Broughton Bank (Hasty Bank)

[NZ 568 035]

Introduction

Broughton Bank (often referred to in the literature as 'Hasty Bank'; (Figure 3.22) and (Figure 3.23)) has yielded an extensive flora of 87 species, and is important for the number of reproductive organs that are associated with the more common shoots and leaves. Cuticles are well preserved here, providing important evidence for linking different plant organs together, which in turn helps in the development of part- or whole-plant reconstructions.

Alum workers first made the exposure at Broughton Bank during the last century, but it was not until the 1920s that Hamshaw Thomas and Maurice Black discovered it to be an important plant fossil locality. It was longer still before Mabel Kendall (1952) published the first record of plant fossils found here, including descriptions of fragments of conifer foliage. Tom Harris was actively collecting from here for some time in the 1940s and 1950s, and some specimens were published by him (Harris, 1950, 1952b, 1953). However, it was not until he published his main series of monographs on the Yorkshire Jurassic floras (Harris, 1961a, 1964, 1969, 1979a; Harris *et al.,* 1974) that he documented any of his finds from here. Hill and van Konijnenburg-van Cittert (1973) and Hill (1974) gave lists of the taxa then known to occur at Broughton Bank. In recent years, van Konijnenburg-van Cittert (1975a,b, 1989, 1996) has carried out research on the flora here, especially on the ferns and their spores. Spicer and Hill (1979) investigated the plant palaeoecology of the site in an attempt to establish what controlled the variations in the composition of the flora across the site.

Description

Stratigraphy

The exposure at Broughton Bank extends over 100 m and is up to 7 m thick. The plant-bearing rocks are at the base of the Saltwick Formation and are, therefore, of early Aalenian age. Here at Broughton Bank the Saltwick Formation was deposited in an eroded depression of the lower Aalenian Dogger Shales.

Harris, in his unpublished notebooks, identified three plant beds here, shown in (Figure 3.24) as A–C. The basal mudstones overlie marine shales containing animal fossils and marine algae, which suggest the region was sometimes flooded by sea water during this period of deposition. Above the mudstones is a siltstone layer that Hill (1974) suggested was the slow part of a river channel. A sandstone-filled erosion channel immediately to the south-east of the siltstone is probably the main river channel. The top dark clay layer is relatively thin and narrow, and lenticular sandstones that form the cliffs at the top of the bank cover the fossiliferous beds.

There is also a leaf coal above the capping sandstone that has yielded abundant plant fragments (mostly cuticles). The flora of this leaf coal includes abundant bennetitaleans, and the conifer *Marskea jurassica* is also present. It is, therefore, rather different from the main Broughton Bank flora below.

Palaeobotany

This locality has a large and important flora of about 90 species (Table 3.1). For seven species, it is the type locality: *Osmundopsis hillii* (Figure 3.25), *Pteroma thomasii, Androstrobus prisma, Hastystrobus muirii, Paracycas cteis, Sphenobaiera gyron* and *Palissya harrisii.*

All the major groups of Yorkshire Jurassic plants, except the lycopsida, have been found here and most are represented by well-preserved specimens yielding good cuticles and/or spores. The most common species are pteridophytes, the *Caytonia* leaf *Sagenopteris colpodes,* cycads and the seed fern *Pachypteris papillosa.* There are only small numbers of bennettites, ginkgos and conifers. Because this is a relatively new locality, very few type species have been described

from it. Harris described his *Cycadites cteis* from here, and van Konijnenburg-van Cittert (1968, 1975a) described both the small cycad cone *Androstrobus major,* and the marattialean fern *Angiopteris blackii,* which has been suggested to be intermediate between older genera and living *Angiopteris.*

Hill (1987) also studied *Angiopteris blackii* from Broughton Bank and showed it to have localized dead areas, most probably caused by a rust fungus. The ferns also showed tilting of sporangia in about one-third of the specimens, which Hill interpreted as being produced by currents acting on the waterlogged, somewhat decayed material, before or during the early stages of burial. Similar post-mortem changes occurred in the related fern *Marattia anglica* (Figure 3.26). Both species are more likely to have been susceptible to post-mortem changes than to have decayed during long-distance transportation.

