Brora

[NC 896 029]–[NC 904 033]

Introduction

The coastal exposures at Brora are of Bathonian age. They yield a well-preserved, but fragmentary, flora of at least 12 species that is of considerable research potential.

The Brora region was referred to by geologists even before Murchison (1827) because of the economic importance of workable coal and building stone. Coal extraction began here in 1529 and the first pit was sunk in 1598. Since then, coal has been mined periodically until the last pit closed in 1974 (Owen, 1995). Plant fossils were first described by Konig in Murchison (1827) and Nicol (1844), and then by Judd (1873) in his memoir on the secondary rocks of Scotland. However, only *Equisetites columnaris* was named. The assemblage was not described in detail until Stopes (1907) revisited the site. The most recent contribution was by Harris and Rest (1966) who examined cuticle fragments macerated from the coal.

Description

Stratigraphy

The beds exposed at Brora range from Bathonian to Callovian in age, although the palaeobotanical interest is limited to the Brora Coal Formation (named by Neves and Selley, 1975), which is Bathonian in age (Figure 5.3). Hurst (1981) later divided the formation into the Doll Member with its fluvial succession of channel sandstones and floodplain mudstones, and the overlying Inverbrora Member of dark shales with thin coals, bituminous shales and some shell beds of lagoonal origin. The lagoonal area is thought to have extended parallel to the Helmsdale Fault system and was probably invaded periodically by the sea from the north-east (Trewin, 1993). The recovery of the dinoflagellate cyst *Tubotuberella* cf. *dangeardii* Sarjeant in the topmost shell bed has permitted the whole of the Brora Coal Formation to be dated as Bathonian, with the boundary between it and the overlying Callovian being placed at the roof of the coal. The exposure comprises the only rocks that can be compared closely, with regard to sedimentology and palynofacies, to the economically important sedimentary rocks in the Moray Firth and further into the North Sea.

Palaeobotany

The plants are drifted fragments found in association with the fresh-brackish water crustacean *Euestheria.* Stopes recorded the following species:

Equisetales: *Equisetites beanii* Bunbury, *Equisetites broraensis* Stopes, *Equisetum columnaris* Brongniart (Harris)

Filicales: *Coniopteris hymenophylloides* Brongniart, *Coniopteris quinqeloba* Phillips, *Todites williamsonii* Brongniart, *Cladophlebis denticulata* Brongniart, *Dictyophyllum* sp.

Cycadales: *Zamites* sp.

Bennettitales: *Otozamites* sp.

Ginkgoales: *Ginkgo digitata* Brongniart

Pinales: *Cheirolepis* sp.

Interpretation

The Bathonian assemblage at Brora is the youngest Jurassic flora in the area. No detailed assessment of the plants has been made for 90 years so the site has, therefore, considerable research potential.

The assemblage is very similar in composition to those of some sites in the Yorkshire Jurassic succession. It is dominated by pteridophytes and contains very few gymnosperms. This suggests that it largely represents vegetation growing fairly close to the site of deposition, most probably in a freshwater swamp. There is no seat earth below the coal, which led Trewin (1993) to infer that the coal formation was initiated by plant material that drifted into a lagoon too deep to allow plants to root. Stopes counted the individuals of each species and deduced from this that *Equisetum columnaris* and *Ginkgo digitata* were the most numerous of the plants. This, however, tells us very little about the original vegetation other than that *Equisetum columnaris* probably grew in quantity close to the area of deposition. The larger, but less perfectly known, *Equisetites beanii* is a distinct species that is never found mixed with *E. columnaris.* It must have grown away from the edges of the watercourses that fed the area of sedimentation. Stopes described *Equisetum brorarensis* (as it is preferably named) from small round discs representing nodal diaphragms dispersed from the disintegrating stems. Their size distinguishes them from the other two species. They may represent the remains of plants growing some distance from the area of sedimentation.

The *Ginkgo* leaves are the best-preserved fossils in this assemblage and agree entirely with those found in Yorkshire. Most are deeply bilobed although Stopes found one or two small unlobed leaves. She prepared cuticles from these leaves and showed that the stomata are confined to the lower surfaces. Harris *et al.* (1974) took a different view and suggested that the leaves are very similar in form and epidermal structure to his *Sbhenobaiera* Byron from Broughton (Hasty) Bank.

Most of the plant remains are poorly preserved, suggesting that they had been transported to the site of deposition. *Ginkgo* leaves do not decay rapidly and appear to fossilize well, so they could also have been blown, or washed, in, from quite a distance. The comparatively few specimens of *Zamites* and *Otozamites* again suggest that they came from some distance away.

