments it is possible that a thorough revision of this group, based on good specimens will result in new taxa being established for them.

Harris (1926) discussed the generic characteristics of *Podozamites* and concluded that a thin cuticle should be regarded as typical. In this context he was in some doubt whether the *Podozamites lanceolatus* described by Feistmantel (1877) should have been assigned to that genus.

Tenison-Woods (1883) reviewed Australian material mainly from the mesozoic of Victoria previously described by McCoy (1874) as *Zamites (Podozamites)* but also from the Ipswich Basin in Queensland. The specimens from the former location were all "pinnate fronds," which he identified as,

Podozamites barkleyi (McCoy) Tenison-Woods.
Podozamites ellipticus (McCoy) Tenison-Woods.
Podozamites longifolius (McCoy) Tenison-Woods.

Most of the Queensland material consisted of isolated leaves but some, according to Tenison-Woods, showed the mode of attachment of the leaves to the rachis and these he referred to Lindley and Hutton's species *Podozamites lanceolatus*.

Later, Walkom (1917) commented on the presence of *Podozamites* from Ipswich by saying that he was doubtful of Tenison-Woods determination which was based on extremely poor material.

Florin (1952) examined material from Bellarine, Victoria which had previously been described by McCoy (1874) as *Zamites (Podozamites) barkleyi* and erected the genus *Bellarinea* for leaves which he regarded as a podocarpaceous conifer.

Halle (1913) also revised some coniferous material including *Podozamites* and erected the form genus *Elatocladus* to which he referred some mesozoic coniferous material from Australia.

Walkom (1919) described several species of *Podozamites* from the Burrum Coal Measures in Queensland.

With the exception of the detached leaves described by Walkom (1924), and those from Springfield Basin, almost all of the Victorian and Burrum specimens are foliage shoots. Douglas (1969) concluded that the *Podozamites* of McCoy (1878) and of Walkom (1919) were Lower Cretaceous in age.

In summary, it is likely that there are two distinct groupsrepresented by these leaves despite the close similarity in their forms; the pinnate leaves of Lower Cretaceous age from Victoria and the Burrum series in Queensland and the isolated leaves from Ipswich in Queensland and the Springfield Basin which are clearly comparable with similar leaves from the Triassic of Argentina, and possibly with Feistmantel's specimens from the Rewa Basin in India. Whether any or all of these specimens should be referred to *Podozamites* is uncertain until further evidence is available.

Podozamites lanceolatus (Lindley and Hutton)

(Plate 5, figs, 1,2,5; text-fig. 3.3)

1837 *Zamia lanceolata* Lindley and Hutton, pl. 194.

1874 *Podozamites distans* (Lindley and Hutton): Schimper, Vol. 2, p. 159, pl. 71, fig.1.

1877 *Podozamites lanceolatus* (Lindley and Hutton): Feistmantel, pl. III, figs. 7-14; pl. IV, figs. 1-10.

1924 *Podozamites lanceolatus* (?) Lindley and Hutton: Walkom, Pl. 1, pl. XXI, fig. 3-A.

1967 *Podozamites lanceolatus* var. *genuinus* Heer (1876) (Lindley and Hutton): Jain and Delevoryas, pl.97, figs. 6-8.

Diagnosis.

Feistmantel (1877). "Follis remotis, deciduis, integerrimis, basi angustatis, lanceolatis, apice acuminatis, nervis pluribus, supra basim furcatis, dehine simplicibus, apicem versus convergentibus".

Description of Springfield Basin material.

Two specimens from Springfield Basin are referred to this species. Both are detached leaves. P14132A,B (i) (pl. 5, figs.1,2;text-fig 3.3) is a lanceolate leaf 18mm. long and 3mm. wide at the broadest point which is near the apex. The apex and the base are both somewhat obscured but the apex appears to be rounded. The leaf tapers gently towards the base. There are approximately 12 longitudinal veins across the broadest part of the lamina and these converge towards the apex and base. Near the base there are fewer veins but the mode of forking cannot be seen because of the rather poor preservation of this leaf impression.

Specimen S0142 (pl. 5, fig. 5) is 30mm. long and 4.5mm. wide. The apex and the base are both missing but the overall shape of the remaining fragment is the same as for the other specimen. There are about 22 veins at the widest point and these merge near the base. Forking, if present, cannot be observed.

Discussion.

The form and venation of these leaves (or leaflets) coincides with those of *Podozamites lanceolatus* and the specimens from Springfield Basin are referred to this species in the same sense as Oishi (1932), viz. "The name *Podozamites* is here used in a wide sense for .... detached leaves .... characterised by the more or less broad lanceolate form of the leaves provided with blunt apex".

The leaves or leaflets are similar to those illustrated by Feistmantel (1877), Walkom (1924) and Jain and Delevoryas (1967). All of these Gondwanaland specimens are isolated leaves and no foliage shoots from this region are known to have been recorded. Whilst this is negative evidence, it suggests, with the comment by Harris (1926) concerning the cuticle of the Indian specimens, that the Gonwanaland material may prove to be specifically, if not generically distinct from *P. lanceolatus*.

Order GINKGOALES

Florin (1936) carried out a detailed revision of the Ginkgoales and this is now used as the basis for studies of plants in this group. Using patterns of venation, degree of dissection of the lamina and epidermal characteristics, Florin re-ordered many of the taxa and provided a useful basis for the classification of this difficult group of leaves. The two genera represented by Springfield Basin fossils are *Ginkgo* L. and *Ginkgoites* Seward emend. Florin.

Genus *GINKGO* L.

Florin reserved this genus for those fossil leaves which agreed closely with the gross morphological features and epidermal characteristics of the extant species *Ginkgo biloba* L.

Ginkgo digitata (Brongniart) Heer

(plate 4, figs. 3,7,8; text-figs. 5.2, 5.3)

1828 *Cyclopteris digitata* Brongniart, p.219, pl. 61, figs. 2,3.

1876 *Ginkgo digitata* Heer, p.40; pl.viii,fig.1a; pl.x, figs.1-6.

1917a *Ginkgo digitata*(Brongniart) : Walkom, p.8,9; pl.1, figs.3-5.

1919 *Ginkgoites digitata* (Brongniart) Seward, p.14-17, text-figs. 633, 634, 635 C,D,F,H,I,J,K,M; 636 A,B.

1936 *Ginkgo digitata* (Brongniart): Florin, p.32,33.

1947 *Ginkgo digitata* (Brongniart): Jones and deJersey, p.57,58; pl.vi, fig.4; text-fig.54.