Van Konijnenburg-van Cittert (1975b, 1989) also used specimens of *Coniopteris murrayana, Dicksonia kendalliae* and *Marattia anglica* from here in her studies of in-situ spores of these species.

Muir (1964) studied the palynology of this locality. She identified four ecological groups of palynomorphs, representing species that were living on the lowland swamps, in the lowlands but not in the swampy areas, in the hinterland, and growing both in the hinterland and in the drier lowland areas.

Interpretation

This is a very rich assemblage of nearly 90 species, with many ferns and cycads, which makes it different from that of the Saltwick Formation on the coast. *Equisetum columnare* occurs *in situ* here, in contrast to its obviously drifted nature at most other localities.

The presence of relatively large and well-preserved pieces of *Pachypteris lanceolata,* in association with the male fructification *Pteroma thomasii,* suggests that they were preserved close to their original position of growth. Harris suggested that *Pachypteris* grew in a salt marsh environment at sea level. The consistent association of *Pachypteris, Cladophlebis harrisii* and the cycad *Nilssonia kendalliae* with the micro-fossils *Tasmanites* and dinoflagellate cysts strengthens this idea and suggests that all were early colonizers of channel banks close to the sea. In contrast, the fragmentary nature of the conifers *Marskea jurassica* and *Bilsdalea dura* suggests that these species lived some distance inland.

As at Roseberry Topping, the pteridosperm leaf *Pachypteris lanceolata* is closely associated here with the pollen organ *Pteroma thomasii* (for which this is the type locality) and both are now usually attributed to the same parent plant (Harris, 1964). Harris (1983) also used specimens from here in his interpretation of *P. papillosa* as a large shrub with succulent young stems, which formed mangrove-like thickets along tidal rivers.

Broughton Bank has also played an important role in the study of Mesozoic cycads. The male cone *Hastystrobus muirii* is as yet known only from two specimens from this site (van Konijnenburg-van Cittert, 1971). It is a small cone, about 20 mm long and 7 mm across, with spirally arranged microphylls whose entire lower surface was probably covered with sporangia. Its pollen compares closely to the common dispersed pollen genus *Eucommiidites troedonii* Erdtman. Pollen referable to this genus have also been found in the micropyles of the gymnosperm seeds *Spermatites* and *Allicospermum.* Van Konijnenburg-van Cittert suggested that *Hastystrobus* belongs to the cycads because this is the only group that has the whole lower surfaces of its micosporophylls covered with sporangia.

Although not as diverse as in some of the other Yorkshire Jurassic sites, there have been some important bennettite discoveries at Broughton Bank. Most notable has been some finely preserved examples of the female flower *Williamsonia hildae,* which have revealed a number of crucial features of the peduncle and the perianth scales (Harris, 1969).

Conifers are also not particularly rich at this site, but it is the best-known locality for *Brachyphyllum crucis.* Harris (1979a) showed that many of these have undamaged apices where the leaves become progressively shorter, suggesting that the shoots had been shed deciduously. There are also good examples of juvenile shoots of *Geinitzia,* suggesting that the

mature tree produced the occasional juvenile shoot, as happens in some modern conifers, such as *Juniperus sabina.* There are abundant shoots of *Elatides thomasii,* sometimes with attached male or female cones. Fragments of *Marskea jurassica* and *Bilsdalea dura* are also found here.

This is the only site where the Yorkshire Jurassic flora has been the subject of a multivariate statistical analysis. Quantitative data on species abundance were analysed by Spicer and Hill (1979) using 'Correspondence Analysis' and 'Principal Component Analysis'. The main component of the pattern of distribution was apparently controlled by lithology, with two main assemblages being recognized.

1. The Siltstone Assemblage characterized by *Marattia anglica, Nilssonnia syllis* and *Nilssoniopteris vittata.*
2. The Claystone Assemblage characterized by *Clathropteris obovata, Cladophlebis harrisii, Nilssonia tenuinervis, Pseudoctenis lanei, Ctenozamites cycadea, Sbhenobaiera gyron, Brachyphyllum crucis, B. mamillare* and *Hirmeriella* sp..

