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# Pettycur

## Highlights

Pettycur is one of the classic Lower Carboniferous palaeobotanical sites and has yielded the most diverse British Visean petrification assemblage. It is the type locality for a number of species and is particularly important for lycopsids and ferns; it is also the only known locality for the equisete family Cheirostrobaceae. It is one of the most important palaeobotanical sites in Britain.

## Introduction

Prior to the discoveries at Rhynie (see Chapter 4), Pettycur possessed by far the best known assemblage of pre-Late Carboniferous plant petrifications in the world. Together with the coal-ball petrifications from Yorkshire and Lancashire, it played a key role in developing an understanding of Palaeozoic plant life. The site (Figure 5.22), on the coast at Pettycur, near Burntisland, Fife [NT 262 863], was discovered in 1871 by the local Fifeshire geologist George Grieve. In May of that year, a fossil was exhibited to the Botanical Society of Edinburgh by J.H. Balfour. However, the 'formal unveiling' of the site may be taken as being at the meeting of the British Association for the Advancement of Science held in Edinburgh in August 1871. Details of the site were described during the meeting and afterwards an excursion was conducted there (Gordon, 1909). Numerous publications followed, dealing with parts of this important Lower Carboniferous flora, usually described in tandem with material from the Upper Carboniferous coal balls (Williamson, 1872, 1873, 1874a, b, 1877, 1893; Williamson and Scott, 1894, 1895; Scott, 1897, 1900, 1901, 1908; R. Scott, 1908).

The most detailed investigation of the site was by Gordon (1908b, 1909, 1910a, b, 1911a, b, 1912). Other significant publications were by Benson on the lycopsids, ferns and pteridosperms (Benson, 1908, 1911, 1914, 1922, 1933), as well as some shorter contributions by Kidston (1907, 1908), Bertrand (1907, 1909), Chodat (1912) and Graham (1935).

As at Rhynie, the development of the acetate peel method of investigating petrifications Joy *et al.*, 1956) had a significant impact on the study of the Pettycur fossils, allowing more detailed reconstructions to be achieved. It proved particularly significant for the ferns, whose complex branching patterns could only be properly resolved by very fine serial sectioning. The most important contributions using the method have been by Surange (1952a, b), Lacey *et al.* (1957), Chaloner (1958), Holden (1962), Chaphekar (1963) and Chaphekar and Alvin (1972). In subsequent years, there has been little published work on the palaeobotany of Pettycur, although there has been considerable interest in its stratigraphy and sedimentology (Scott *et al.*, 1984; Scott and Rex, 1987; Rex and Scott, 1987).

## Description

### Stratigraphy

The geology at Pettycur has been extensively discussed by Rex and Scott (1987). The sequence (Figure 5.23) consists of about 25 metres of volcanic igneous rocks (lavas and sills) and mainly volcanogenic sediments of Asbian age (Scott *et al.*, 1984). Petrifications occur at two main horizons. The most important is the Pettycur Limestone, numerous blocks of which are found on the beach, but which has not yet been located *in situ*. Rex and Scott interpret it as a preserved peat, which developed in a relatively tranquil environment, probably prior to the development of volcanic activity in the area; it is in some ways a Lower Carboniferous equivalent of the habitat represented by the Upper Carboniferous coal-balls (Scott and Rex, 1987). The second plant-bearing bed is the Zygoterid Limestone, which also includes abundant fusain. This does not represent an *in situ* peat, but probably the remains of plants growing in a volcanically disturbed habitat, which were transported into a small lake and buried. Rex and Scott also report less well-preserved petrifications together with fusain at four other horizons (the Harbour 'Peat' and Ashy Limestones 1–3), and some adpressions in a dolomitic mudstone.

## Palaeobotany

The following form-species preserved as petrifications and/or fusain have been reported here:

Lycopsida:

*Paralycopodites brevifolius* (Williamson) DiMichele

*Lepidophloios scottii* Gordon

'*Lepidodendron*' *pettycurensis* Kidston

*Flemingites scottii* (Jongmans) Brack-Hanes and Thomas

*Lepidostrobos cylindricus* Gordon M.S.

*Lepidocarpon wildianum* Scott

*Mazocarpon pettycurense* Benson

*Stigmara ficoides* (Sternberg) Brongniart

Equisetopsida:

*Protocalamites pettycurensis* (Scott) Scott

*Protocalamostachys pettycurensis* Chaphekar

*Sphenophyllum insigne* Williamson

*Cheirostrobos pettycurensis* Scott

Filicopsida:

*Botryopteris antiqua* Kidston

*Metadineuron ellipticum* (Kidston) Galtier

*Diplolabis roemeri* (Solms-Laubach) Bertrand

*Metaclepsydropsis duplex* (Williamson) Bertrand

*Musatea duplex* Chaphekar and Alvin

*Stauropteris burntislandica* Bertrand

*Bensonites fusiformis* Scott

Lagenostomopsida:

*Heterangium grievii* Williamson

*Rhetinangium arberi* Gordon

*Sphaerostoma ovale* (Williamson) Benson

*Physostoma* sp.

*Bensoniotheca grievii* (Benson) Mickle and Rothwell *Amyelon* sp.

In addition, Rex and Scott (1987) list as adpressions *Lepidodendron* sp., *Lepidocarpon* cf. *waltonii* Chaloner, *Sphenopteris affinis* Lindley and Hutton, *Sphenopteris* sp., *Sphenopteridium* sp., *Adiantites machanekii* Stur and *Cardiopteridium* sp.

