

## A NEW LOOK AT THE FLORA OF THE BOUXHARMONT COAL BALLS FROM BELGIUM<sup>1</sup>

by

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(1 table and 5 plates)

**RESUME.**— Une révision de la flore à structure conservée du Westphalien A basal de Bouxharmont est présentée sur la base de l'étude de plus de 500 coal balls de la collection Leclercq récoltés au début du siècle. Une brève comparaison est effectuée avec la flore contemporaine de la veine Union en Angleterre en mettant l'accent surtout sur les fougères. Les deux flores sont dominées par les Lycophytes mais celle de Bouxharmont diffère par les proportions de toutes les autres divisions de plantes et se caractérise par des populations riches et localement abondantes de sphénophytes et de fougères. Plusieurs nouveaux taxons sont signalés pour la première fois - *Miadesmia*, *Spencerites*, *Calamostachys casheana*, *C. ludwigii* et une nouvelle espèce de *Bowmanites*. Les Ptéridospermales sont rares et la présence de leurs graines n'avait pas été mentionnée avant cette étude. Cinq nouveaux taxons de filicales sont signalés dont deux nouvelles espèces de *Anachoropteris* et un nouveau genre avec un faisceau foliaire à courbure adaxiale. Les genres *Zygopteris* et cf. *Clepsydropsis* sont reconnus. En fait la flore de Bouxharmont ressemble davantage à celle de la veine Upper Foot d'Angleterre, toutes deux montrant la présence de *Cordaites*.

Mots clés : coal balls, Westphalien, Lycophyta, Sphenophyta, Pteridospermopsida, Cordaitopsida, Fougères.

**ABSTRACT.**— A brief survey of the structurally preserved flora of the Bouxharmont coal balls (early Westphalian A) is given following a study of over 500 unsorted specimens from the Leclercq collection (Liège) collected earlier this century. A comparison with the Union Seam flora of Britain, of the same age, is afforded with particular emphasis on the fern content. Lycopods are dominant in both assemblages but the Bouxharmont coal balls differ from those of the Union in the proportions of all other major plant divisions and are conspicuous by rich and locally abundant sphenophyte and fern floras. Many new taxa are reported for Belgian coal balls including *Miadesmia*, *Spencerites*, *Calamostachys casheana*, *C. ludwigii* and a new species of *Bowmanites*. Pteridosperms are rare and their seeds have not been reported before now. Five filicalean taxa new to Belgium occur and include two new species of *Anachoropteris* and a new genus with a catenalean foliar strand. The genera *Zygopteris* and cf. *Clepsydropsis* are recorded for the first time. In fact this flora bears greater resemblance to that of the Upper Foot seam of England with which it shares the presence of *Cordaites*.

Key words : coal balls, Westphalian, Lycophyta, Sphenophyta, Pteridospermopsida, Cordaitopsida, Ferns.

### INTRODUCTION

The flora of the coal balls of the Bouxharmont seam in Belgium has not been extensively studied since the works of Leclercq (1925, 1930, 1935, 1936a). This seam is of lower Westphalian A age and the horizon is equivalent to the seams Finefrau-Nebenbank in Holland and Halifax Hard, Upper Foot and Union in Great Britain. All the coal balls examined in the study reported here came from a single pocket in the Werister colliery which yielded some five tons of coal balls (Leclercq, 1936a). Their contents cannot therefore be considered representative of the floral content over the whole geographic area of the seam. One of the authors (JCH) has extensively studied the Union seam

coal balls in Britain from several localities over a wide area and, during a visit to Liège in 1983, sawed through over 500 uncut coal balls from Bouxharmont. These coal balls were collected by Professor Renier and given to Professor S. Leclercq. Cellulose acetate peels were

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made on the exposed faces and examined under the binocular microscope by reflected light. This revealed a significantly different floral composition from the Union seam and, besides further reporting on the Bouxharmont flora, this paper provides a brief comparison between the two seams. Major differences occur in the representation of all the main plant groups, Cordaitopsida (*Cordaites*), Lycophyta, Pteridospermophyta, Sphenophyta and the ferns Coenopteridopsida and Filicopsida (terminology and classification sensu Taylor, 1981) and this is of interest in comparing two geographically close coal seams of the same age. The only selection effected prior to sawing was to throw out the highly decomposed coal balls. The most outstanding result of this study is the discovery of new (for Belgium) and rare taxa of Ferns, Pteridosperms and Sphenophytes. The Bouxharmont coal balls seem to be more specifically characterized by a number of fern taxa that are as yet unreported from other localities in Europe of the same age.

#### Cordaitopsida

Locally abundant roots of *Cordaites* occur in the coal balls but aerial axes are only seen occasionally. Very rare leaf fragments of the *Cordaites felicis* Benson type have been found (Pl. 1 : 10) and were reported by Leclercq (1928a). Five or six specimens, probably all of the same type of *Cordaites* seed have been observed. These platyspermic seeds have a particular kind of sarcotesta (Pl. 2 : 7, 8, 9) ; in transverse section they have two lateral wings traversed by several small vascular bundles. These seeds are similar to the genus *Mitrospermum* Arber and probably represent a new species.