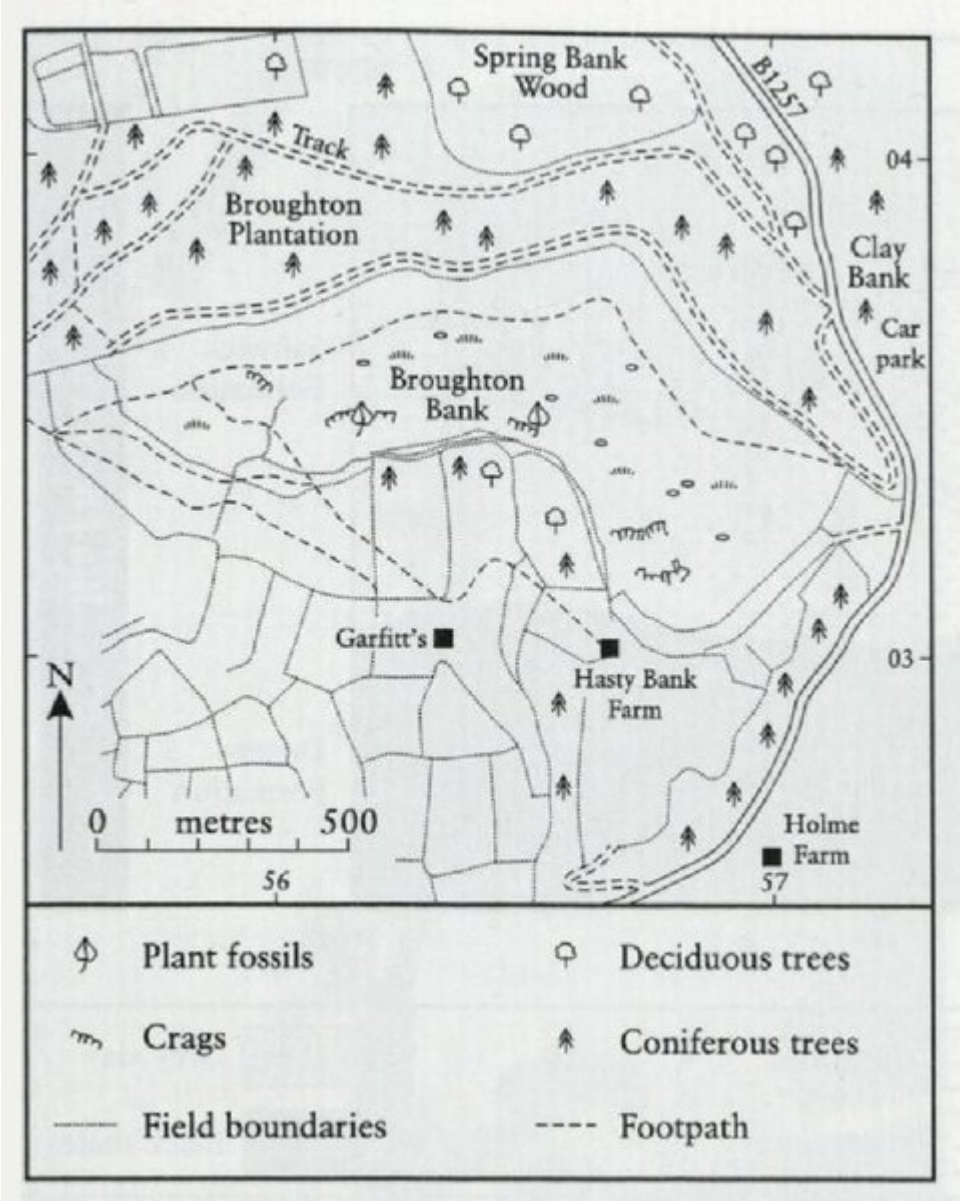
Spicer and Hill also recognized associations between biologically related but physically separated organs. Correspondence Analysis revealed that many of the components of the '*Williamsonia hildae'* plant, as reconstructed by Harris (1969), were found close to one another (i.e. the leaf *Ptilophyllum pectinoides,* the perianth scales *Cycadolepis hypene*, the male flowers *Weltrithia whitbiensis,* and the stem *Bucklandia pustulosa*). Only the female flower (*Williamsonia hildae*) did not occur in this association, but this flower is always rare as a fossil.