1969 *Ginkgo antarctica* (Brongniart): Amtsberg, p.80; pl.1, fig.1.

Description of Springfield Basin specimens

Specimen P14117 (pl.4, fig.7; text-fig.5.3) is a deeply once-dissected leaf fragment with broad secondary segments. The veins are sub-parallel and dichotomously divided. There are 8 to 10 veins across the middle section of the narrowest segment which is 4mm. wide. S0124 (pl.4, fig.3) is poorly preserved and the morphological detail is difficult to interpret. The lamina is dissected in a similar way to specimen P14117 and has broad secondary segments with dichotomously divided veins.

Specimen P17394 (pl. 4, fig.8; text-fig.5.2) is another poorly preserved leaf fragment which is smaller than other *G. digitata* specimens and has finer veins.

Amtsberg (1969) referred specimen P14117 to *Ginkgo antartica,* but the venation and the degree of dissection of the lamina clearly indicate that it should properly be referred to *G. digitata*.

Discussion.

Ginkgo digitata has well defined features which allow it to be easily distinguished from other dissected ginkgoalean leaves. The closest form to *G. digitata* is *Ginkgoites simmondsi* (Shirley) Florin from the Ipswich series, Queensland from which it can be distinguished by the density of veins and other characteristic features such as the presence of many fine veins in *Ginkgoites simmondsi* and fewer, widely spaced veins in *Ginkgo digitata*.

Genus *GINKGOITES* Seward emend Florin.

Seward formally established this genus for leaves which have obvious gingoalean affinities, but through lack of sufficient evidence, cannot be regarded as part of the genus *Ginkgo*. Florin (1936) emended Seward's diagnosis of the genus on the basis of cuticle studies and other morphological evidence.

Jones and deJersey (1947) used Florin's emended diagnosis to reassess the designation of all of Walkom's (1917) Queensland Ginkgoalean specimens, and redesignated those specimens referred to as *Baiera* to *Ginkgoites*. *Baiera* is distinguished from *Ginkgoites* by having repeatedly subdivided leaves in which the ultimate segments have no more than 2 to 4 narrow, parallel veins, whereas *Ginkgoites* has dissected leaves in which there are 4 to 6, though usually more, sub-parallel veins in the central region of the segments.

Ginkgoites antarcticus(Saporta) Seward

(plate 4, fig. 2; text-fig 5.1.)

1884 *Salisburia antarctica* Saporta, p.142, fig. 71A.

1898 *Ginkgo antartica* (Saporta) Shirley, p. 11;t. 1, fig.1.

1917a *Ginkgo antartica* (Saporta): Walkom, pp.7,8; pl.1,figs. 1,2.

1919 *Ginkgoites antartica* (Saporta) Seward, pp. 13,14, text-fig. 632B.

1947 *Ginkgoites antarcticus* (Saporta): Jones deJersey, p.58.

1969 *Ginkgo antartica* (Saporta):Amtsberg, p.80; pl.1, fig.2.

Description of Springfield Basin material.

Specimen P14118 (pl.4, fig.4; text-fig. 5.1)consisting of part and counterpart is the only fossil complete enough to be referred to *Ginkgoites antarticus*. It is typically fan shaped, approximately 28mm. broad at the distal end and 30mm. long. The petiole and base of the leaf cannot be seen. The apical margin is somewhat wavy and has a single 5mm. deep cleft in which may be a natural feature of the leaf but might represent the effect of mechanical damage. The veins are fine, dichotomously branched and there are 4 per mm. across the width of the lamina.

Insertae Sedis

Specimen S0092 (pl.16,fig.5) is a small fragment of a leaf or leaflet 25mm. long and 15mm. wide. One edge appears to be a lateral margin which is slightly curved. There are numerous veins running approximately parallel to the margin. There are about 20 veins per 5mm. across the width of the fragment.

No definite conclusion about the taxonomic status of this specimen can be drawn because of its fragmentary nature. It is possible because of the above characteristics that it has Cycadalean affinities, perhaps being part of a leaflet of a much larger leaf.

Specimen S0252 (pl.16, fig.6.) is an impression of a thick seed-like structure. The structure is 18mm. long and 10mm. wide, tapering at both ends, broadly acute at one end and truncated at the other. At the truncated end there is a small attached structure, almost triangular in outline which gives the overall impression, together with the other part, of a winged seed. The "wing" part of the structure has longitudinal sculpturing of very numerous fine ridges. However, the broadly acute apex is relatively deeply impressed which indicates that this part of the structure was 2-3mm. thick. It can be concluded that the structure is a gymnospermous seed of unknown affinities.

CHAPTER 6.

DISCUSSION AND CONCLUSIONS.

1. Plant Taxonomy.

In discussing the taxonomy of the plant megafossils from the Springfield Basin, the limitations imposed by the extremely fragmentary nature and poor preservation of most of the specimens is significant. This, together with the relative paucity of even moderately well preserved specimens and complete absence of cuticle material, precludes any possibility of a thorough revision of the bases of classification of the various groups of fossil plants represented in this fossil flora. A conservative, and somewhat tentative treatment of the flora has been followed in the light of these limitations. A sound, phylogenetically based scheme of classification of fossil plants demands adequate material. Adequate in terms of data relating to the morphology of the plants, adequate in terms of variations which occur in populations of related plants and adequate in terms of the stratigraphic evidence which will allow temporal relationships to be described.

Of the groups of plants represented in the Springfield Basin flora the corystosperms are the only group which suggest the possibility of a thorough taxonomic revision. Close examination of the data relating to this group confirms that in absolute terms it is far from adequate. Despite this limitation imposed by the lack of more definite data, the material available provides a basis for description and analysis of the flora.

The relative abundance of the corystosperm material illustrates the wide variety of morphological forms in this group of fossil plants. As described in the previous chapter the problem of circumscribing the limits of the taxa in this group are difficult to solve. Two leaf genera are recognised, *Dicroidium and Xylopteris*. The gross morphological forms of specimens referred to *Xylopteris* are regarded as distinct from the generally mesphytic leaf forms of *Dicroidium* and therefore maintained as a separate genus. At the species level several distinct taxa are recognised. Although there are difficult individual specimens, they are all referrable to taxa previously described in the literature and have been identified on this basis.

The poor preservation and a paucity of corystosperm fructifications does not allow for other than a tentative appraisal of Springfield Basin specimens comparable to South African material described in detail by Thomas (1933). The presence of these structures in association with corystosperm leaf material is further evidence of the supposed biological link between these two organs found in Gonwanaland sediments.