## Interpretation

### Lycopsida

Lycopsid fragments are the most abundant fossils here, particularly in the Pettycur Limestone. The commonest type is *Paralycopodites brevifolius* (Figure 5.24), a lycopsid stem found abundantly in both the Lower and Upper Carboniferous (Williamson, 1872, 1893; DiMichele, 1980). It had a straight, rarely dichotomizing trunk, with a crown of deciduous lateral branches, at the ends of which were small, bisporangiate strobili. The strobili found at Pettycur are known as *Flemingites scottii* (in the Upper Carboniferous, slightly different strobili are associated with *Paralycopodites*, known as *F. diversus* (Felix, 1954) and *F. schopffii* (Brack, 1970)). Megaspores found in *F. scottii* have been reported with endosporal gametophytes (Gordon, 1908a, 1910b; D.H. Scott, 1908–1909), similar to those of the extant *Selaginella* (Gordon, 1908a; Phillips, 1979). The rooting structures are unknown, although Williamson (1872) noted that *Stigmaria ficoides* is often found in close association. Evidence from the Upper Carboniferous suggests that these lycopsids were opportunistic plants, occupying slightly drier parts of the coal-swamps (Phillips and DiMichele, 1992). Its predominance in the Pettycur Limestone (Rex and Scott, 1987), appears to confirm that it favoured peat-accumulating swamps. However, the detailed community structure of the Pettycur swamp has still to be worked out.

Smith (1962c) argued that the stems now called *Paralycopodites* were intermediate between *Lepidodendron* and *Lepidophloios*, but DiMichele (1980) clearly showed they differed from both these lycopsids in having a smooth-surfaced siphonostele, a homogeneous periderm and cortex, and deciduous branches. He further argued that it could be distinguished by the presence of persistent leaves, although some large *Lepidodendron* stems have also now been shown to have been leafy (Leary and Thomas, 1989). A closer analogue might be with the adpression stems known as *Ulodendron*, as defined by Thomas (1967b). There are differences in the epidermis of the leaves, the stomata being restricted to two bands along each leaf in *Paralycopodites* (Graham, 1935), whereas in *Ulodendron* they are more evenly distributed (Thomas, 1967b); but this may just reflect differences at the species level.

Neither DiMichele (1980) nor Thomas and Brack-Hanes (1984) give any opinion as to the taxonomic position of *Paralycopodites*. However, the likelihood that it bore *Flemingites* strobili must surely place it at least as a satellite form-genus of the Flemingiaceae, as defined by Thomas and Brack-Hanes.

A second, but less abundant, lycopsid in the swamps produced the stem known as *Lepidophloios scottii* Gordon (1908b). These stems have a siphonostele surrounding a mixed pith, a feature which is normally regarded as relatively 'primitive'; other *Lepidophloios* species usually have a fully medullated siphonostele, except in the more distal branches (DiMichele, 1979). Gordon noted that it has leaf cushions similar to those seen in the adpression species *Lepidophloios scoticus* Kidston, which occurs commonly in the Lower Carboniferous of Scotland (see also Galtier and Scott, 1986b). Sections through stomata on the leaf cushions have been described by Thomas (1974).

*Lepidophloios* is thought to have borne mega-sporangiate strobili known as *Lepidocarpon* (Phillips, 1979; Thomas, 1981b). It is not surprising, therefore, that isolated sporophylls known as *Lepidocarpon wildianum* Scott (1900, 1901) are associated with *Lepidophloios scottii* at Pettycur. Being found as isolated sporophylls supports Phillips' (1979) view that they operated as seedlike disseminules. The Pettycur sporophylls are very similar to *Lepidocarpon lomaxii* Scott from the Upper Carboniferous coal-balls, and Scott distinguished them taxonomically mainly because they came from stratigraphically different horizons. Until complete strobili are found at Pettycur, however, it will be impossible to make any final decision as to the relative taxonomic positions of *L. wildianum* and *L. lomaxii*. The relationship of *L. wildianum* to the adpression from the Pettycur mudstones, described by Rex and Scott (1987) as *Lepidocarpon* cf. *waltonii* Chaloner, is also at present unclear.

A third type of lycopsid stem from the Pettycur Limestone is known as '*Lepidodendron pettycurense*'. It is often quoted in the literature as a prime example of a primitive *Lepidodendron*, since it has a solid protostele (e.g. Taylor, 1981). However, it is only known from two decorticated axes (Kidston, 1907), and there is little definitive evidence that the fossil really is a *Lepidodendron*. Significantly, the axes are found closely associated with *Mazocarpon pettycurense* Benson (1908) sporophylls, this type of fructification usually being linked with the Sigillariostrobaceae (Schopf, 1941). To determine the taxonomic position of these stems will clearly need better preserved material.

The *Mazocarpon* described by Benson (1908) is only known from incomplete sporophylls, but appears to represent a reproductive strategy similar to that adopted by *Lepidocarpon* (see above). If correctly assigned to the Sigillariostrobaceae, these sporophylls are the oldest evidence of this family in the fossil record.

A fourth type of lycopsid fructification is *Lepidostrobus cylindrica* Gordon M.S. Although mentioned in species lists for the site (Gordon, 1914; Walton and Long, 1964), it has never been effectively published and so for the time being must remain a *nomen nudum*.

## Equisetopsida

The remains of two equisetopsid orders have been found at Pettycur: the Equisetales ('archaeo-calamitids') and Bowmaniales ('sphenophylls'). Equisetalean stems are relatively abundant, although Rex and Scott (1987) state that they are often preserved 'in the immature form'. They were originally described as *Calamites pettycurenensis* Scott (1902) and then *Protocalamites pettycurenensis* D.H. Scott (1908–1909). Chaphekar (1963) argued that the differences from '*Archaeocalamites goeppertii* (*Protocalamites goeppertii* (Solms-Laubach) Bateman) merely reflected different positions within the plant. However, Bateman (1991) has found that the Pettycur stems have consistently fewer primary vascular strands than typical *P. goeppertii*, such as found at Laggan and Loch Humphrey Burn (Walton, 1949b; Chaphekar, 1963), and that they probably represent smaller, shrubby plants.