In view of the abundance, diversity and fine preservation of the plant fossils found here, it ks perhaps surprising that there has been so little published work on the flora. There is clearly considerable scope for further investigation of this important flora.

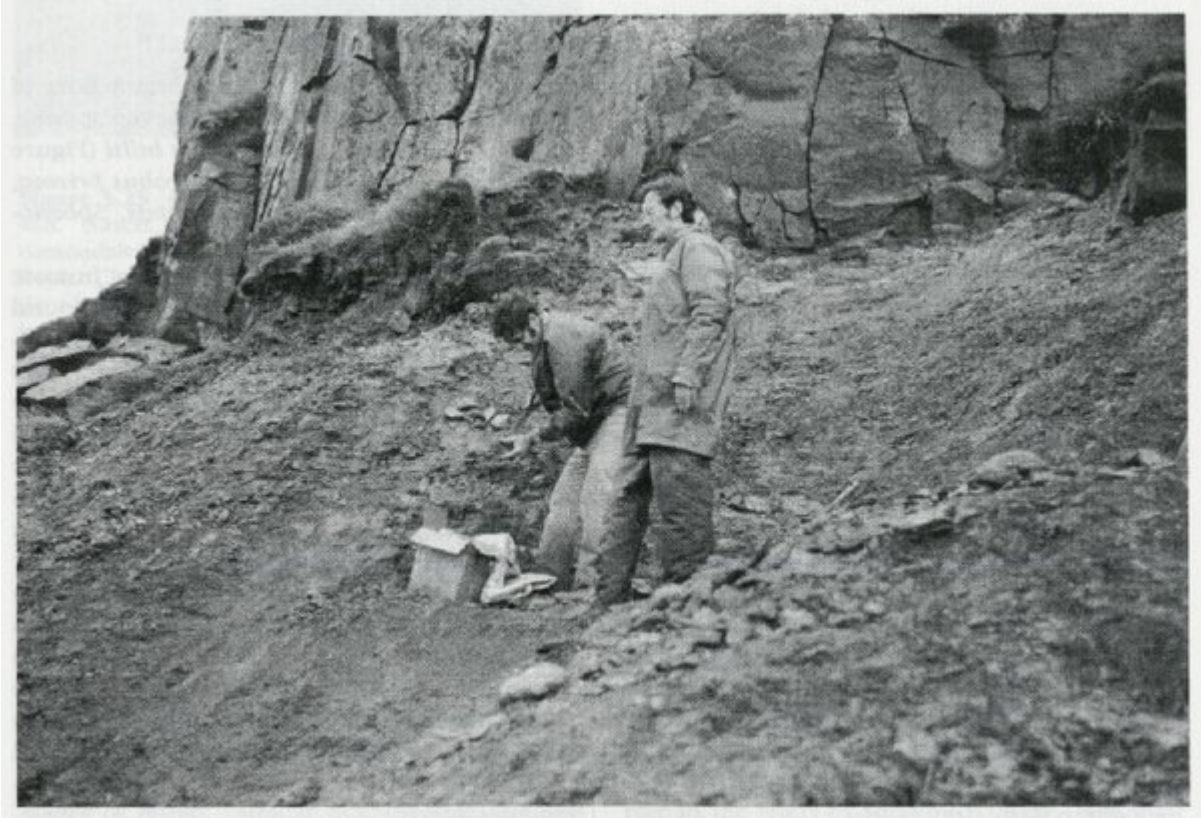
Conclusions

Broughton Bank is an important locality for the Yorkshire Jurassic flora, which has yielded a large number of species of many groups of plant fossils. Cuticles and spores are well preserved, which makes the specimens valuable research material. It has already proved of great importance in the study of fossil cycads and of the extinct group of plants called the corystosperms. It is a site of undoubted potential for helping to improve the understanding of the plant life that was growing in Britain 170 Ma ago.