The taeniopteroid leaves, *Taeniopteris and Yabeiella* are gymnosperms of unknown affinities. It is probable that they have cycadalean affinities but no further evidence has been obtained from Springfield Basin specimens to shed light on this problem. The taxonomic treatment of this group of leaves confirms many of the difficulties demonstrated by others in studying fossils from elsewhere.

Yabeiella is distinguished from *Taeniopteris* on the basis of its marginal vein, however the presence of occasional anastomoses of lateral veins in both genera and the similarity in overall shape of these indicates a probable close relationship between them. *Taeniopteris springfieldensis* sp. nov. has been described on the basis of only two specimens but appears justified by the distinct morphology of these leaves in comparison with those of other species of *Taeniopteris* previously described.

Although equisetalian remains are numerous, most are poorly preserved and only one specimen has leaves associated with the stem material. All the specimens are referred to *Neocalamites carrerei*.

The fossil gymnosperm leaves *Podozamites, Ginkgo and Ginkgoites,* are uncommon in the accessible sediments of Springfield Basin. In common with some other groups of plants represented, there are taxonomic difficulties resulting from the considerable intraspecific variability of leaf form expected amongst these gymnosperms. The extant species *Ginkgo biloba* illustrates this point, having widely variable forms amongst the leaves of any one individual plant.

Considering the flora as a whole, it can be concluded that considerable plant diversity existed in the region of the Springfield Basin in the Triassic when this fossil flora was extant. It is likely however that the diversity of forms available for study here is not representative of the full range of diverse forms then extant in the area. In comparison with other floras of similar age which have been described, for example, the Ipswich Flora of Queensland, far fewer taxa appear to be present. This might reflect relatively poor conditions for fossilization for many of the plants in this area. Alternatively the plant fossils for the mesa are representative of plants drawn from a restricted ecological niche and may not be representative of the whole region.

2. The Geological Age of the Flora.

The most notable feature of the Springfield Basin flora is the dominance of the genus *Dicroidium*, and more particularly of the species *D. odontopteroides* in its various morphological forms. The total number of distinct species of plants in the flora, whilst being quite small compared to triassic floras from many other regions, shows similarities with other floras, in terms of the range of taxa.

The most recent and thorough analysis of a long sequence of mesozoic macrofloras is that of Stipanicic and Bonetti (1969) for the various triassic basins of Argentina. They recognised four sedimentary complexes which ranged in age from Scythian up to Keuperian. The "higher sedimentary complex (IV)" of Stipanicic and Bonetti which included formations bearing typical *Dicroidium* floras posed some interesting problems. Difficulties arose because the age suggested by the fossil vertebrate evidence did not agree with the age determined by the floral and lithological characteristics of the sediments. Despite these difficulties Stipanicic and Bonetti concluded that the flora of the Cacheuta group of rocks, to which the Springfield Basin flora can be compared, should be placed in the interval: Ladinian-Keuper.

Eleven of the fifteen species from the Springfield Basin flora are represented in the Cacheuta Basin flora; viz. *Neocalamites carrerei, Dicroidium odontopteroides, D. zuberi, D. coriaceum, D. dubium, D. acutum, Xylopteris elongata, X. spinifolia, Yabeiella brackebuschiana, Podozamites lanceolatus and Taeniopteris spatulata (=T. daintreei?)* (The taxonomic position of *T. spatulata* has been discussed in Chapter 4)

On the basis of macrofloral evidence the Springfield Basin sediments are therefore likely to be of approximately the same age as many of the Argentina beds, the Molteno beds of South Africa, The Parsora beds of India, the Hawkesbury and Wianamatta beds of New South Wales, the Ipswich and Esk beds of Queensland and the Feldspathic Sandstone beds of Tasmania and probably the Leigh Creek beds of South Australia.

Chapman and Cookson (1926) regarded the Leigh Creek beds as of Lower Triassic age. Later work based on microfloral evidence suggested Lower Triassic (Glaessner and Parkin, 1958), Rhaetic (Dettman,1961) and Rhaeto-Liassic (Playford and Dettman, 1965). Banks (1969) also regarded the Leigh Creek beds as Rhaeto-Liassic and referred to the Springfield Basin as of approximately the same age. Retallack (personal communication, 1975) is of the opinion that Playford and Dettman's spore analyses are in urgent need or reassessment.

The macrofloral evidence given in this thesis supports the suggestion that the Springfield Basin flora is of Middle to Upper Triassic age.

3. Future Studies.

It is unlikely that the elucidation of further botanical and geological problems concerning the triassic era in South Australia based on macrofloral studies will be forthcoming from studies of the Springfield Basin (there is no likelihood that mining will occur in the basin). The Leigh Creek region offers the best opportunities for future study in these fields. Considerable field work would be required as a basis for such studies since palaeobotanical specimens (macroflora) now available in the various collections are inadequate and the methods employed in their collection were largely unsystematic. The availability of cuticle material, particularly of corystosperms, from Leigh Creek many help lead to a more soundly based taxonomic treatment of South Australian triassic fossil floras.

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Addendum

Halle, T.G. 1913. The Mesozoic Flora of Graham Land. *Wiss. Ergebn. Schwed. Sudpolar-Exped, 1901-1903.* 3(14): 1-123.

PLATES

PLATE 1.   fig. 1.

The mesa at Springfield Basin viewed from a position approximately 800m. N-W.

PLATE 1.