Associated with these stems are strobili, *Protocalamostachys pettycurenensis* Chaphekar (1963). Although never found in organic attachment, the structure of the pedicle is very similar to that of the smaller branches of *Protocalamites pettycurenensis*. It differs from *Protocalamostachys arranensis* Walton found at Laggan (p. 155) in being smaller, having more sporangiophores in each whorl, fewer vascular strands in the pedicle, and containing smaller spores (Bateman, 1991).

The Bowmaniales are rare in the Pettycur Limestone. Stems described by Williamson (1874a) and Williamson and Scott (1894) have a primary xylem strand with the characteristic triangular cross-section of this order (cf. Meyen, 1987, fig. 21), and are known as *Sphenophyllum insigne* Williamson. Two specimens have been reported with roots attached to one side (Williamson and Scott, 1894), which supports the evidence from the Upper Carboniferous that *Sphenophyllum* was a creeping or scrambling plant (Batenburg, 1981).

The order is generally rare in the Lower Carboniferous, although there is evidence of its range extending down to the Upper Devonian (Remy and Spassov, 1959). Petrifications have also been reported from Saalfeld (Solms-Laubach, 1896) and the Montagne Noire (Galtier, 1970), but the Pettycur specimens remain the best documented Lower Carboniferous examples to date.

*Cheirostrobos pettycurenensis* (Figure 5.25) is also often included in the Bowmaniales, based partly on its occurrence in a deposit supposedly 'rich with *Sphenophyllum* stems' (e.g. Taylor, 1981); in fact such stems are relatively rare at Pettycur, and Scott (1897) argued that they could not have borne *Cheirostrobos* strobili. Nevertheless, there is an underlying similarity between the peltate sporangiophores of *Cheirostrobos* and those of *Bowmanites* and other bowmanitalean strobili. The most significant difference is that *Cheirostrobos* is a far more complex structure than any other reported bowmanitalean strobilus, and it superficially resembles certain lycopsid strobili such as *Flemingites*. It has whorls of thirty-six sporophylls, each sporophyll bearing four elongate sporangia (Scott, 1897). Its taxonomic position is uncertain, but is usually assigned to a mono-specific family (Cheirostrobaceae) within the Bowmaniales. If correct, it suggests that there was a marked reduction in structural complexity of bowmanitalean strobili during the Carboniferous. It remains a considerable palaeobotanical enigma, and is only known from Pettycur.

## Filicopsida

The ferns fall broadly into two groups: (1) species of Zygopteridaceae (Coenopteridales), which occur mainly in the Zygopterid Limestone; and (2) species of Stauropteridaceae (Coenopteridales) and Botryopteridaceae (Botryopteridales), which occur mainly in the Pettycur Limestone (for details of their distribution, see Rex and Scott, 1987, fig. 11).

### Zygopterid community

Pettycur is probably the best known British locality for zygopteridacean ferns, and it has provided valuable information on the evolution of the vascular systems of the stem (Gordon, 1911a, b, 1912; Dennis, 1974) and the phyllophores (Gordon, 1911b; Galtier, 1964). They appear not to have been growing in the main peat-swamp, but were probably a pioneer community which would have invaded the areas nearer the volcanic centres during periods of eruptive quiescence (Rex and Scott, 1987). The best understood of the Pettycur species is *Metaclepsydropsis duplex* (Figure 5.26); Williamson, 1874b; Bertrand, 1909; Gordon, 1911b; Chaphekar and Alvin, 1972). For many years, it was only known from here, although there are now reliable records also from Glenarbut (see below), Roannais (Galtier, 1970) and Esnost (Galtier, 1980). It is interpreted as a scrambling plant with little or no secondary wood in the stems and bearing upright fronds. The branching pattern of the vascular traces within the fronds (Gordon, 1911b, text-figs 2–3) is a characteristic feature of the early members of the family. Fertile pinnules associated with these fronds have been named *Musatea duplex* Chaphekar and Alvin (1972); these have sporangial clusters apparently borne superficially at the margins of the abaxial surface (Galtier, 1981). They are similar to fructifications associated with other Lower Carboniferous zygopteridaceans (Galtier, 1968), but contrast markedly with the more complex *Biscalitheca* borne by Upper Carboniferous to Permian zygopteridaceans (Mamay, 1957).

Of similar habit and anatomy was *Diplolabis roemeri* (Figure 5.27) (synonyms *Zygopteris pettycurensis* Gordon, *Diplolabis esnostensis* Renault and *D. forensis* Renault) (Renault, 1896; Gordon, 1909, 1911a). As with *Metaclepsydropsis*, there is little evidence of secondary wood development. The fertile pinnules were also similar to those of *Metaclepsydropsis*, and have been named *Musatea globata* Galtier (1968).

The third of the Pettycur zygopteridacean axes, *Metadineuron ellipticum*, is only known from fragments of phyllophore (Kidston, 1908; Galtier, 1964, 1970). It is presumed to have been of similar habit to the other members of the family from Pettycur.

### Filicopsids of the swamp community

Within the peat-forming swamp, the Coenopteridales were represented by *Stauropteris burntislandica* (Williamson, 1874b; Bertrand, 1907, 1909). It has also been reported from Roannais in central France (Galtier, 1971), but most work on the species has been based on Pettycur material. Although the overall form of the plant has not been confirmed, it is assumed to have been herbaceous. The fronds were reconstructed by Surange (1952a), and are generally similar to those of the Zygopteridaceae, including the presence of basal aplebiae (Lacey *et al.*, 1957), but have a less-planated, more primitive aspect.