#### Lycophyta

The stigmarian rootlets which make up the bulk of the organic matrix are rarely crushed and a typical aspect of a peel from a Bouxharmont coal ball is the mass of large white patches throughout the peel which represent the calcite-filled roots. *Stigmaria ficoides* Brongn. and *S. bacupensis* Scott & Lang, which have already been figured by Leclercq (1925, 1930) are very abundant. The rootlets of *S. arachnoides* Koopmans are less common and the exact relationships of this species are not clear. Some *Stigmaria* have characters which suggest Sigillarian affinities such as the cortical anatomy and mode of vascular trace emission as shown by Eggert (1972). Pieces of Sigillarian cortex and leaves with a double vascular trace are present but remains of *Sigillaria* are much less common than those of other lycopods. A few well-preserved specimens of *Lepidophloios* occur as well as several *Bothrodendron* and a large number of *Lepidophylloides* belonging to several species. However entire aerial vegetative axes are not very common whilst masses of lycopod cortex are frequent. Several specimens of *Selaginella fraipontii* (Leclercq) Shlanker & Leisman (Pl. 1 : 6) and six isolated sporophylls of *Miadesmia* have been seen. The latter are

most similar to those of *M. membranacea* Bertrand illustrated by Benson (1907). Some sections show the fringed appearance of the velum (Pl. 1 : 7) and others clearly show the ligule (1, Pl. 1 : 8). Several beautiful specimens of *Achlamydocarpon* cones occurred as well as some *Lepidostrobus* and numerous detached sporophylls of *Achlamydocarpon* and *Lepidocarpon*. One very well preserved cone of *Spencerites insignis* Scott shows the distal attachment of the *sporangia* which contain the characteristic winged spores (Pl. 1 : 5). A 2 cm wide specimen whose stele is lacking (Pl. 1 : 1) is also attributed to this species because of the identical sporangial attachment and spore morphology.

#### Sphenophyta

Numerous sections of stems, leaves and roots of *Calamites* and *Sphenophyllum* are in the peels and several types of cone are associated with them. By far the commonest is *Calamostachys binneyana* Will. and more than twenty specimens have been seen with diameters ranging from 2.7 to 6.8 mm. Two heterosporous cones with bracts inserted more obliquely than in *C. binneyana* indicate the presence of *C. casheana* Will. Besides these two species, five specimens of *C. ludwigii* Car. have been discovered in two different nodules.

In *Bowmanites dawsonii* of which seven new specimens occur, the cone stele is usually triarch but one perfectly preserved specimen clearly shows a pentarch stele (Pl. 1 : 9). The morphology of the cone of *Bowmanites fertilis* (Scott) Hoskins was worked out by Leclercq (1936b) from a Bouxharmont nodule and only one further specimen has turned up in this study. A particularly interesting cone is illustrated in Pl. 1 : 2, 3 and 4. The cone axis has a tetrarch stele and the sporangiophores are branched. Their peltate extremities bear at least two anatropous sporangia. This is probably a new species of *Bowmanites*.

#### Pteridospermophyta

The Lyginopteridales are not at all common at Bouxharmont. A single identifiable fragment of a stem of *Lyginopteris* H. Potonié has been identified in this study and *Heterangium* Corda is represented by five fusainized stems. One or two petioles of the type figured Pl. 2 : 3 are assignable to this genus. *Microspermopteris* Baxter is represented by several narrow stems with typically stellate outlines (Pl. 2 : 1) and larger specimens with secondary wood (Pl. 2 : 2). These latter specimens are, however, difficult to distinguish from *Heterangium* without being able to follow the petiole traces. This problem was discussed by Taylor & Stockey (1976).

Of the several Lyginopterid seeds observed *Conostoma oblongum* Will. is rare but six specimens have been identified as well as two examples of *C. anglo-germanicum* Oliver & Salisbury (Pl. 2 : 5, 6). Two specimens of another seed with radial symmetry and

lobed integument (Pl. 2 : 4) are very similar if not identical to *Physostoma stellatum* Holden.

The Medullosales are even more rare than the Lyginopteridales and include a single example of a stem of *Medullosa anglica* Scott. The stem vascular system is well preserved but the surrounding petioles are very damaged. Several pieces of petiole debris occur in other coal balls as well as several very badly preserved "possible" pollen organs.

### Pteridophyta

Coenopteridopsida - Zygopteridales. *Zygopteris* is one of the commonest ferns in the flora and is represented not only by the stems, Pl. 4 : 3, which are recorded for the first time, but also by the phyllophore *Etapteris* and the probable fertile portions of this plant *Corynepteris* (Galtier & Holmes, 1976).

- Stauropteridales. The genus *Stauropteris* has not been encountered in the coal balls examined, although it was found by Leclercq (1935) filling an entire coal ball from the Saurue seam in the Violette colliery, which is synonymous with Bouxharmont. *Rowleya trifurcata* Long was found beautifully preserved several times (Pl. 5 : 6).

Filicopsida - Marratiales. *Psaronius* is very rare and is represented in two coal balls each with one leaf and two others with *Psaronius* roots.

- Filicales. The genus *Ankyropteris*, represented by the stem species *A. corrugata* (Will) Bertrand and the phyllophore species *A. westphaliensis* (Will) Bertrand (Pl. 4 : 8) is quite common. The positional association of the two species is strongly suggestive of their being the same plant. Concrete evidence for the dichotomy of the stem of *A. corrugata* has been discovered (Pl. 4 : 4-7). A single and very well preserved specimen of *Ankyropteris* showing axillary branching and attributable to *A. brongnartii* (Renault) Stenzel (Pl. 5 : 4) is witness to the occurrence of this plant as a probable marginal member of the swamp community. Another coal ball contains fertile lamina borne on foliar members with similar anatomy to the phyllophore of the *A. brongnartii* specimen (Pl. 5 : 1-3).

