Middridge Quarry

Highlights

Middridge Quarry has yielded the most diverse assemblage of plant fossils from the Upper Permian of Britain. It includes the best British examples of the conifer families Ullmanniaceae and Majonicaceae, and what may be the earliest British example of cycad foliage.

Introduction

The Upper Permian exposures near Bishop Auckland, County Durham, have long been famous for their plant fossils (Sedgwick, 1829; King, 1850; Kirkby and Duff, 1872; Howse, 1890; Stoneley, 1958; Mills and Hull, 1976). Most of the specimens were collected during the nineteenth century from localities which are no longer available. In 1977, however, a new exposure was made at Middridge Quarry, between Bishop Auckland and Newton Aycliffe [NZ 249 252], which allowed Late Permian fossils to be collected in this area for the first time in nearly 100 years (Bell *et al.,* 1979). A useful summary of the palaeobotany of this site is provided by Schweitzer (1986).

Description

Stratigraphy

The geology of this site is described by Bell *et al.* (1979). The 'Basal' Permian Breccia lies unconformably on Langsettian (Upper Carboniferous) sandstones and shales, and is overlain by about 2.5 metres of mainly calcareous siltstones known as the Marl Slate. These are in turn overlain by massive dolomitic limestones of the Lower Magnesian Limestone. The plant fossils occur in the Marl Slate, which here represents a shallow water deposit formed near the margin of the Zechstein Sea. The plant remains were presumably transported into the sea by rivers. The Marl Slate has been interpreted as a lateral equivalent of the Kupferschiefer Formation of Germany, and thus probably belongs to the Kazanian Stage.

Palaeobotany

The plant fossils are preserved as adpressions, often with cuticles still present. The following species have been described to date:

Algae:

Algites virgatus (Munster) Stoneley

Equisetopsida:

Neocalamites mansfeldicus Weigelt

Peltaspermales:

Peltaspermum martinsii (Germar) Poort and Kerp

Cycadopsida(?):

Pseudoctenis middridgensis Stoneley

Pinopsida (?Ginkgoales):

Sphenobaiera digitata (Brongniart) Florin

Pinopsida:

Pseudovoltzia liebeana (Geinitz) Florin

Ullmannia frumentaria (Brongniart) Göppert

U. bronnii Göppert

Uncertain affinities:

'*Neuropteris*' *buttoniana* King

Psygmophyllum cuneifolium (Kutorga) Schimper

Lesleya eckhardtii (Kurtze) Remy and Remy

Plagiozamites middridgensis Schweitzer

Interpretation

A single Middridge specimen was described briefly by Stoneley (1958) as *Algites virgatus.* It shows slender, forking axes originating from a basal patch of carbonized tissue (?holdfast). Two of the axes bear a terminal 'plume-like' structure, although no details were preserved. Similar, albeit smaller, bodies are present in the holotype specimen of the species figured by Munster (1842).

Stems and foliage of the equisetopsid *Neocalamites mansfeldicus* were first recorded from Middridge by Bell *et al.* (1979). Stoneley (1958) recorded examples of similar stems from other localities in north-east England as *Paracalamites kutorgai* (Geinitz) Zalessky, which she regarded as an earlier synonym of *N. mansfeldicus.* However, *P. kutorgai* probably belongs to the equisete family Tchernoviaceae, which is restricted to Angaran assemblages (Meyen, 1971) and would thus not be expected to occur in Britain. As the fructifications of *N mansfeldicus* are unknown, there seems little justification at this stage for combining it in synonymy with this Angaran species.

Both King (1850) and Bell *et al.* (1979) record '*Neuropteris*' *huttoniana* from Middridge, but the specimens have not been illustrated. Stoneley (1958) referred to this taxon as *Mixoneura* sp., but it does not have the broadly attached pinnules seen in the type-species of this form-genus (*Odontopteris subcrenulata* (Rost) Zeiler). Equally, however, it is unlikely to belong to *Neuropteris* (as originally assigned by King, 1850) as interpreted by Cleal *et al.* (1991), since this is mainly restricted to Westphalian assemblages. Stoneley suggested a comparison with *Neurocallipteris neuropteroides* (Göppert) Cleal *et al.,* but that species has never previously been reported from higher than the Lower Permian. Establishing the taxonomic position of this Middridge species will have to wait until larger specimens become available to determine the frond architecture, and also preferably with cuticles preserved.

Although neither Stoneley (1958) nor Townrow (1960) record *Peltaspermum martinsii* from Middridge, it is listed (but not figured) by Bell *et al.* (1979), Schweitzer (1986) and Poort and Kerp (1990).