Of particular interest is the fact that *S. burntislandica* was heterosporous. The megasporangia had been initially identified as *Bensonites fusiformis* R. Scott (1908) but the connection with *Stauropteris* was confirmed by Chodat (1912; see also Surange, 1952a). They are spindle-shaped structures, consisting mostly of parenchyma with a longitudinal vascular strand, but with a distal cavity that opens out to the sporangium apex via a narrow tube. The cavity contains a tetrad of two operative and two aborted megaspores, corresponding to *Didymosporites scottii* Chaloner (1958) (see also Hemsley, 1990b). Similar dispersed megaspores are known from various Lower Carboniferous localities in Britain (Chaloner, 1958). For some time, these sporangia were thought of as possible ancestors of gymnosperm seeds (e.g. the nucellar modification concept of Andrews, 1961), but this view has now lost favour (see discussion on the Whiteadder earlier in this chapter). Instead, it would appear that it represents a seed-like reproductive strategy, comparable to that achieved by the lycopsids (*Lepidocarpon*) and equisetes (*Calamocarpon*).

Microsporangia have not been found in organic connection with *S. burntislandica*, but R. Scott (1908) reported that structures very similar to *Stauropteris oldhamia* Binney sporangia occur in close association. Unlike most fern sporangia, they lacked an annulus, and spore-release was achieved via a small stomium.

The Botryopteridales are represented by *Botryopteris antiqua*, for which this is the type locality (Kidston, 1908; Benson, 1911; Surange, 1952b; Holden, 1962). Holden's work, in particular, has clarified the overall habit of the plant, which seems to have had a creeping stem, giving off erect fronds with digitate, three-dimensional pinnules, and a similarity to the adpression form-genus *Rhodeopteridium*. A distinctive character of the fronds is the frequent presence of small plantlets, which were presumably a means of vegetative propagation (see also Galtier, 1969), a feature generally rare in the Filicopsida. The sporangia were borne laterally to the ultimate segments of the frond (Galtier, 1967, 1981). They have a transverse annulus and contain spores of the form-genus *Granulatisporites*.

There has been some disagreement as to the taxonomic position of *B. antiqua*. It differs from typical *Botryopteris* (e.g. *B. forensis* Renault, *B. globosa* Darrah), which has fertile organs consisting of large clusters of several hundred sporangia. Good (1981) argued that it should therefore be transferred to *Psalixochlaena*, but this ignores the differences in vascular structure and position of attachment of the sporangia (Holden, 1960; Holmes, 1977, 1981). It is arguable that *B. antiqua* should be transferred to a different form-genus but, in the absence of a detailed taxonomic analysis of the problem, the traditionally accepted combination is used here.

## Lagenostomopsida

Unlike most other Lower Carboniferous petrification sites in Britain, Pettycur does not have a diverse assemblage of pteridosperms; there are just two types each of stem and seed, and one of pollen-bearing organ. The most abundant fossils are the stems *Heterangium grievii*, for which Pettycur is the type and best locality (Williamson, 1873; Williamson and Scott, 1895; Benson, 1933). This is the best known of the 'primitive' group of *Heterangium* species, which are assigned to the subgenus *Heterangium* (synonym *Euheterangium* auct.), and is characterized by a mesarch protostelic vascular system and transverse sclerotic plates in the cortex. The latter feature imparts a transverse bar-pattern to the outer surface of the stems, allowing a correlation with *Sphenopteris elegans* Brongniart and *S. affinis* Lindley and Hutton types of foliage preserved as adpressions. These fronds have deeply dissected pinnules, in contrast to the *Eusphenopteris* fronds borne by *Heterangium* subgenus *Polyangium* from the Upper Carboniferous, which have rounded pinnules (Shadle and Stidd, 1975).

The present distribution of *H. grievii* suggests that it came from a plant that was abundant in the Pettycur Limestone peat-swamp (Rex and Scott, 1987), and was probably a ground-cover creeper, growing below the arborescent lycopsids.

Associated with *H. grievii* are small *Sphaerostoma ovate* seeds (Williamson, 1877; Benson, 1914). Although never found in organic connection, Benson argued strongly that they were parts of the same plant. Such seeds have a number of 'primitive' features, such as the integument and nucellus being only partially fused and an abscission layer between the integument and the cupule. However, the salpinx is considerably reduced and there is a well-developed micropyle. It is thus apparently intermediate between the primitive lagenostomean seeds from the Tournaisian (e.g. *Stamnostoma* from the Whiteadder — see above) and *Lagenostoma* from the Upper Carboniferous.

Also in association with *H. grievii* are some poorly preserved pollen-bearing organs identified by Benson (1922) as *Heterotheca grievii* (later renamed *Bensoniotheca grievii* by Mickle and Rothwell (1979)). Consisting of an ovoid cluster of completely fused sporangia, they contrast markedly with the loose clusters of free sporangia associated with other Lower Carboniferous *Heterangium* stems, and known as *Telangium* or *Telangiosis* (e.g. Jennings, 1976). It is possible, however, that they are merely immature forms of *Telangium*.

The second type of pteridosperm stem found at Pettycur is *Rhetinangium arberi* Gordon (1912), for which this is again the type locality. Like *Heterangium*, these stems have a single protostele, but it is exarch and there is no evidence of sclerotic plates in the cortex.

No seeds have been found in organic connection with *Rhetinangium* at Pettycur, but Gordon (1910a) reported a poorly preserved example of what seemed to be *Physostoma* in close association. Gordon's description is only brief and was not accompanied by an illustration. It is perhaps worth noting that in the Tournaisian assemblage at the Whiteadder, there is evidence that *Rhetinangium* bore *Genomosperma* seeds.

Walton and Long (1964) reported *Amyelon* from Pettycur, which may represent pteridosperm roots. However, they have not been described in the literature.

Rex and Scott (1987) list and illustrate a number of pteridosperm foliage fragments preserved as adpressions. However, there is no published taxonomic account of these fossils, and they are thus difficult to judge.