Other ferns commonly found in the British Union seam coal balls also occur frequently in the Bouxharmont seam namely : *Botryopteris ramosa* (Will.) Scott, *B. hirsuta* (Will.) Scott (Pl. 3 : 1), *Psaliyochlaena cylindrica* (Will.) Holden and *Rhabdoyxylon dichotomum* (Will.) Holden. *Anachoropteris williamsonii* Koopmans occurs very rarely in Union seam coal balls but is much more frequent at Bouxharmont (Pl. 3 : 4). Besides these now quite familiar ferns the Bouxharmont seam is characterized by a number of rare species, most of which have not been reported from coal balls from other localities in Europe. These are *Anachoropteris gillotii* Corsin (Pl. 3 : 3) *Botryopteris mucilaginoso* Kraentzel, *Botryopteris dichotoma* Holmes & Galtier, two new species of

*Anachoropteris* with C-shaped foliar vascular strands (Pl. 3 : 5, 7) and an interesting new fern represented by a foliar member with a catenalean vascular strand (Pl. 3 : 6). Several examples of each of these ferns have been found which, in the case of the genus *Anachoropteris*, is important as it suggests that they are separate species and that one is not an ontogenetic stage of the other. Finally one specimen of a plant strongly resembling *Catenopteris simplex* Phillips & Andrews has been found in a coal ball that, interestingly, contains little else but a mass of decayed lycopod bark.

Along with the abundant vegetative remains of these ferns there are groups of leptosporangiate-type sporangia that occur relatively commonly and are often well preserved (Pl. 4 : 1, Pl. 5 : 1, 2).

### DISCUSSION

Cordaitopsida : The abundance of *Cordaites* roots does not seem consistent with the rarity of aerial portions (leaves, twigs, pollen organs). On the assumption that in calm conditions some of these organs would drop into the peat around the tree trunks, several explanations are possible ; either the coal balls were formed at a time when these organs were not shed or the trees were growing some distance from the swamp border and the roots were extensive and penetrated a long way into it. Alternatively these organs, especially twigs, were not often shed. Compared for example to lycopods with their wide cortex, a greater part of cordaite biomass was wood and was probably much more resistant to decay and breakage. *Cordaites* has never been reported from the Union seam of Britain although leaves of this plant occur as compressions in shales overlying the seam.

Lycophyta : Remains of these plants occur in all Bouxharmont coal balls and include large and small roots, masses of cortex and detached aerial parts. The morphological monotony of the *Stigmaria* tends to mask the wide diversity of the species present in the peat. Most of these are arborescent, and herbaceous forms occur in association. *Selaginella fraipontii* figured by Leclercq (1925) is not infrequent and the megasporophylls of *Miadesmia*, attributed by some authors to the Selaginellales, was only previously known from England. *Spencerites* is described here for the first time from Belgium.

Sphenophyta : Sphenophyte remains are very abundant at Bouxharmont. They are not, however, found in all coal balls and are of much more restricted distribution than the Lycophyta whose rooting system makes up the matrix of the permineralized peat. *Calamostachys binneyana* and *Bowmanites dawsonii* are two common species which are frequently reported from some of the oldest coal ball localities from the Westphalian of Europe and early Pennsylvanian of the USA. The pentarch specimen of *B. dawsonii* figured here

again illustrates the variability of the vascular strand in this species as do also the specimens figured by Good (1978) from the USA. The presence in the Bouxharmont peats of *Calamostachys casheana* was suspected by Leclercq (1925) and is proven here. Compressions of *C. ludwigii* are locally abundant in the roof shales of certain lower Westphalian A coals (Floriffoux measures) in the Liège area, mainly in the roof of the Grande Delsemme seam (Renier, 1912) but are here reported from the Bouxharmont for the first time. *Bowmanites fertilis* is an interesting species because of its apparently limited geographic distribution. The new species of *Bowmanites* figured here adds to the variety of Sphenophytes reported from the Bouxharmont coal balls.

**Pteridospermopsida :** No single pteridosperm seems to form dense masses of remains in the swamp as does, for example, *Lyginopteris oldhamia* (Binney) H. Potonié in Union seam coal balls from England where it sometimes occurs in thick masses of stems, leaves and foliage occupying the whole thickness of the coal ball. A similar abundance of *Lyginopteris* occurs in the coal balls from the Sainte Barbe coal seam at Floriffoux (mining concession at Masses-Diarbois, Ransart) which, in the Hainaut region, is synonymous with the Bouxharmont seam (Leclercq, 1928b). In addition to the fragment of *Lyginopteris* stem mentioned above there is that figured by Leclercq (1925) and other specimens noticed by Leclercq (1935) and Phillips (1981) in Bouxharmont peels. The presence of *Microspermopteris* has already been reported by Phillips (1981, p. 23). This

rare pteridosperm is often found in association with *Cordaites* and seems to be the case at Bouxharmont. This association is well known from the USA (Phillips, 1981) and Bouxharmont is the second European locality after Shore, England where *Microspermopteris lirata* (Holden 1955, Phillips, 1981) has been found with *Cordaites*.

Phillips (1981) reports *Medullosa* in 7.5 % of the Bouxharmont coal balls but from our preliminary investigation of more than 500 unselected coal balls the proportion seems much lower.

Surprisingly, pteridosperm seeds have not been previously reported and the rarity of the pteridosperm genera may indicate that these plants have been washed in from swamp surrounds.