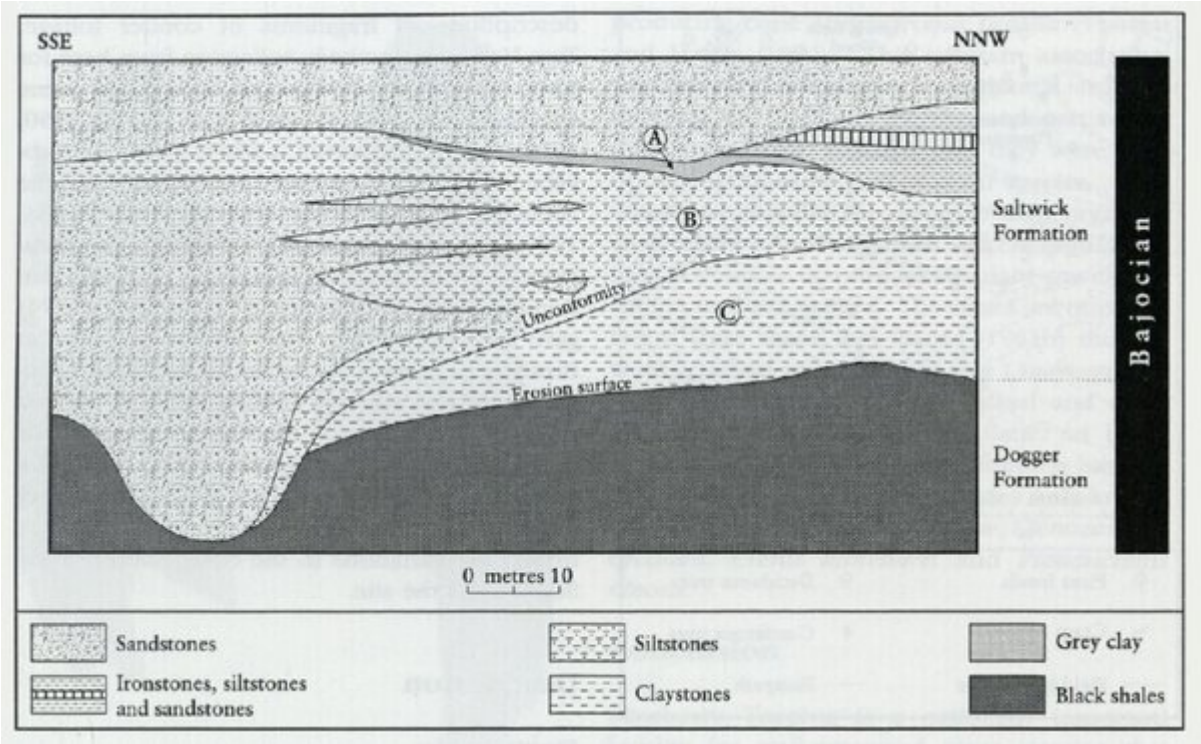
References



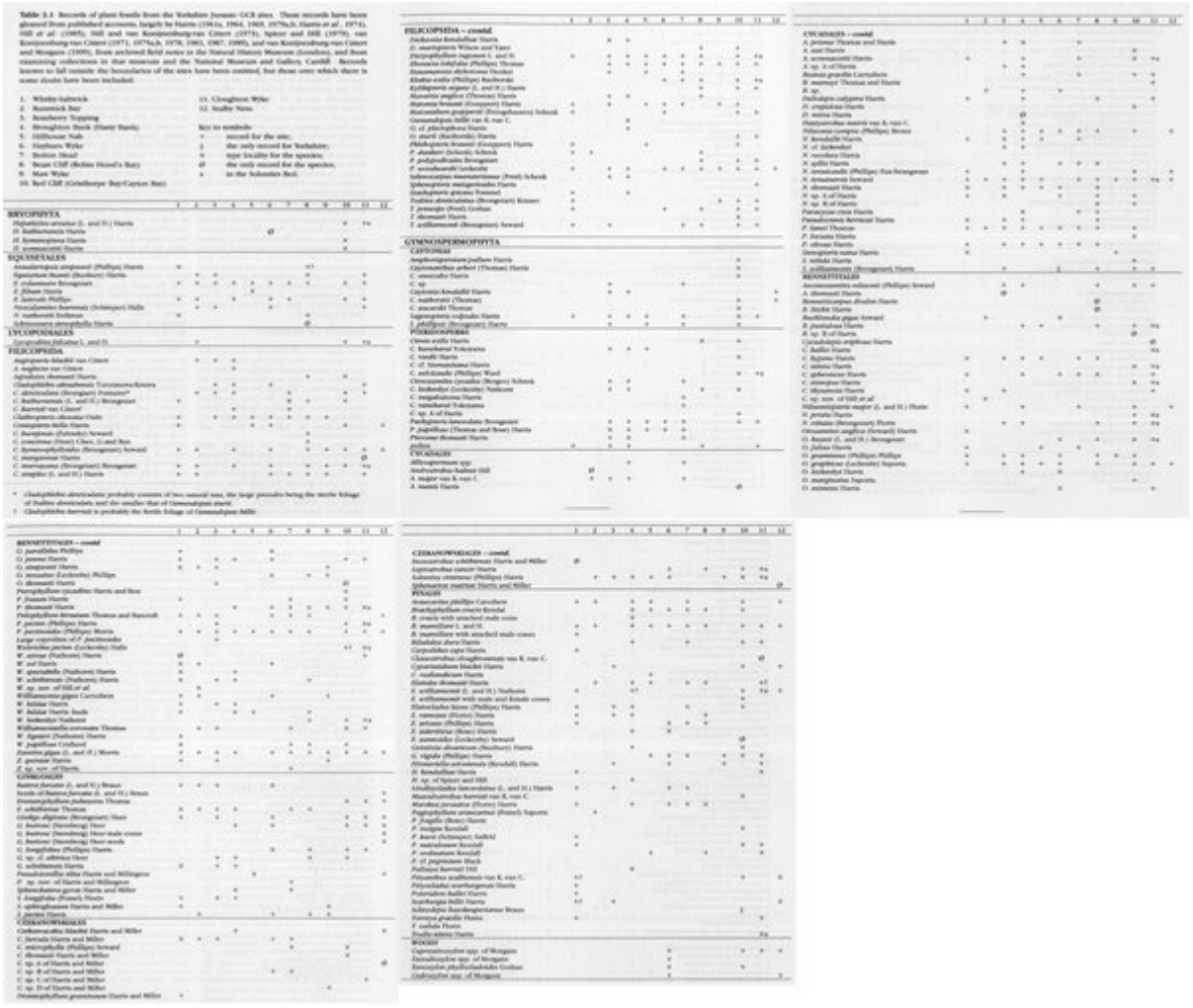
(Figure 3.22) Location of the Broughton Bank GCR site. (After van Konijnenburg-van Cittert and Morgans, 1999.)



(Figure 3.23) Collecting from the plant bed at Broughton Bank. (Photo: J.H.A. van Konijnenburg-van Cittert.)