Another type of foliage was described by Stoneley (1958) as *?Psygmophyllum cuneifolium,* a species belonging to the pteridosperm order Peltaspermales. Although showing some similarities to fragments of cycad frond, they have a more complex architecture, consisting of both sub-dichotomous and pinnate branching. Fragments of cuticles prepared from the Middridge specimens show sunken, cyclocytic stomata not arranged in distinct bands, and thus quite compatible with the epidermal structure usually associated with *Psygmophyllum* (Meyen, 1987). Whether the comparison with *P. cunei-folium,* a species more usually associated with Angaran assemblages, is valid will have to await the discovery of more complete material.

Stoneley (1958) based her description of *Pseudoctenis middridgensis* on a single fragment from Middridge, although Bell *et al.* (1979) report that they have since found additional material. Small fragments of adaxial cuticle prepared from the Stoneley specimen showed simple intercellular flanges (anticlinal walls), which preclude the assignment of the frond fragment to the Bennettitales, and Schweitzer (1986) argued that it probably belonged to the cycads. However, no evidence of abaxial cuticle was found. Consequently the stomatal structure, which is a key feature for recognizing *Pseudoctenis* (Harris, 1964), is unknown. If correctly assigned, it would be the only cycad frond found below the Mesozoic in Britain, although cycad remains have been reported from the Lower Permian of China (Gao and Thomas, 1989).

Sphenobaiera digitata is also listed, but not figured, from here by Stoneley (1958) and Bell *et al.* (1979). None of the Middridge specimens were found to yield cuticles, but Stoneley figures examples from Hilton Beck with sunken stomata surrounded by prominent papillae, of a type normally associated with this species. Stoneley (1958) and Schweitzer (1986) referred the species to the Ginkgoales, following Florin (1936), which would have made it the earliest example of the order known from Britain. In the absence of evidence of its fructifications, its taxonomic position must be regarded as provisional (the 'capsule' from Hilton Beck described by Stoneley is neither attached to *Sphenobaiera* foliage nor does it show any structure).

By far the most abundant plant fossils found at Middridge are conifer twigs, belonging to *Ullmannia* (Ullmanniaceae) and *Pseudovoltzia* (Majonicaceae). These two form-genera are best distinguished by their fertile structures, the epidermal structures being essentially indistinguishable. The naming of the Middridge conifers has relied on the leaf morphology, which must clearly raise some doubt as to the reliability of the identifications.

Pseudovoltzia shoots tend to be extremely heterophyllous, with needle-like leaves anything up to 20 mm long. Although not reported to date from Middridge, the characteristic lobed cone-scales of this group of conifers has been found at other Marl Slate localities, such as Kimberley Railway Cutting (see below). Stoneley (1958) identified all the Marl Slate specimens as *P. liebeana,* the best known species of the form-genus.

The leaves of *Ullmannia frumentaria* (Figure 7.8) are very similar to the above, except that they tend to be laxer and lie more parallel to the stem. Attached to one such shoot, Stoneley (1958) described what may be a female cone, similar in shape to *U. frumentaria* cones reported from Germany (Florin, 1938–1945), although no structure is preserved.

A specimen with smaller, broader leaves was described by Stoneley (1958) as *Ullmannia bronnii,* and further specimens as *Hiltonia rivulii* Stoneley. They were distinguished from *U. bronnii* by the leaves having a rounder apex, a decurrent base and no clearly marked vein. Also mentioned were differences in the thickness of the walls of the subsidiary cells surrounding the stomata. However, Schweitzer (1962) has shown that these differences are not sufficient to justify the separation of the two species, and that they should be regarded as synonymous.

A single problematic specimen was described by Stoneley (1958) as *Taeniopteris eckhardtii* Kurtze. Although fragmentary and without cuticles preserved, it shows a thick mid-vein and simple, straight lateral veins, very similar to the specimens from the Kupferschiefer of Mansfeld in Germany, the type area of this species (Schweitzer, 1968, fig. 4). Remy and Remy (1977) have argued that this type of nervation pattern is more characteristic of the form-genus *Lesleya,* to which they transferred Kurtze's species. The taxonomic position of this species is totally unclear. Schweitzer (1986) argued that it was most likely cycad foliage, but Meyen (1987) regarded at least some *Lesleya* leaves as belonging to the Dicranophyllales, a primitive order of conifer-like plants, that became extinct at the end of the Permian.