**Ferns :** The Bouxharmont coal balls are striking by their rich and often well preserved fern flora. In fact 25 % of the coal balls examined contained fern remains.

In 20 % of the coal balls only one fern genus was found. Two genera occurred together in 4 % of them and three genera in less than one per cent. In one coal ball six fern genera were found in an area of only 11 cm<sup>2</sup>. Such rich specimens are very rare and these figures indicate that in general each fern occupied its own ecological niche and that they rarely mix. *Etapteris* - *Ankyropteris* and *Psalixochlaena* - *Rhabdoxylon* are associations that occur more frequently than others. The high percentage of *Zygopteris* (*Etapteris*) and *Ankyropteris* (see table 1) is worthy of record.

Table 1.- Percentage of coal balls examined containing ferns.

		Bouxharmont 1 locality 500 coal balls	Union 4 localities 1000 coal balls	
Filicales	:	<i>Anachoropteris</i>	4.2	0.5
		<i>Botryopteris</i>	4.6	20.0
		<i>Psalixochlaena</i>	1.9	5.1
		<i>Rhabdoxylon</i>	2.5	0.2
		<i>Ankyropteris</i>	5.4	1.0
		<hr/>	<hr/>	
		18.6	26.8	
Marattiales	:	<i>Psaronius</i>	0.7	0
Zygopteridales	:	( <i>Etapteris</i> + <i>Zygopteris</i> )	4.6	( <i>Etapteris</i> ) 0.4
Stauropteridales	:	<i>Rowleya</i>	1.3	1.3
		<i>Stauropteris</i>	0	0.2
		<hr/>	<hr/>	
		25.2 %	28.7 %	

An analysis of nearly 1000 Union seam coal balls from four different localities around Burnley in Britain revealed ferns in 29 %/o, however compared with Bouxharmont the preservation is rarely good and the relative proportions of each genus is very different. In the Union the genus *Botryopteris* occurs in 20 %/o of coal balls and *Psalixochlaena* in 5 %/o, both much higher than in Bouxharmont, the Union however, has a much