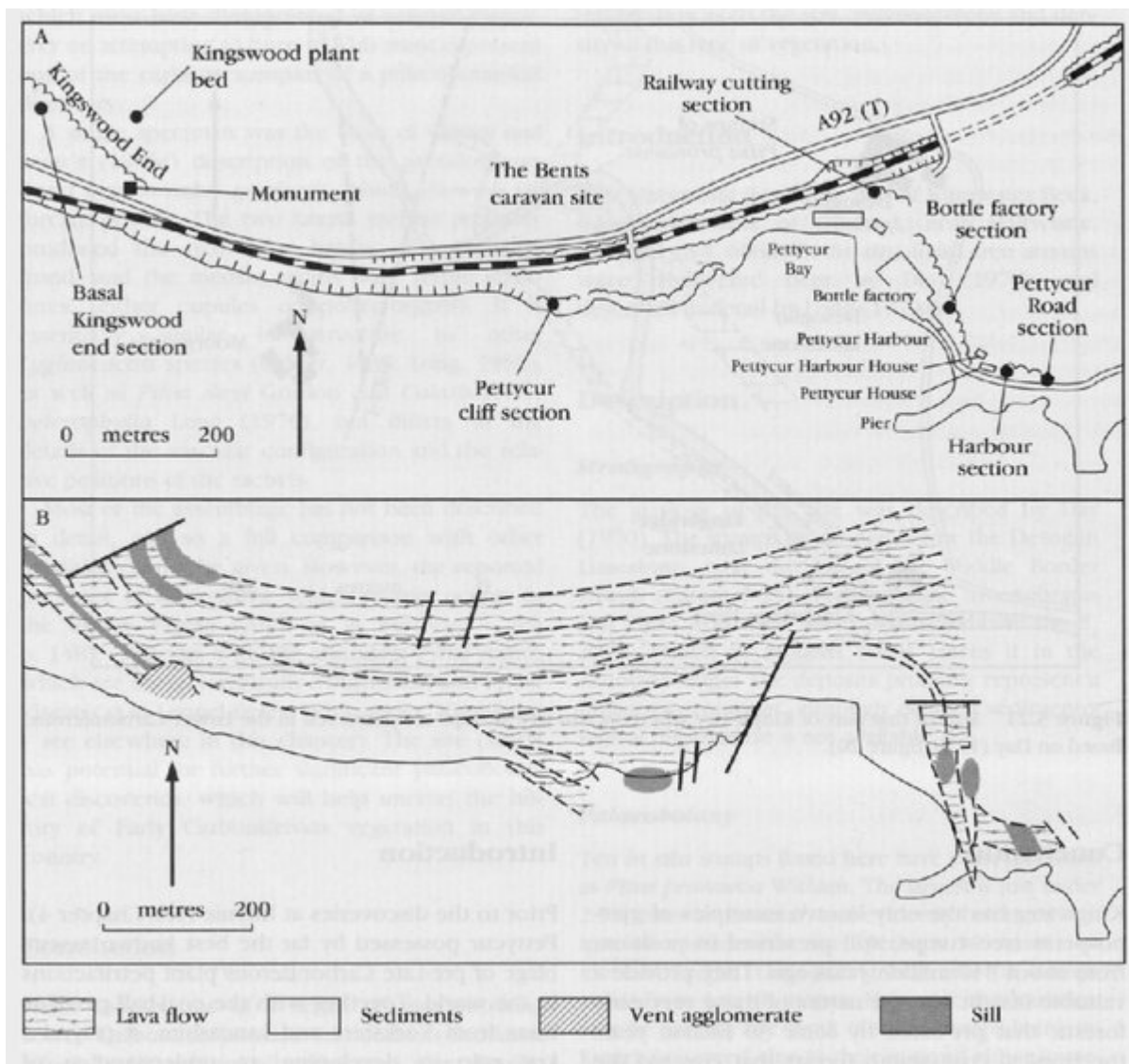
## General remarks

This site has yielded the most diverse Visean plant petrifications known from Britain, and is of great historical significance, having been central to the work of such leading palaeobotanists as W.C. Williamson, D.H. Scott and W.T. Gordon. One of the plant-bearing horizons (the Pettycur Limestone) is the best known example of an *in situ* peat-swamp from the Lower Carboniferous. It provides a useful comparison with the Late Carboniferous coal-swamps, which were not formed in a volcanic setting, but in a more tranquil, lower delta-plain setting (see Chapter 6). Elsewhere in Britain, Glenaruck (p. 164) has yielded the most comparable Lower Carboniferous fossil plant assemblage, being also dominated by lycopsids, but the preservation is not so good and it does not have such diverse fern or equisete components. The ferns (especially those from the Zygopterid Limestone) provide a ready comparison with upper Visean petrifications from Esnost and Roannais in France (Galtier, 1970, 1971, 1980; Scott *et al.*, 1984), but there, in contrast to Pettycur, pteridosperms are virtually absent. Also similar is the Visean assemblage from Glatzisch-Falkenberg, Germany (Solms-Laubach, 1892), but the absence of recent work on that assemblage makes a detailed comparison difficult (Scott *et al.*, 1984). Visean petrifications from outside Europe are virtually unknown, and this presumably reflects the unusual conditions necessary for the formation and preservation of petrified plant fossils (in this case lake sediments and peats accumulating in a lowland, volcanic environment).