Plagiozamites bellii, for which Middridge is the type locality, has been interpreted as shoots with helically arranged leaves up to 90 mm long (Schweitzer, 1986). Although some details of the epidermal structure are known, including stomata, the affinities of the shoots are unclear beyond that they are almost certainly gymnospermous.

Plant fossils are known from a number of exposures of the Marl Slate and its lateral equivalents in northern England (evidence reviewed by Stoneley, 1958). Of these, Middridge Quarry has yielded the most diverse assemblage of abundant plant remains. The nearest comparison is with the Hilton Beck Plant Bed in Cumbria (Murchison and Harkness, 1864; Stoneley, 1958), but that locality has not yielded the *Pseudoctenis, Lesleya, Psygmophyllum, Plagiozamites* or

'*N.europteris*' species found at Middridge. The assemblage from Kimberley Railway Cutting in Nottinghamshire (see below) is also not as diverse as that from Middridge, although it has yielded rather better examples of the peltasperm *Peltaspermum.*

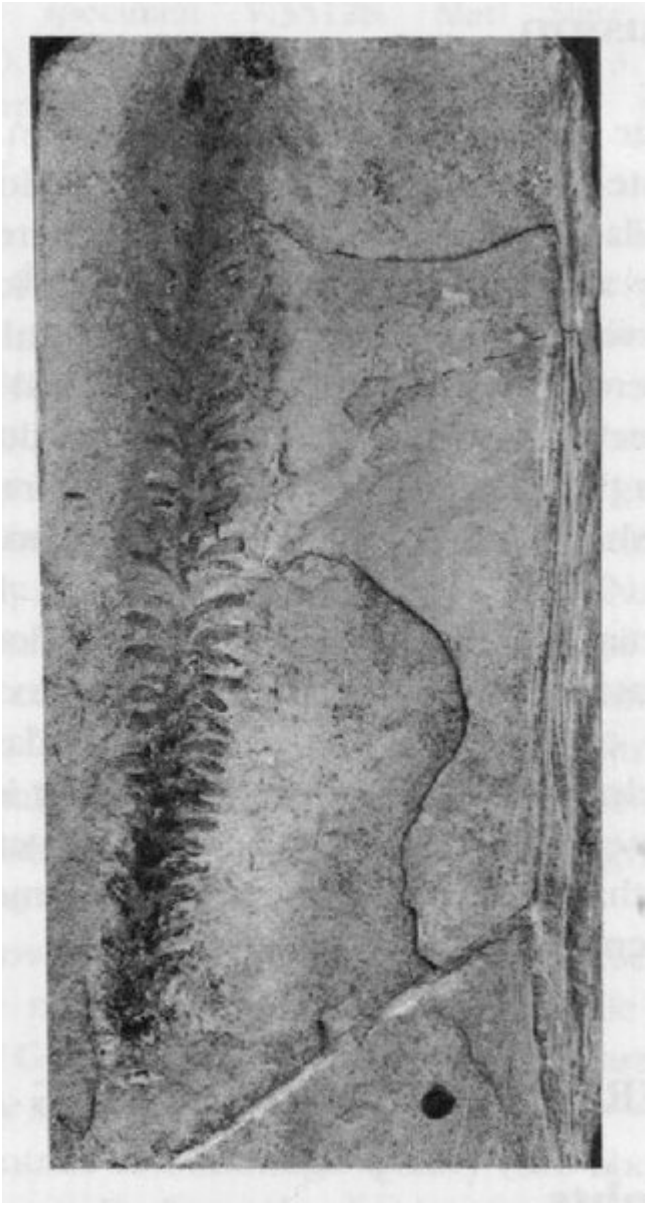
The Marl Slate assemblage belongs to the Atlantic Palaeoarea of Vakhrameev *et al.* (1978) (also called the Zechstein 'flora' by Meyen, 1987), which probably extended throughout present-day Europe, although the fossil evidence is relatively sparse. This is a subdivision of the Europe Palaeokingdom of Cleal and Thomas (*in* Cleal, 1991; see also (Figure 7.2)). The closest comparison outside of Britain is with the flora from the Kupferschiefer of the Lower Rhine, Saxony and Thuringia in Germany (Schweitzer, 1962, 1968, 1986), and Pec (formerly Funfkirchen) in Hungary (Heer, 1876). These continental localities yield most of the species contained in the British assemblages. However, they also include a number of species not found in Britain, such as the conifers *Quadrocladus, Culmitzischia* and *Rhenania.*

The vegetation represented by the Atlantic Palaeoarea is thought to reflect the relatively sparse vegetation growing in semi-arid conditions around the hypersaline Zechstein Sea. It contrasts markedly with the situation further east in the palaeoequatorial belt, such as in China, where the vegetation was dominated by lush, lycopsid-dominated swamp-forests (Li, 1980). This difference in vegetation was probably the result of the collision between the Gondwana and Laurussia continental plates during the very late Carboniferous. The collision would have had its maximum effect in Europe and North America, and the resulting topographical changes there would have caused a marked lowering of the water-table, making conditions unsuitable for the growth of the swamp-forests. China escaped the effects of this orogenic event, however, thus allowing the lycopsid-dominated swamp-forests to persist there.