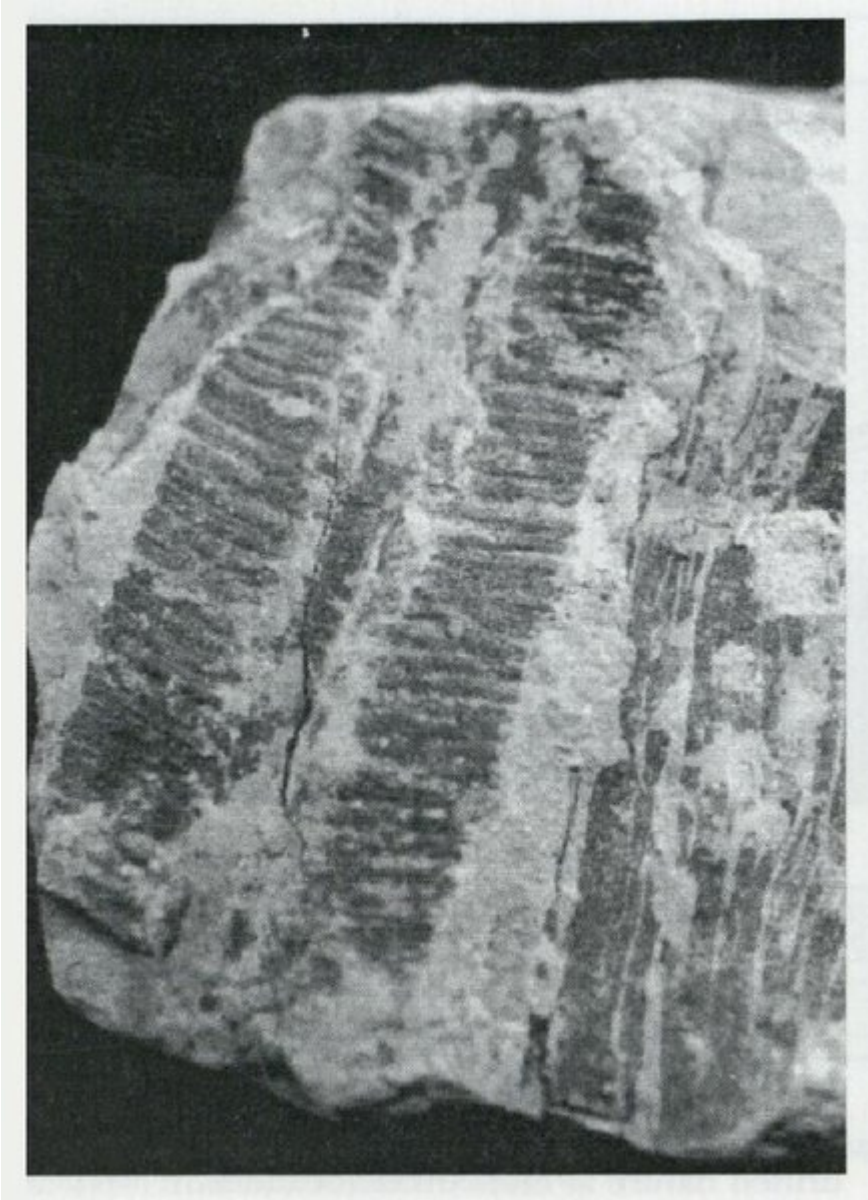


(Figure 3.24) Schematic section of the exposure at Broughton Bank, showing the three main plants beds (A–C). Redrawn from Spicer and Hill (1979).



(Table 3.1) Records of plant fossils from the Yorkshire Jurassic GCR sites. These records have been gleaned from published accounts, largely by Harris (1961a, 1964, 1969, 1979a,b; Harris et al., 1974), Hill et al. (1985), Hill and van Konijnenburg-van Cittert (1973), Spicer and Hill (1979), van Konijnenburg-van Cittert (1971, 1975a,b, 1978, 1981, 1987, 1989), and van Konijnenburg-van Cittert and Morgans (1999), from archived field notes in the Natural History Museum (London), and from examining collections in that museum and the National Museum and Gallery Cardiff. Records known to fall outside the boundaries of the sites have been omitted, but those over which there is some doubt have been included.

(Figure 3.25) Osmundopsis hillii van Konijnenburg-van Cittert. This exceptionally rare fertile osmundalean fern is known only from Broughton Bank. Clusters of sporangia replace the normal sterile segments of the fern, which when found are known as Cladophlebis harrisii van Cittert. Natural History Museum, London, specimen V60955, Saltwick Formation, Broughton Bank, × 7.2. (From van Konijnenburg-van Cittert and Morgans, 1999; photo: J.H.A. van Konijnenburg-van Cittert.)



(Figure 3.26) Marattia anglica (Thomas) Harris. Pinnae and leaf fragments of this Marattiaceae fern are quite common at Broughton Bank, although a complete leaf has yet to be found. Pinnae can reach 300 mm in length and 15–25 mm in width and have entire margins. Veins depart perpendicularly from the midrib at about 10–12 per 10 mm. More than half the specimens found at Broughton Bank are fertile like the one illustrated here. The elongated synangia (fused clusters of sporangia) are about 5–7 mm across. Laboratory of Palaeobotany and Palynology, Utrecht, specimen S.2703, Saltwick Formation, Broughton Bank, × 1.8. (From van Konijnenburg-van Cittert and Morgans, 1999; photo: J.H.A. van Konijnenburg-van Cittert.)