## Conclusion

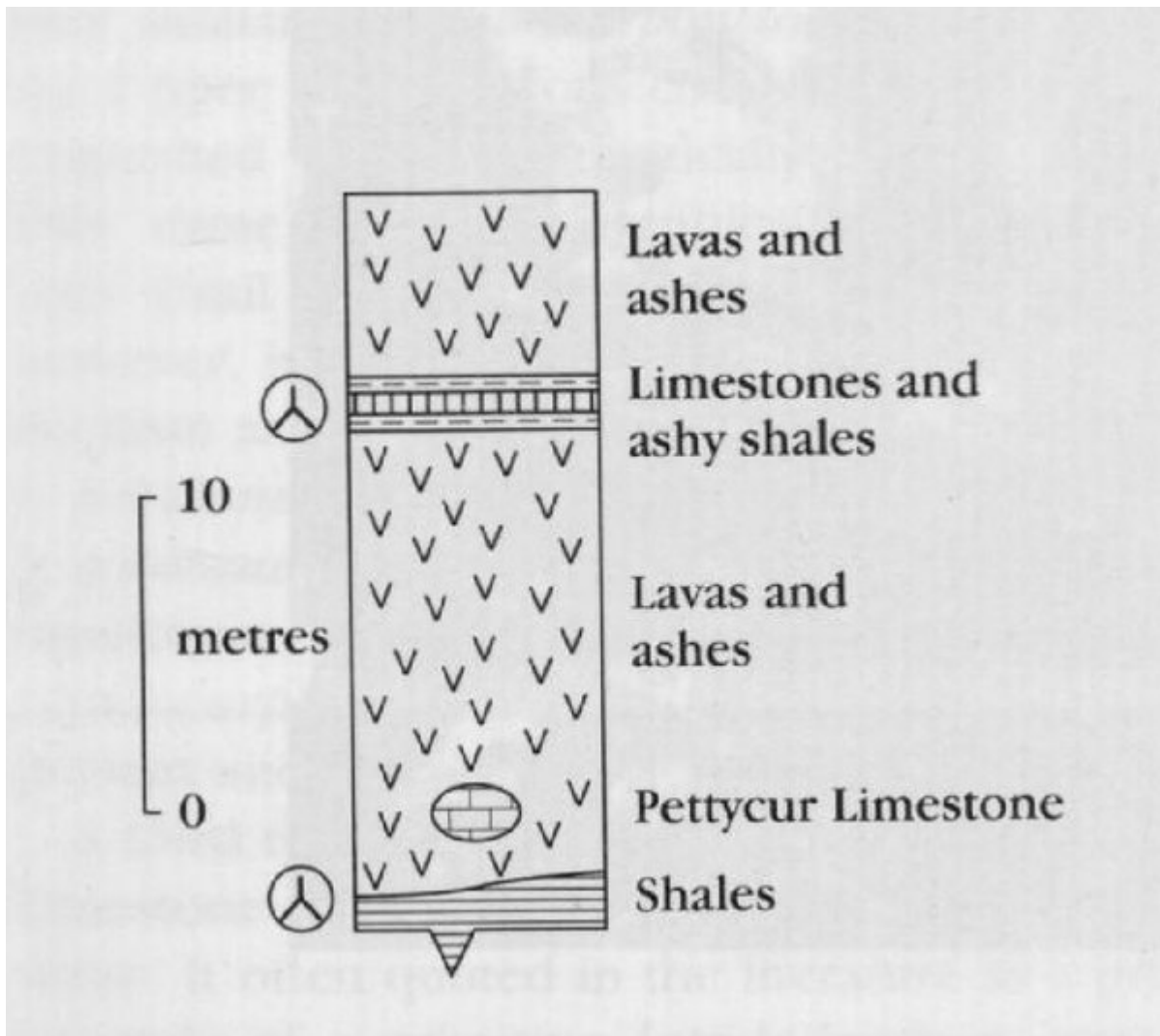
Pettycur is one of the classic Palaeozoic palaeobotany sites in Britain, yielding anatomically-preserved plant remains about 330 million years old. Together with the peat-floras of the Devonian Rhynie Chert (see Chapter 4) and the Upper Carboniferous coal-balls (see Chapter 6), it was for many years regarded as the best guide to the vegetation of the Palaeozoic. Although many other Lower Carboniferous sites, in this country, France and Germany, are now known to yield anatomically-preserved plant fossils, Pettycur remains of great palaeobotanical significance, particularly for the study of the early fern-like plants and club-mosses. It is also the only known locality for the horsetail family, the Cheirostrobaceae. Despite being one of the oldest known types of equisete, it has by far the most complex reproductive organs ('cones') that have been found in that group of plants, either living or in the fossil record.