lower frequency of Zygoteridales which occur only in about 0.4 %/o of coal balls. The exception is *Rowleya* which occurs in the same proportion in both seams and is invariably well preserved. This may indicate that *Rowleya* was a widely spread, locally abundant plant growing in the peat.

The detail of the comparison of fern floras between Bouxharmont and Union is shown in the table 1.

The general texture of the Bouxharmont coal balls, their well preserved fern content, the presence of *Cordaites*, *Medullosa*, *Microspermopteris* and the occasional occurrence of *Psaronius* greatly resembles the coal balls from the Upper Foot seam of Great Britain formerly mined at Shore and Oldham and differs considerably from the Union which is continuous with the Upper Foot. The mines working the latter seam closed earlier this century and large amounts of unselected material are not available for analysis. The presence of geographically restricted species of *Anachoropteris* and *Botryopteris*, the discovery of new fern taxa unreported from other contemporaneous coal ball localities and the negligible amount of *Lyginopteris* may be imputable to the isolated pocket that yielded these coal balls representing a particular ecological niche. *Lyginopteris*, it may be recalled, occurs abundantly in Bouxharmont equivalents elsewhere in Belgium.

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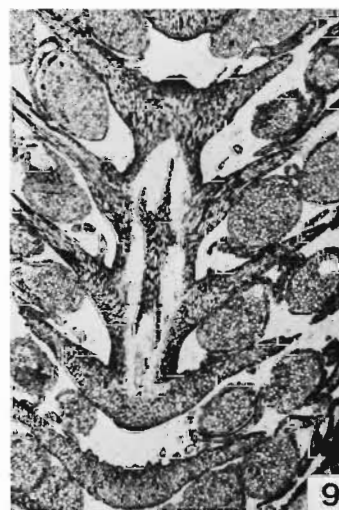
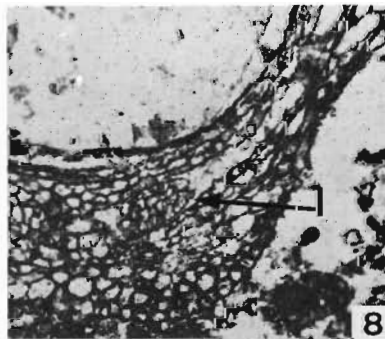
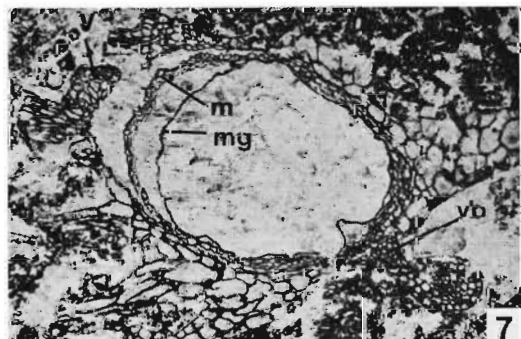
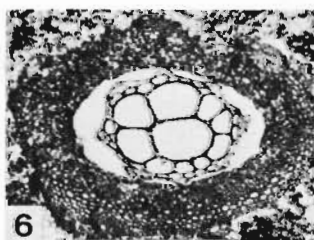
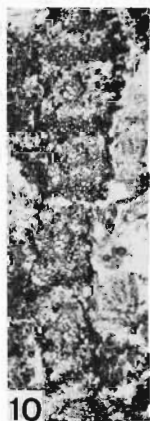
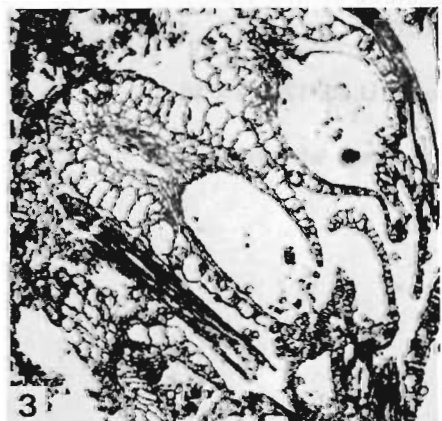
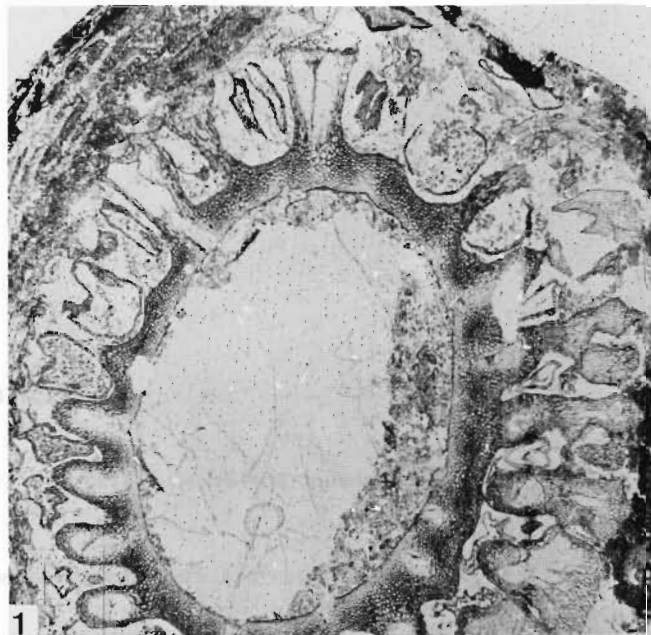
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## PLATE 1