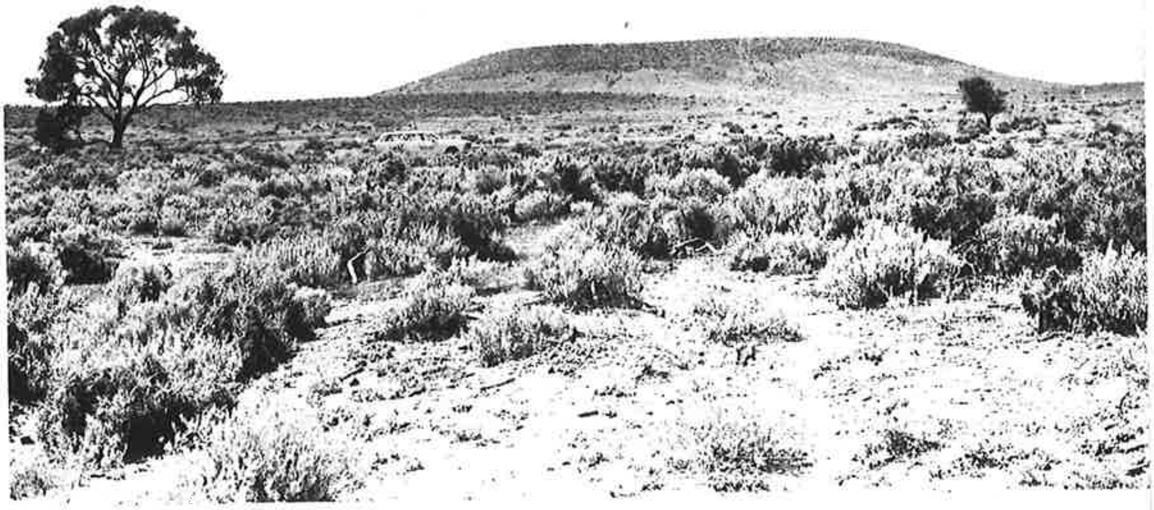

fig. 1

PLATE 2. fig. 1.

Top of mesa at the N-W corner where much of the mining for fossils took place.

fig. 2.

Sandstone strata exposed in small gully on Eastern side of mesa about 15m. from top.

PLATE 2.

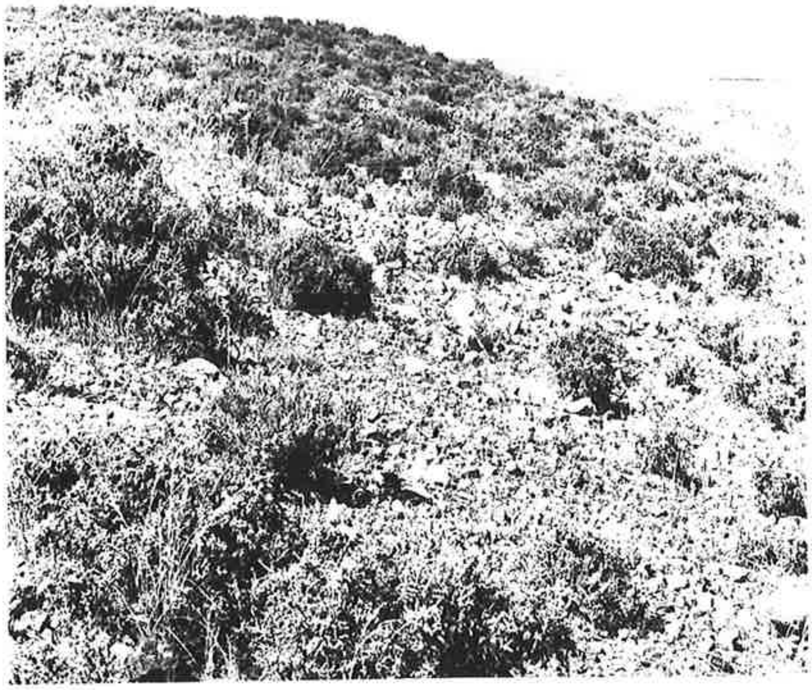

fig. 1

fig. 2

PLATE 3.

fig. 1.

Neocalamites carrerei. Specimen P14120. (natural size)

fig. 2

Neocalamites carrerei. Specimen P14120 with part of cast removed. (natural size)

fig. 3

Neocalamites carrerei. Specimen P17382. (" ")

fig. 4

Neocalamites carrerei. Specimen P14119. (" ")

fig. 5

Neocalamites carrerei. Specimen P17378. (" ")

fig. 6

Neocalamites carrerei. Specimen S0273. (" ")

fig. 7

Neocalamites carrerei. Specimen P14146. (" ")

fig. 8

Neocalamites carrerei. Specimen P17383. (" ")

PLATE 3.

fig. 1

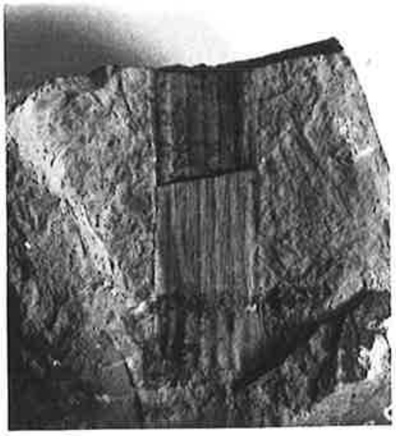

fig. 2

fig. 3

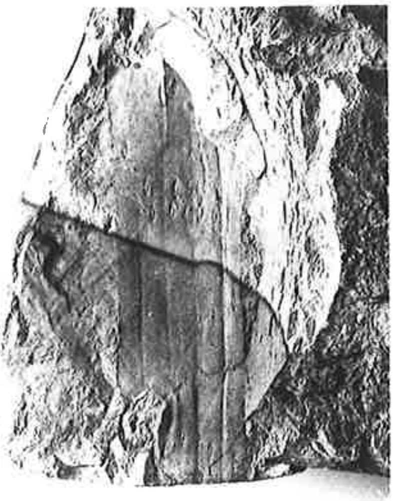

fig. 4

fig. 5

fig. 6

fig. 7

fig. 8

PLATE 4.

fig. 1.

Neocalamites carrerei. Specimen P17396. (Natural size)

fig. 2.

Ginkgoites antarcticus. Specimen S0130. (Natural size)

fig. 3.

Ginkgo digitata. Specimen S0124 (" ")

fig. 4.

Ginkgoites antarcticus. Specimen P14118.(" ")

fig. 5.

Neocalamites carrerei. Specimen P17395. (" ")

fig. 6.

Neocalamites carrerei. Specimen P14122. (" ")

fig. 7.

Ginkgo digitata. Specimen P14117. (" ")

fig. 8.

Ginkgo digitata. Specimen P17394. (" ")

PLATE 4.

fig. 1

fig. 2

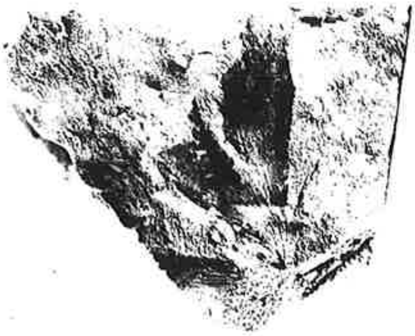

fig. 3

fig. 4

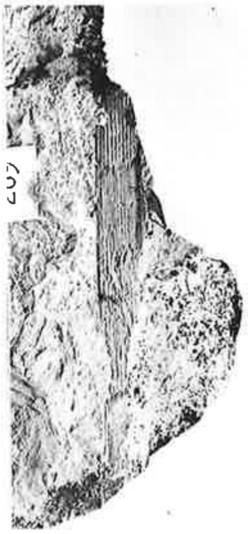

fig. 5

fig. 6

fig. 7

fig. 8

PLATE 5.

fig. 1.