## [References](#)

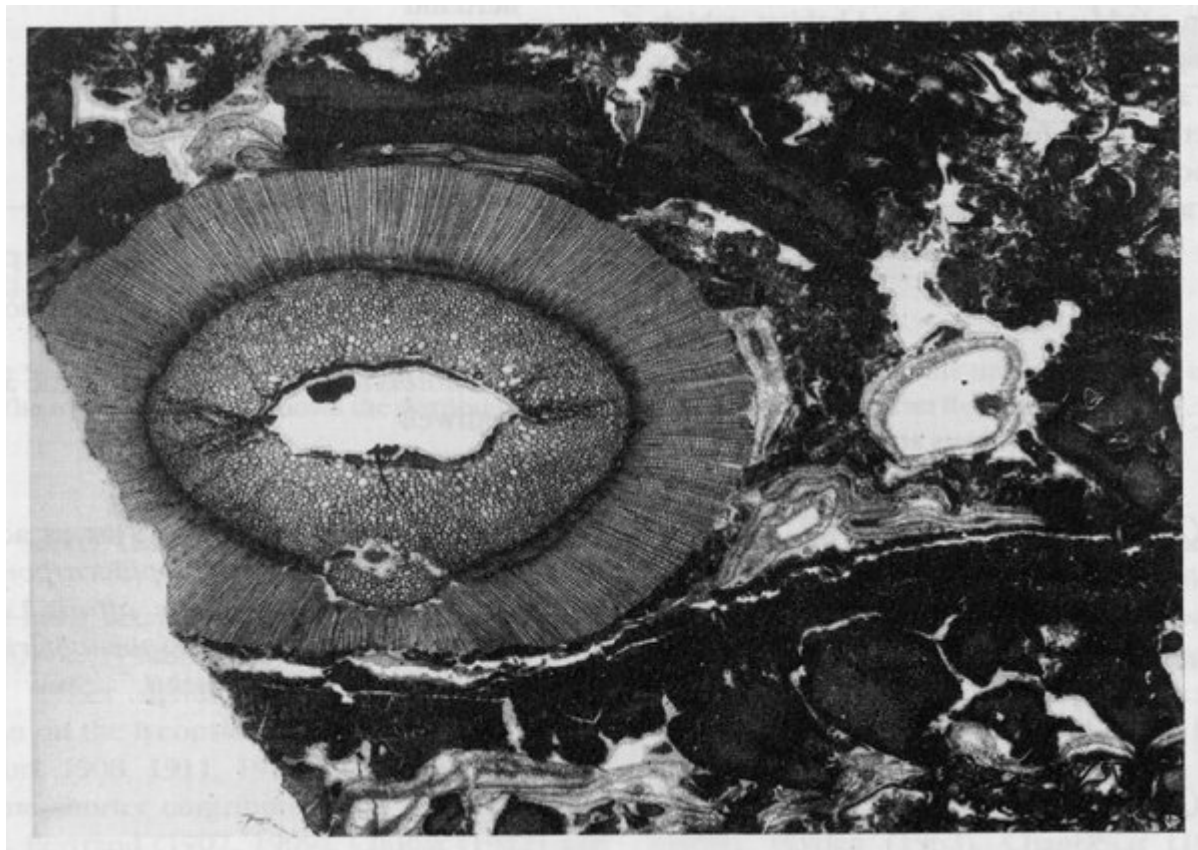


(Figure 5.22) Maps of the Pettycur and Kingswood End GCR palaeobotany sites. The upper illustration is a locality map. The lower illustration shows the distribution of the main lithologies. Based on Rex and Scott (1987, figure 2).