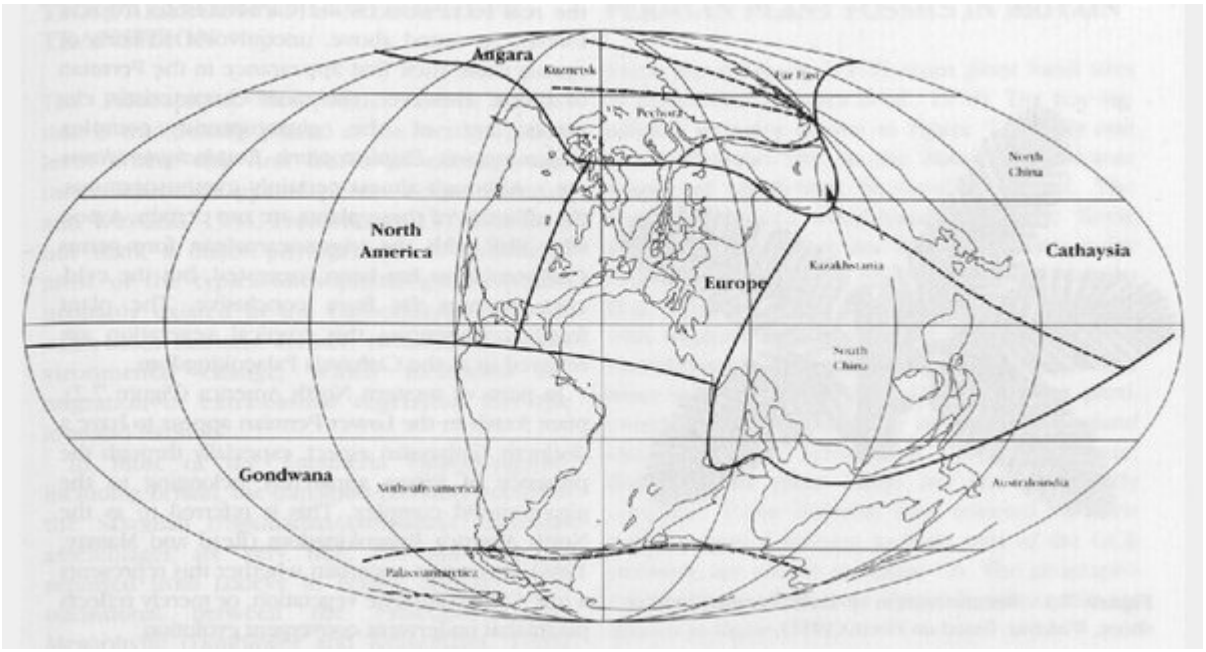
Conclusion

Middridge Quarry is the best site in Britain for fossils of Late Permian plants, about 270 million years old. Similar fossil floras have been reported from Germany and Hungary, and are thought to represent the vegetation surrounding a large, inland sea that covered parts of northern and central Europe — the Zechstein Sea. Conifers are the dominant plants in the flora, mainly preserved as fragments of leafy shoot, but occasionally with reproductive cones. They belong to two families (Ullmanniaceae and Majonicaceae) that flourished in the Late Permian, but then became extinct at the end of the period. Far less abundant, but nevertheless of considerable evolutionary interest, are fragments that may represent early cycads and ginkgos that later, in the Mesozoic, became major components of the vegetation in Britain.

References



(Figure 7.8) Ullmannia frumentaria (Brongniart) Göppert. Conifer shoot; Natural History Museum, London, specimen V.35130. Marl Slate (Upper Permian), Middridge Quarry. x 0.5. (Photo: Photographic Studio, Natural History Museum, London.)



(Figure 7.2) The palaeogeography of the Permian, showing the distribution of the major floristic zones (phytochoria). Based on Scotese and McKerrow (1990) and Cleal and Thomas in Cleal (1991).