Podozamites lanceolatus. Specimen P14132A(i) (natural size)

fig. 2.

Podozamites lanceolatus. Specimen P14132B(i) (x2)

fig. 3.

Taeniopteris spatulata. Specimen S0244 (Natural size).

fig. 4.

Taeniopteris spatulata. Specimen P14145 (Natural size).

fig. 5.

Podozamites lanceolatus. Specimen S0142 (X2)

fig.6.

Taeniopteris spatulata. Specimen S0169 (Natural size).

fig. 7.

Taeniopteris spatulata. Specimen P14143 (Natural size).

fig. 8.

Taeniopteris spatulata. Specimen P14140 (natural size).

fig. 9.

Taeniopteris spatulata. Specimen P14144 (Natural size).

fig. 10.

Taeniopteris spatulata. Specimen S01316 (natural size).

fig. 11.

Taeniopteris spatulata. Specimen P14149 (Natural size).

PLATE 5.

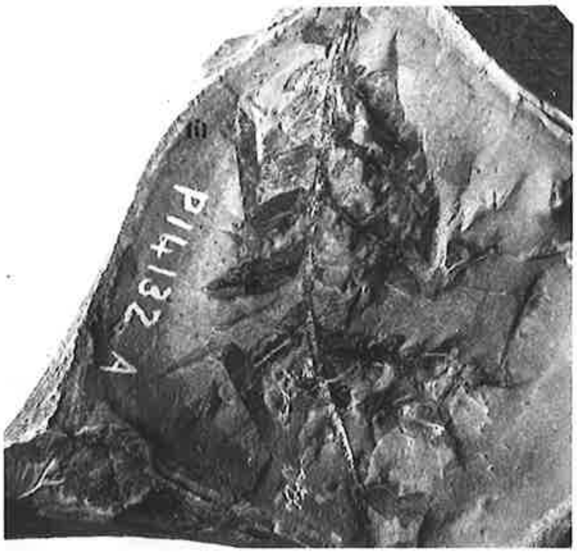

fig. 1

fig. 2

fig. 3

fig. 4

fig. 5

fig. 6

fig. 7

fig. 8

fig. 9

fig. 10

fig. 11

PLATE 6.

fig. 1.

Taeniopteris springfieldensis. Specimen P17385. (natural size)

fig. 2.

Taeniopteris springfieldensis. Specimen P17385. (X4)

fig. 3.

Taeniopteris springfieldensis. Holotype. Specimen S0238a. (natural size)

fig. 4.

Taeniopteris springfieldensis. Holotype. Specimen S0238a. (X4).

PLATE 6.

fig. 1

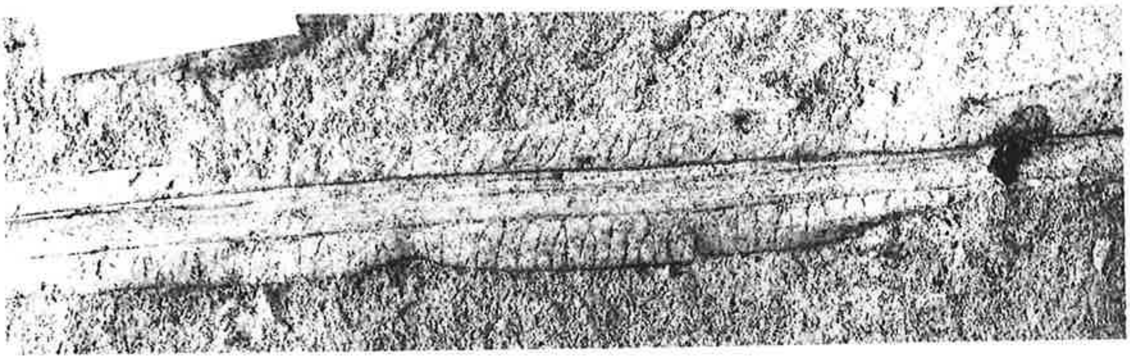

fig. 2

fig. 3

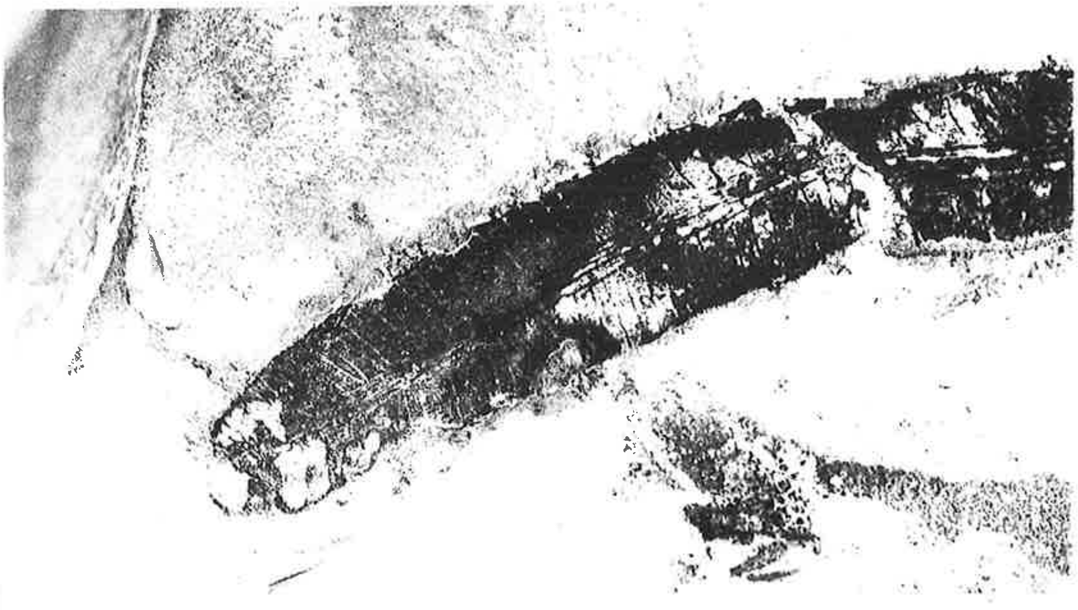

fig. 4

PLATE 7.

fig. 1.