1. *Spencerites insignis* (Will) Scott. Transverse section of cone. U.Lg. 12.643 x 5.
2. *Bowmanites* sp. Detail of cone axis with tetrarch stele U.Lg. 12.643 x 16.
3. Detail of 2 showing mode of attachment of anatrochous sporangia. x 40.
4. Detail of same specimen as 2 showing peltate extremity of sporangiophore. x 40.
5. *Spencerites insignis*. Detail of a sporangium with characteristic winged spores. U.Lg. 12.433 x 40.
6. *Selaginella fraipontii* (Leclercq) Schlanker & Leisman. Transverse section of stem. U.Lg. 12.475 x 32.
7. *Miadesmia membranacea* Bertrand. Section showing fringed aspect of velum.  
v : velum ; m : megaspore ; vb : vascular bundle. U.Lg. 12.796 x 40.
8. *Miadesmia membranacea*. Detail of section through another specimen showing ligule (1). U.Lg. 12.488 x 80.
9. *Bowmanites dawsonii* (Will) Weiss. Oblique section showing pentarch stele of cone axis. U.Lg. 12.377 x 5.
10. *Cordaites felicis* Benson. Transverse section of leaf. U.Lg. 12.458 x 15.

PLATE 1

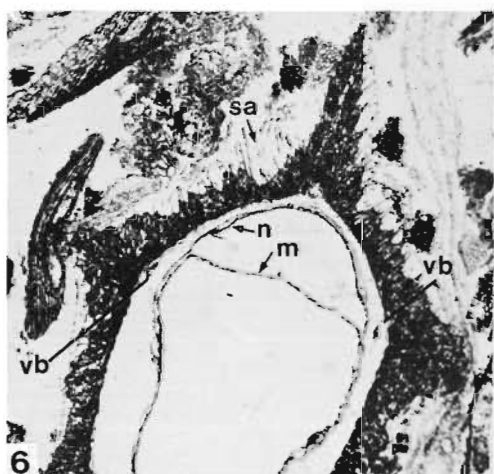
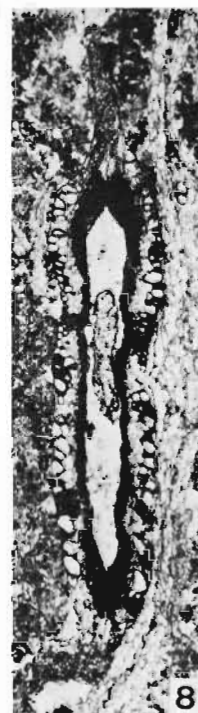
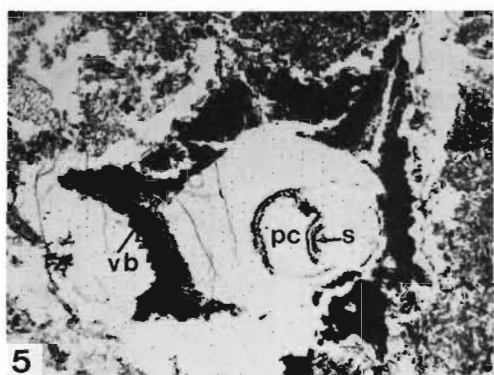
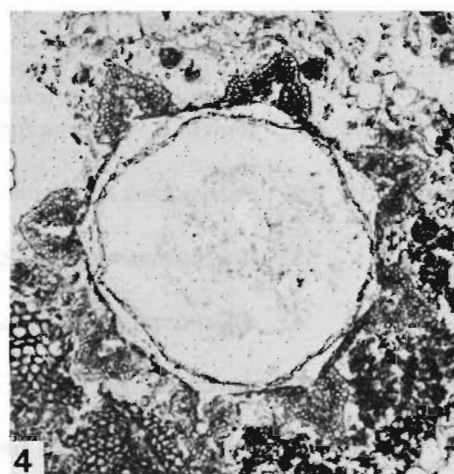
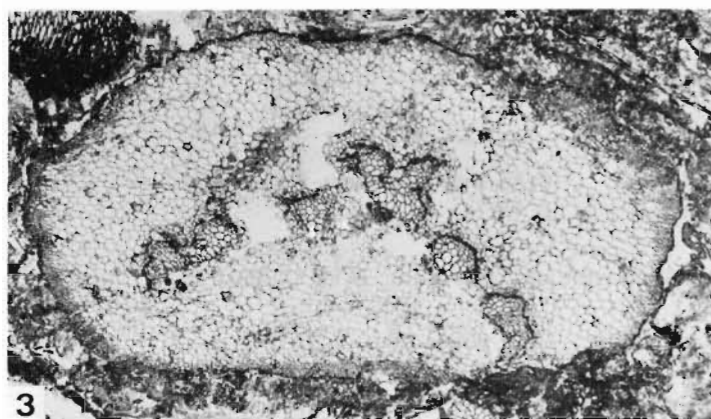
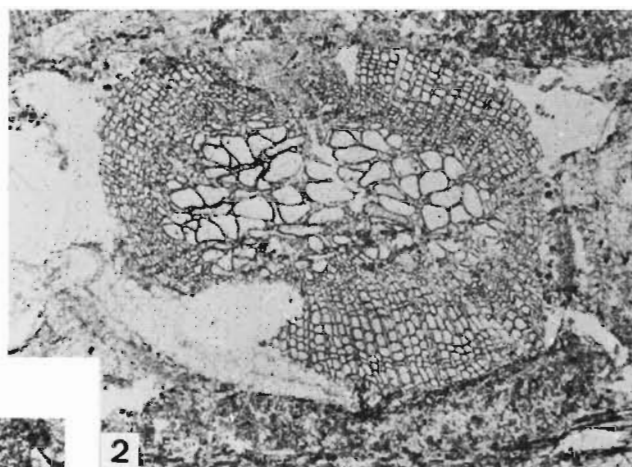


## PLATE 2

1. *Microspormopteris* Baxter. Transverse section through young stem. U.Lg. 12.698 x 20.
2. *Microspormopteris*. Older axis with secondary xylem. U.Lg. 692 x 20.
3. Petiole assignable to the genus *Heterangium* Corda. U.Lg. 12.676 x 16.
4. Lyginopterid seed with lobed integument. U.Lg. 12.656 x 40.
5. *Conostoma anglo-germanicum* Oliver and Salisbury. Oblique transverse section passing through pollen chamber. pc : pollen chamber ; s : salpinx ; vb : vascular bundle. U.Lg. 12.596 x 20.
6. *Conostoma anglo-germanicum*. Oblique section. sa : sarcotesta ; vb : vascular bundle ; m : megaspore wall ; n : nucellus. U.Lg. 12.676 x 20.
7. Seed probably of cordaite origin and similar to *Mitrospermum*. U.Lg. 12.712 x 16.
8. *Mitrospermum* sp. Transverse section showing vascularized wings of sarcotesta. U.Lg. 12.740 x 16.
9. Another specimen similar to that in 8. U.Lg. 12.403 x 16.