The Brora coal does not crop out on the beach, but a study of it does have a bearing on our understanding of the flora growing in the area at that time. Harris and Rest (1966) macerated coal from the Brora mine that was still operative at the time. They found the most abundant plant material to be fusainized conifer wood, which must have been washed down after forest fires to become deposited in a moderately deep lagoon. Most of the coal was formed from such wood. Anaerobic conditions would have prevailed, allowing the debris to build up. Rootlets from a dirt band within the coal suggest that swamp conditions subsequently spread over the lagoon, leading to the accumulation of plant debris that included *Equisetum.* There were also small fragments of the bennettitalean *Pterophyllum cycadites,* which probably grew on the banks of rivers. The other species, found only occasionally, were most probably carried down greater distances by rivers. Harris and Rest listed the following plants from the coal: stem cuticles of *Equisetum* cf. *columnare, E.* cf. *laterale* and *E.* sp. indet.; pteridophyte wood as fusain; leaf fragments of the cycad *Pterophyllum cycadites* Harris and Rest (also found in the Yorkshire Jurassic succession; see (Table 3.1)); *Czekanowskia* sp. indet.; conifer wood of many kinds as fusain; and leaf cuticles of the conifer *Farndalea fragilis* Bose. This last species is perhaps the most widespread of all the Yorkshire Jurassic plants, being always present as scattered fragments in bulk maceration of rock. However, it has never been found as a recognizable hand specimen, suggesting that it must have grown on land either far up river or away from water courses, being washed down only in times of flood and deposited as scattered and finely broken fragments. This species can almost certainly be found in the rocks exposed on the beach.

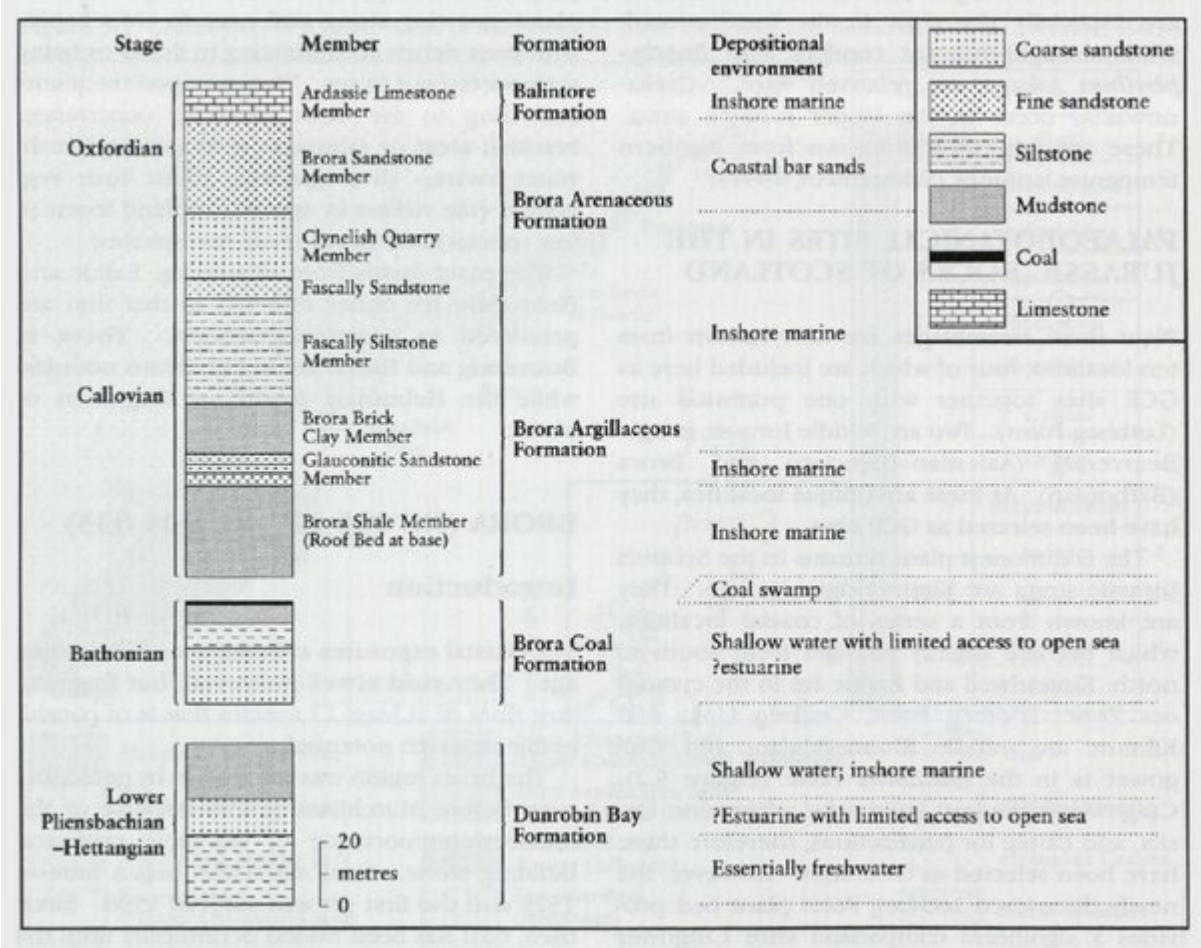
Harris and Rest also reported 'fibrous brown sacs'. Manum *et at.* (1991) have interpreted similar sacs as reproductive cocoons of annelid worms.