Taeniopteris spatulata. Specimen P14142. (natural size).

fig. 2.

Taeniopteris spatulata. Specimen S0237. (natural size).

fig. 3.

Yabiella brackebuschiana. Specimen P14141B. (natural size).

fig. 4.

Yabiella brackebuschiana. Specimen P14141A. (natural size)

fig. 5.

Dicroidium acutum. Specimen S0091. (natural size).

fig. 6.

Dicroidium odontopteroides. Specimen S0088 (natural size)

fig. 7.

Dicroidium dubium. Specimen P17386. (natural size).

fig. 8.

Dicroidium dubium. Specimen P17390. (natural size).

PLATE 7.


fig. 1


fig. 2


fig. 3


fig. 4


fig. 5


fig. 6


fig. 7


fig. 8

PLATE 8.

fig. 1.

Dicroidium odontopteroides. Specimen S0085. (natural size).

fig. 2.

Dicroidium odontopteroides. Specimen S0119. (natural size).

fig. 3.

Dicroidium odontopteroides. Specimen S0134 (natural size).

fig. 4.

Dicroidium odontopteroides. Specimen S0093 (natural size).

fig. 5.

Dicroidium odontopteroides. Specimen S0099a (natural size).

fig. 6.

Dicroidium odontopteroides. Specimen S0082 (natural size).

fig. 7.

Dicroidium odontopteroides. Specimen P14123 (natural size).

PLATE 8.

fig. 1

fig. 2

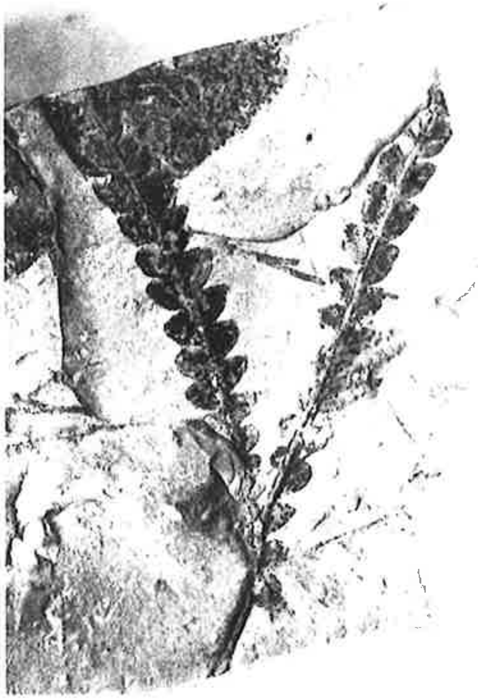

fig. 3

fig. 4

fig. 5

fig. 6

fig. 7

PLATE 9.

fig. 1.

Dicroidium odontopteroides Specimen S0089 (natural size).

fig. 2.

Dicroidium odontopteroides Specimen S0101b (natural size).

fig. 3.

Dicroidium odontopteroides Specimen S022a. (natural size).

fig. 4.

Dicroidium odontopteroides Specimen S0097. (natural size).

fig. 5.

Dicroidium odontopteroides Specimen S0144. (natural size).

fig. 6.

Dicroidium odontopteroides Specimen P14147. (natural size).

fig. 7.

Dicroidium odontopteroides Specimen S0163. (natural size).

PLATE 9.


fig. 1


fig. 2


fig. 3


fig. 4


fig. 5

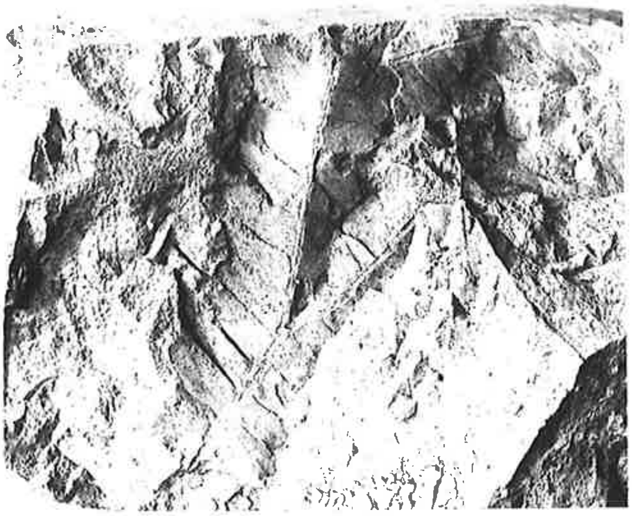
fig. 6


fig. 7

PLATE 10.

fig. 1.

Dicroidium coriaceum. Specimen P17391. (natural size).

fig. 2.

Dicroidium coriaceum. Specimen P17993. (natural size).

fig. 3.

Dicroidium coriaceum. Specimen P17388 (natural size).

fig. 4.

Dicroidium coriaceum. Specimen P17393 (natural size).

PLATE 10.

fig. 1

fig. 2

fig. 3

fig. 4

PLATE 11.

fig. 1.

Dicroidium zuberi. Specimen P14152 (natural size).

fig. 2.

Dicroidium zuberi. Specimen P14124. (natural size).

fig. 3.

Dicroidium zuberi. Specimen P14126 (natural size).

fig.4 .

Dicroidium zuberi. Specimen P17387. (natural size).

PLATE 11.