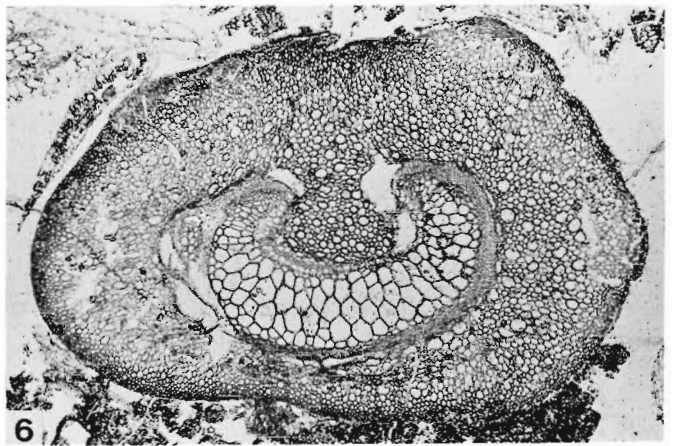
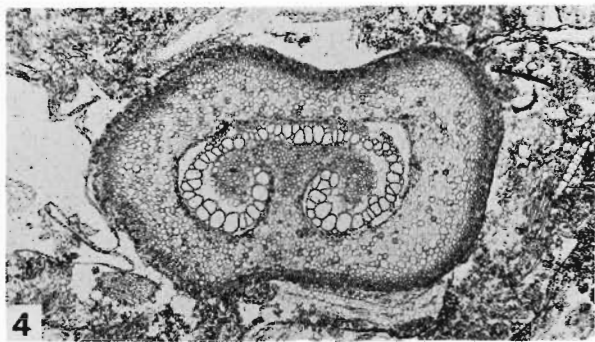
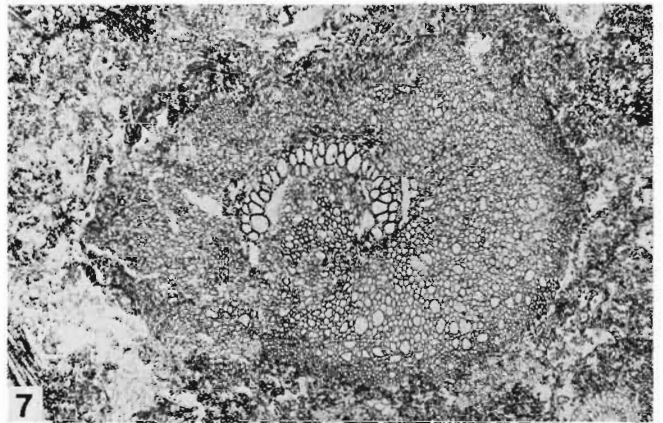
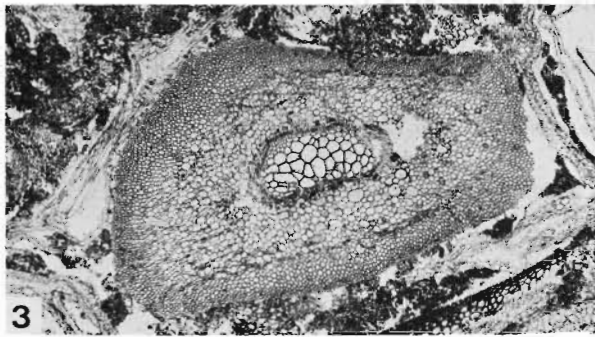
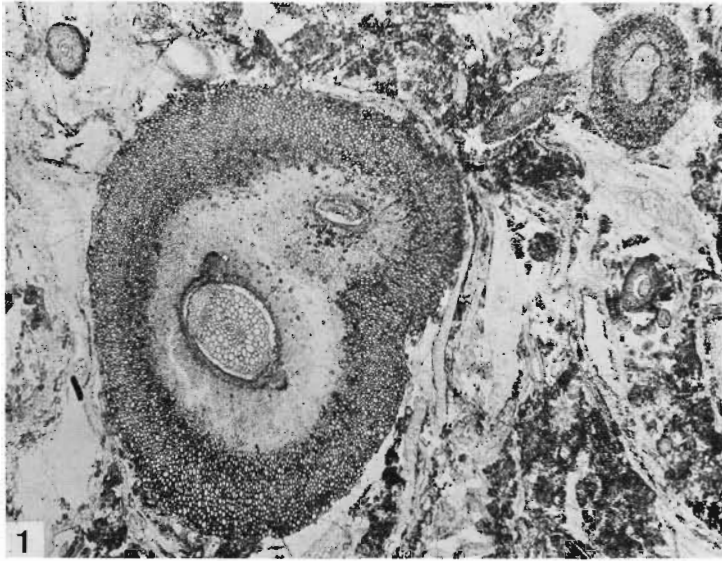
PLATE 2



## PLATE 3

1. *Botryopteris dichotoma* Holmes & Galtier. Stem with leaf trace. Note smaller stem of *B. hirsuta* in top right-hand corner. U.Lg. 1.031 x 15.
2. *Botryopteris mucilaginoso* Kraentzel. Stem with leaf trace at top. U.Lg. 12.450 x 15.
3. *Anachoropteris gillotii* Corsin. Foliar member. U.Lg. 930 x 15.
4. *Anachoropteris williamsonii* Koopmans. Foliar member. U.Lg. 1.041 x 15.
5. *Anachoropteris* sp. 1. Foliar member. U.Lg. 12.780 x 15.
6. Foliar member of a new fern with catenalean vascular strand. U.Lg. 1.035 x 15.
7. *Anachoropteris* sp. 2. Foliar member. U.Lg. 586 x 15.