They also gave brief descriptions of several megaspores identified by W.G. Chaloner. The currently accepted names (Batten and Kovach, 1990) are as follows: *Minerisporites richardsonii* (Murray) Potonié emend. Harris, *Paxillitriletes phyllicus* (Murray) Hall and Nicolson, *Bacutriletes corynactis* (Harris) Marcinkiewicz, and *Triletes murrayi* Harris. These megaspores might easily be recovered from rocks exposed on the beach.

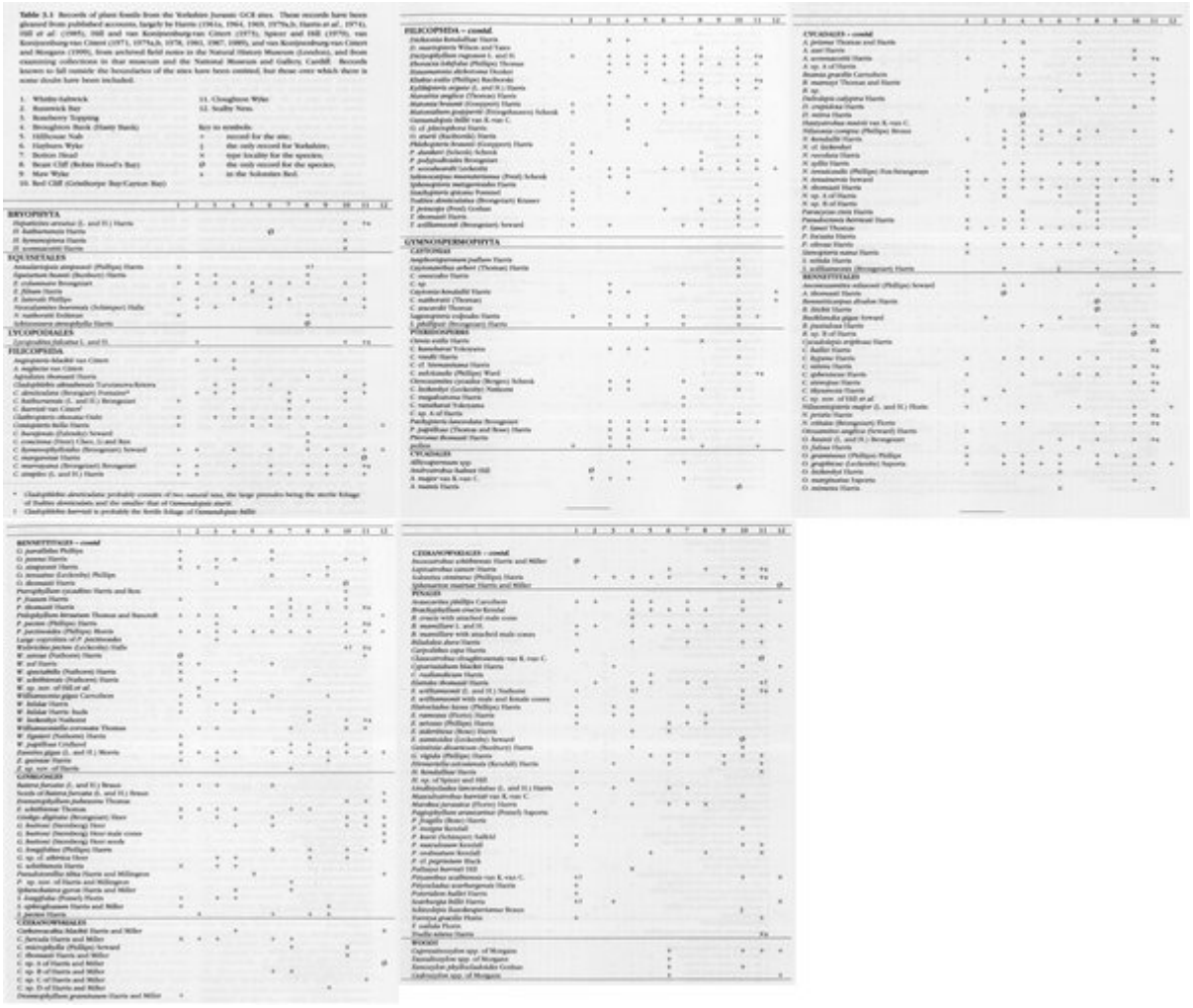
Conclusion

The Bathonian assemblage at Brora is the youngest Jurassic flora in the Moray Forth Basin. Although small, it has many similarities with those of the Yorkshire Jurassic succession. It is a nationally important site of great potential research value.

References



(Figure 5.3) Generalized sequence of Jurassic strata in the Brora outlier. (After Lam and Porter, 1977.)



(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.