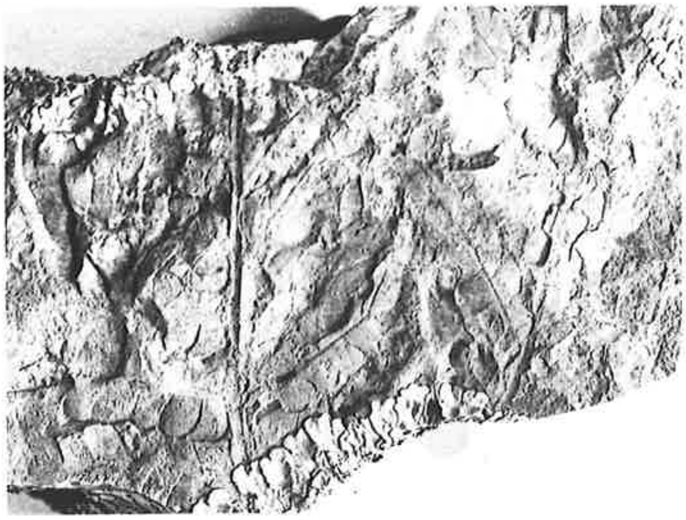

fig. 1

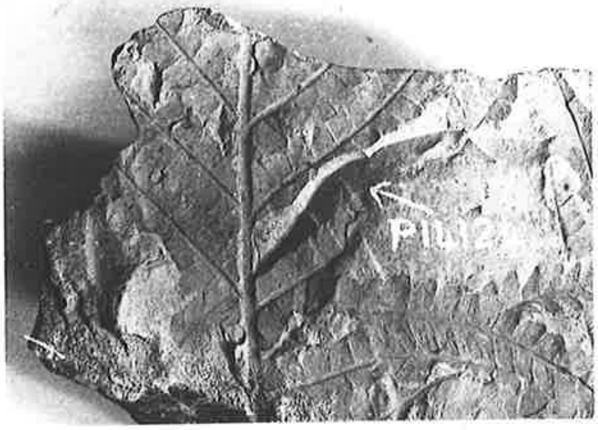

fig. 2

fig. 3

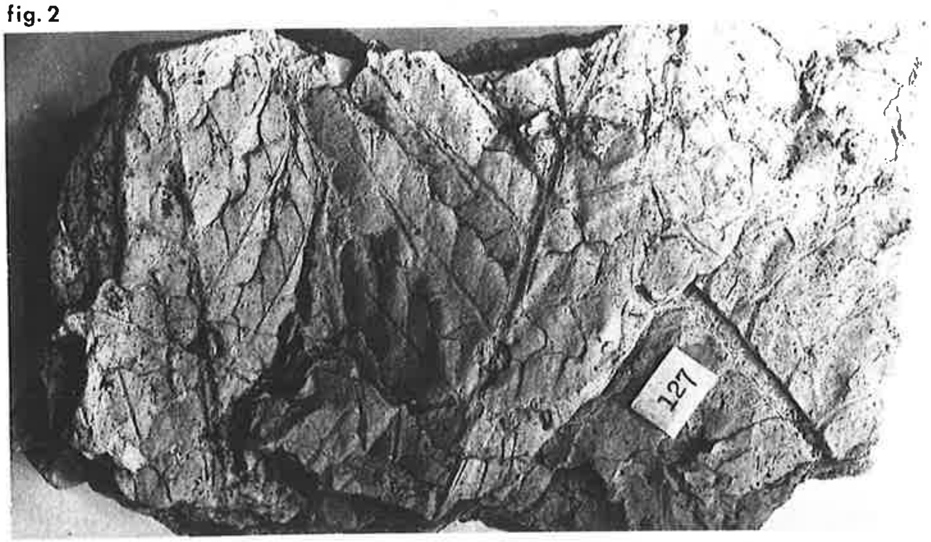

fig. 4

PLATE 12.

fig. 1.

Dicroidium zuberi. Specimen P14125 (natural size).

PLATE 12.

fig. 1

PLATE 13.

fig. 1.

Xylopteris elongata. Specimen P17384. (natural size).

fig. 2.

Xylopteris spinifolia. Specimen P17389. (natural size).

fig. 3.

Xylopteris elongata. Specimen P14129 (natural size).

fig. 4.

Xylopteris elongata. Specimen S0148 (natural size).

fig. 5.

Xylopteris elongata. Specimen S0170 (natural size).

fig. 6.

Xylopteris spinifolia. Specimen P14130 (natural size).

fig. 7.

Xylopteris elongata. Specimen S0192. (natural size).

PLATE 13.

fig. 1

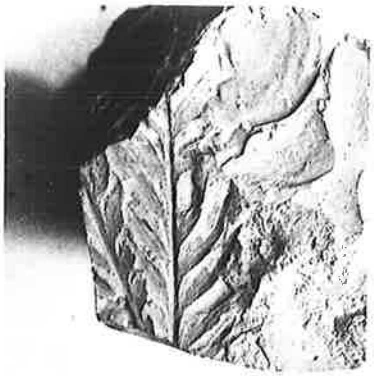

fig. 2

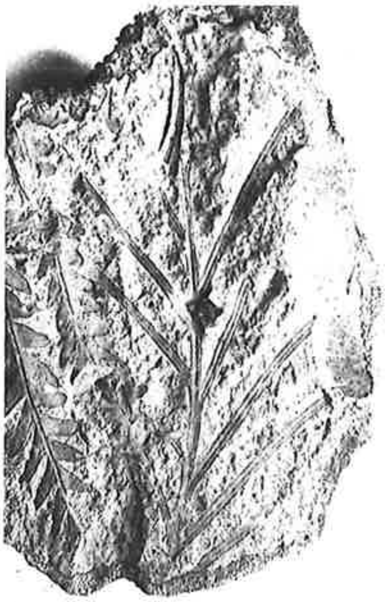

fig. 3

fig. 4

fig. 5

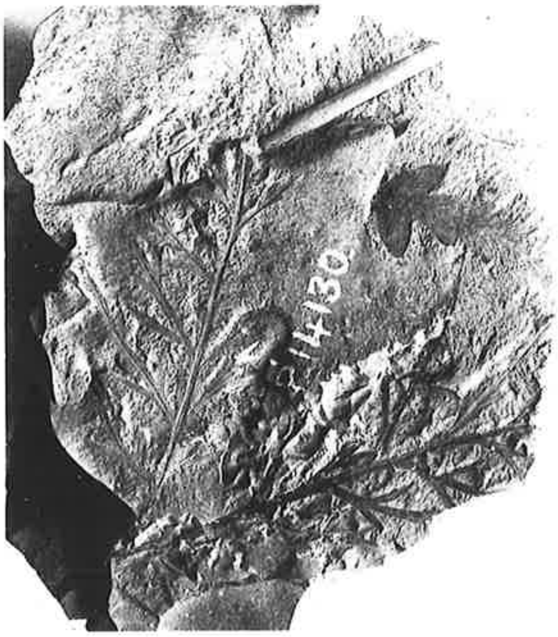

fig. 6

fig. 7

PLATE 14.

fig. 1.

Xylopteris spinifolia. Specimen S0223. (natural size)

fig. 2.

Xylopteris elongata. Specimen P14131. (" ")

fig. 3.

Xylopteris spinifolia. Specimen S0235 (" ")

fig. 4.

Xylopteris elongata. Specimen P14128. (" ")

fig. 5.

Xylopteris elongata. Specimen S0162. (" ")

fig. 6.