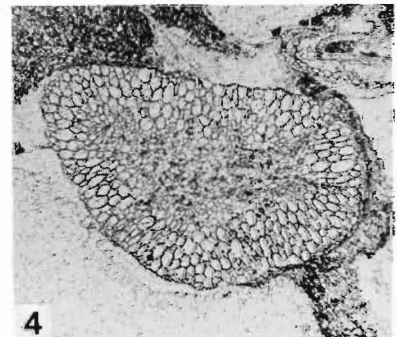
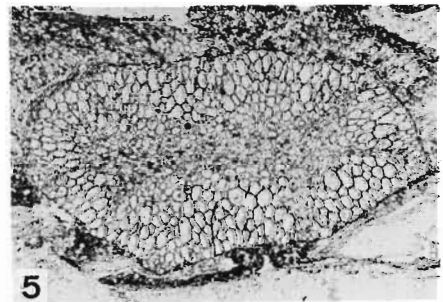
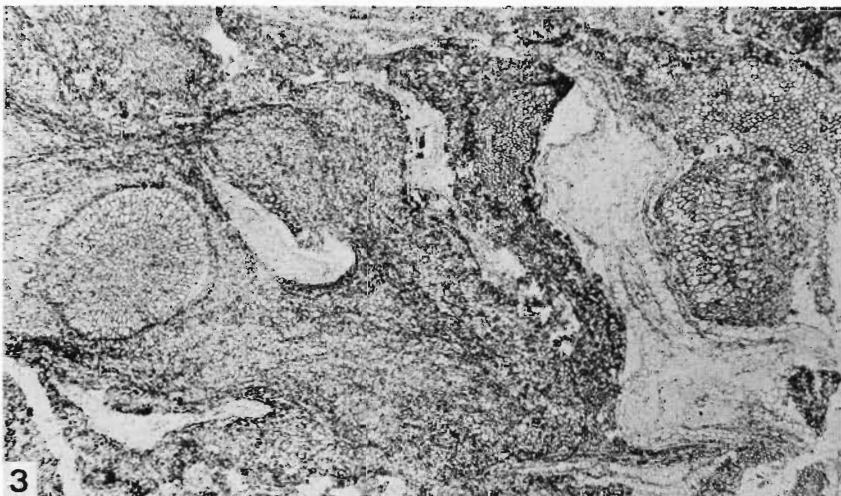
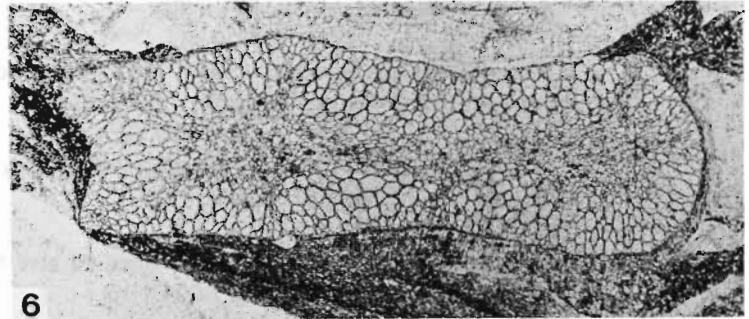
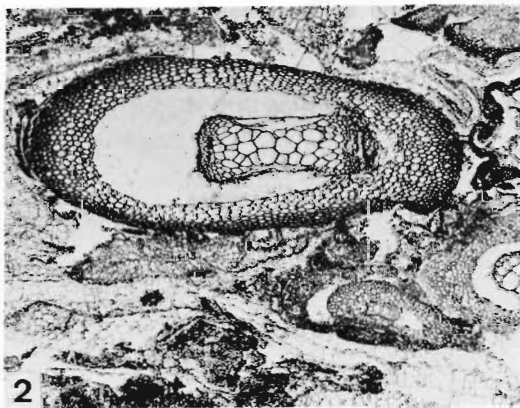
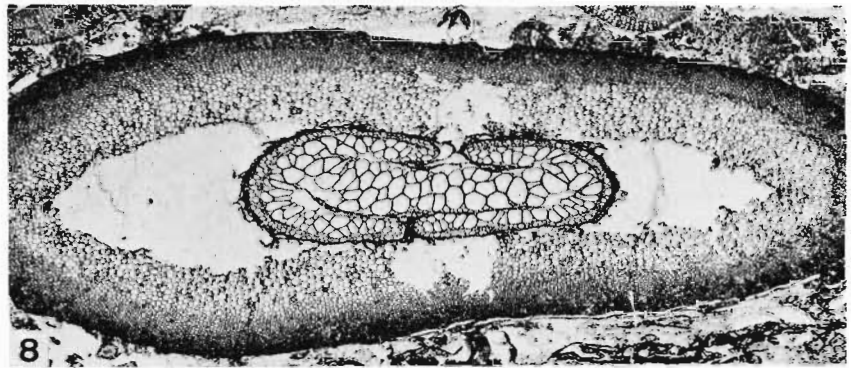
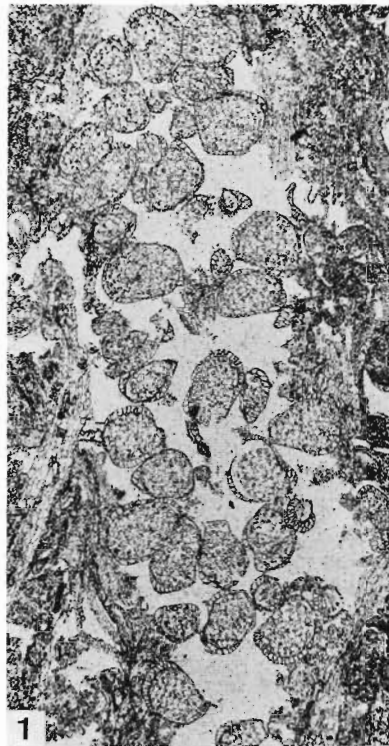
PLATE 3



**PLATE 4**

1. Cluster of sporangia of the leptosporangiate type. U.Lg. 12.561 x 12.
2. Genus cf. *Clepsydropsis*. Section through phyllophore. U.Lg. 951 x 15.
3. Stem of *Zygopteris* with departing phyllophore at right. U.Lg. 12.585 x 12.
- 4-7. *Ankyropteris corrugata*. Detail of stem stele dividing by dichotomy.  
U.Lg. 12.336 x 13.
8. *Ankyropteris westphaliensis*. Phyllophore. U.Lg. 1.034 x 10.

PLATE 4



**PLATE 5**

- 1,2. Detail of fertile lamina borne on foliar members with *Ankyropteris* anatomy. U.Lg. 981 1 : x14 , 2 : x 28.
3. Phyllophore and attached lamina. Note similar anatomy to phyllophore of *A. brongnartii* in 4. U.Lg. 981 x 30.
4. *Ankyropteris brongnartii*. Stem with phyllophore at right and axillary branch between them. U.Lg. 1.033 x 6.
5. Isolated phyllophore with *A. brongnartii* anatomy found in same coal ball as lamina seen in 1, 2. U.Lg. 981 x 14.5.
6. *Rowleya trifurcata* Long. Axis divided to give three subsidiary vascular bundles bound by same cortex. U.Lg. 1.034 x 16.

PLATE 5