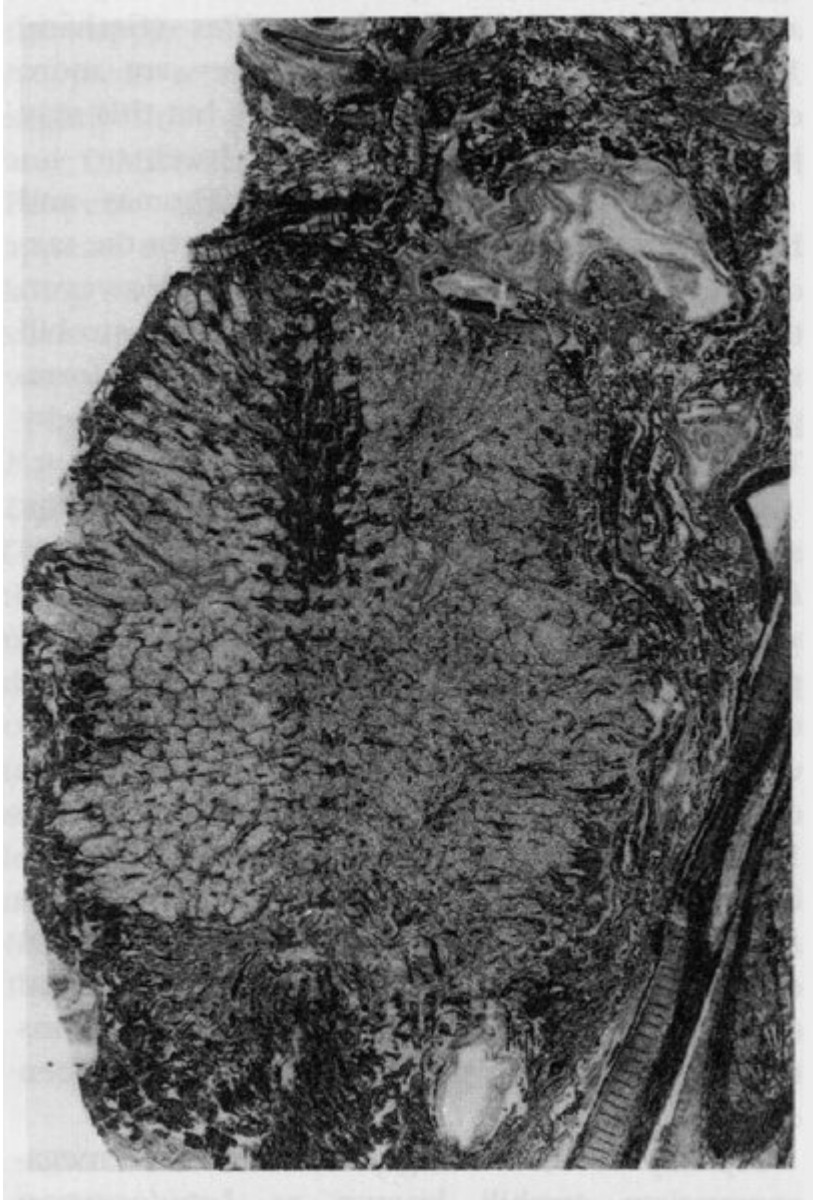




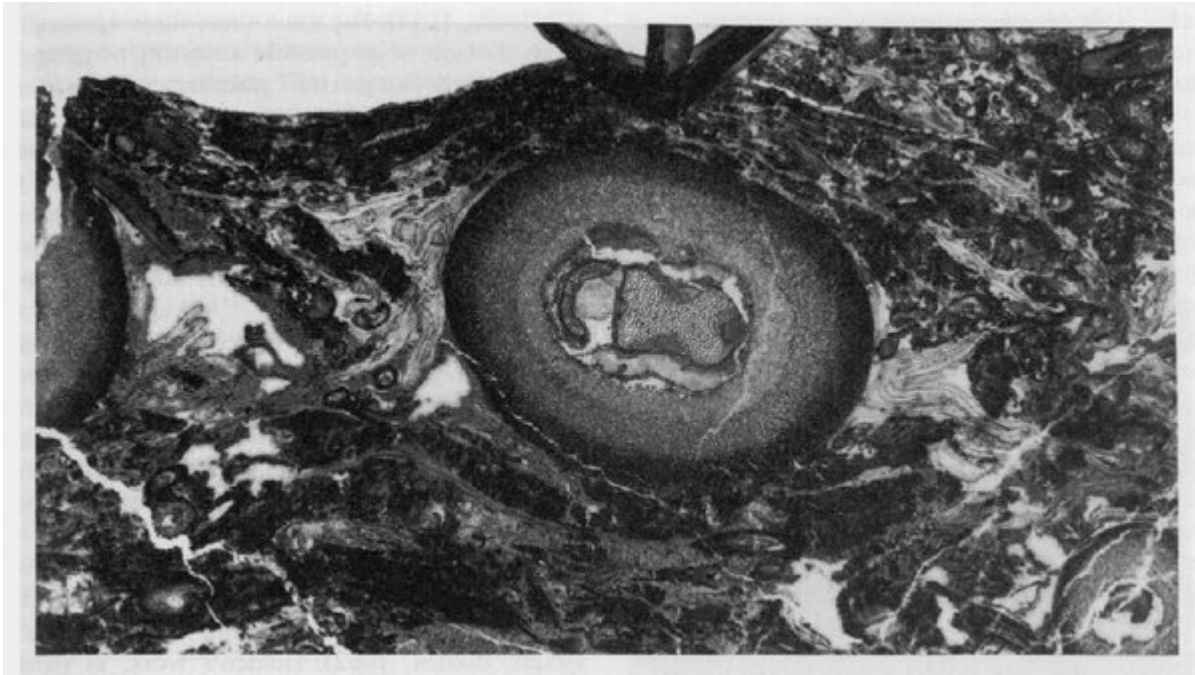
(Figure 5.23) Generalized stratigraphical section at Pettycur. Based on Scott et al. (1984, figure 9).



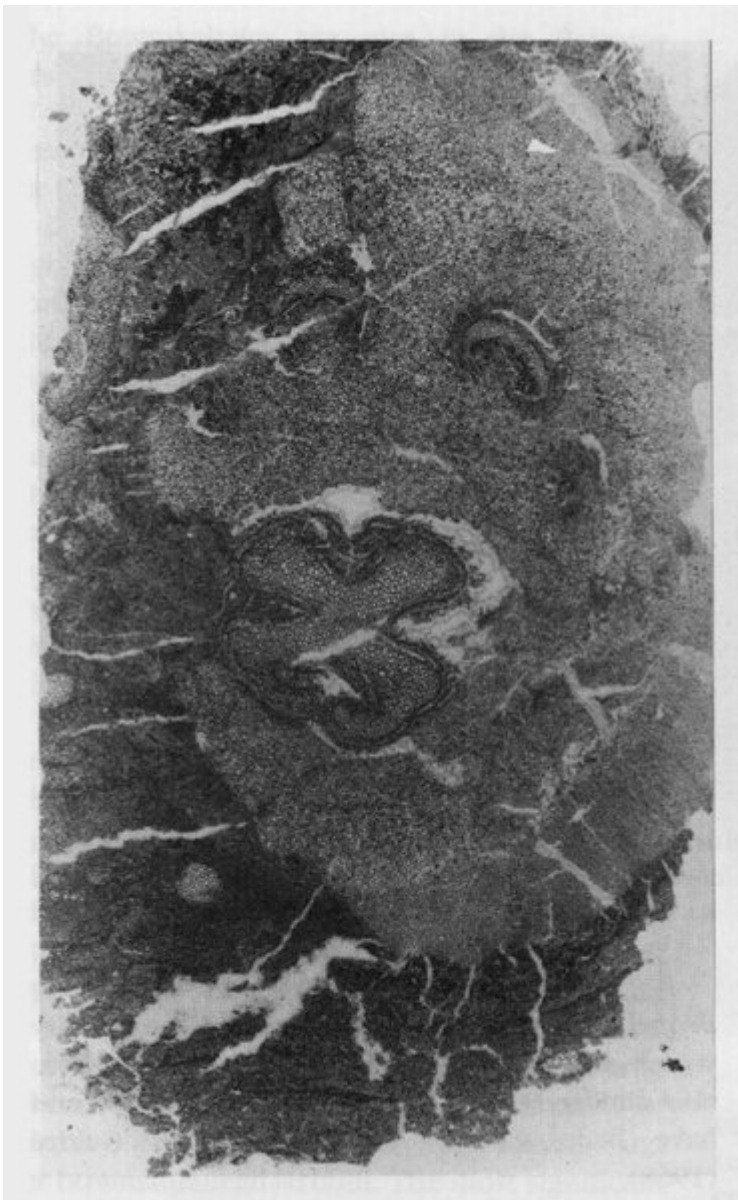
(Figure 5.24) *Paralycopodites brevifolius* (Williamson) DiMichele. Transverse section through lycopsid stem; Natural History Museum, London, specimen WC.502. Pettycur Limestone (Asbian), Pettycur. x 4. (Photo: Photographic Studio, Natural History Museum, London.)



(Figure 5.25) *Cheirostrobis pettycurensis* Scott. Longitudinal section through complex equisetopsid cone showing distribution of sporangia; Natural History Museum, London, SC.3661. Pettycur Limestone (Asbian), Pettycur. x 2. (Photo: Photographic Studio, Natural History Museum, London.)



(Figure 5.26) *Metaclepsydropsis duplex* (Williamson) Bertrand. Transverse section through fern rachis; Natural History Museum, London, specimen WC.223. Pettycur Limestone (Asbian), Pettycur. x 4. (Photo: Photographic Studio, Natural History Museum, London.)



(Figure 5.27) *Diplolabis roemeri* (Solms-Laubach) Bertrand. Transverse section through fern rachis; Natural History Museum, London, specimen GC.789. Pettycur Limestone (Asbian), Pettycur. x 4. (Photo: Photographic Studio, Natural History Museum, London.)