Xylopteris elongata. Specimen S0174. (" ")

fig. 7.

Xylopteris elongata. Specimen S0120. (" ")

PLATE 14.

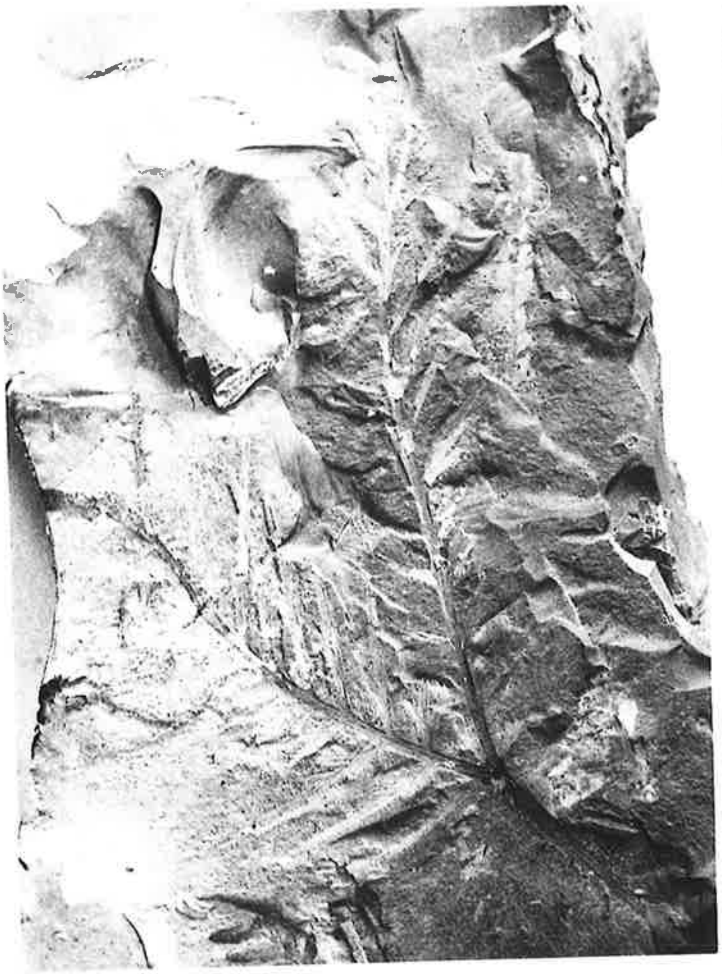

fig. 1

fig. 2

fig. 3

fig. 4

fig. 5

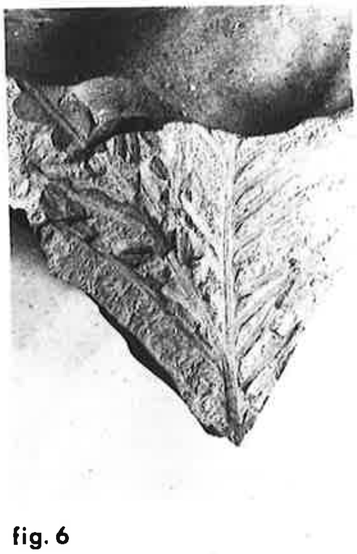

fig. 6

fig. 7

PLATE 15.

Fig. 1.

?Umkomasia macleani. Specimen P17991. (X3).

fig. 2.

?Umkomasia macleani. Specimen P17992. (X3).

fig. 3.

?Umkomasia macleani. Specimen S0253. (X3).

fig. 4.

?Umkomasia macleani. Specimen P17979 (X3).

PLATE 15.

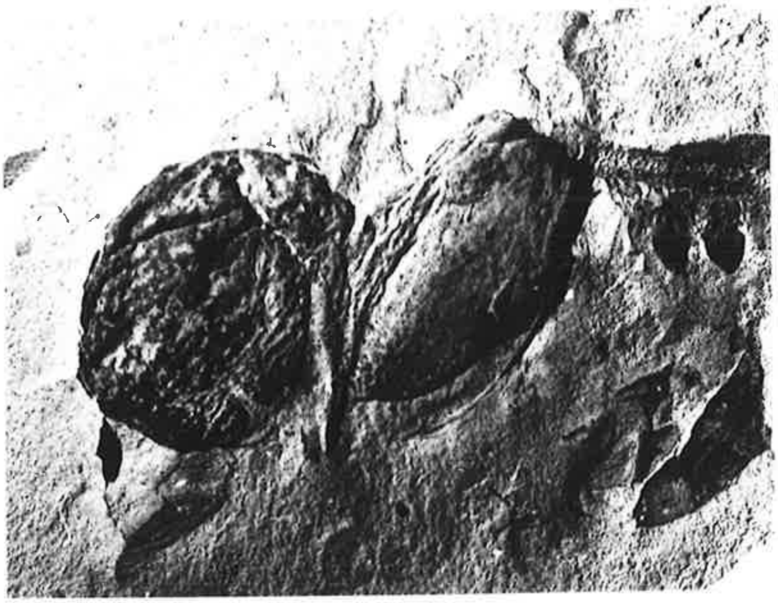

fig.1

fig. 2

fig. 3

fig. 4

PLATE 16.

fig. 1.

?Umkomasia macleani. Specimen P14133a. (X3).

fig. 2.

?Umkomasia macleani. Specimen P17980 (X3).

fig. 3.

?Umkomasia macleani. Specimen P17988 (X3).

fig. 4.

?Umkomasia macleani. Specimen P17981 (X3).

fig. 5.

Insertae Sedis. ?Cycadalean leaf. Specimen S0092. (X3).

fig. 6.

insertae Sedis. ?Gymnosperm seed. Specimen S0252. (X3).

PLATE 16.

fig. 1

fig. 2

fig. 3

fig. 4

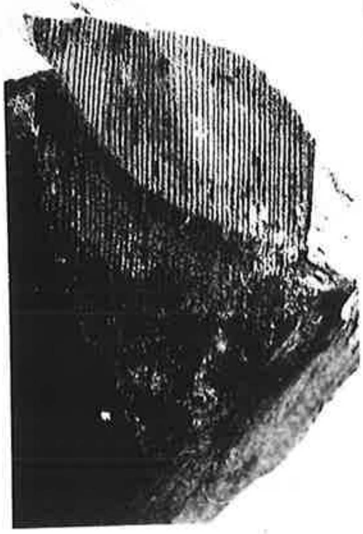

fig. 5

fig. 6