Chapter 9 Late middle Eocene–early Oligocene (Bartonian–Rupelian) and Miocene palaeobotany of Great Britain

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Introduction

This final chapter deals with the British sites yielding plant macrofossils of mainly late Eocene and younger age (i.e. post-Lutetian). It was a time of marked change in British vegetation as the climate cooled from the thermal maximum of early Eocene times. In southern Britain, where the bulk of the macrofossil record occurs, there was also a change from the mangrove and forests that dominated the Ypresian and Lutetian, to marshland. The excellent exposures of the middle and late Palaeogene deposits in southern Britain provide one of the most complete records of changing vegetation during this crucial time and make it an area of international importance for palaeobotanical studies.

Nearly all of the sites described here are Palaeogene in age and, together with the southern British sites dealt with in the previous chapter, form a coherent network. Included in this chapter, however, is a description of the sole GCR representative of the palaeobotany of the Brassington Formation, Bees Nest, in Derbyshire. It is the only known British locality for Neogene plant macrofossils. The conifer-dominated vegetation preserved at this last site seems to indicate far cooler conditions than seen at the Palaeogene sites and represents an intermediate between the more typical paratropical vegetation of early Palaeogene times and the vegetation of today.

History of research

There has not been the long history of research on these floras that there has been on the early and middle Eocene floras dealt with in the previous chapter, especially those from the London Clay. The earliest reports of plant macrofossils from the later Eocene and Oligocene deposits of southern Britain date from the middle to late 19th century. Two sites attracted most interest during these early years; the exposures of lower Headon Hill Formation at Hordle Cliffs, and the exposures of Bembridge Marls at Thorness and Gurnard Bay. They were first investigated in detail by Starkie Gardner, who included descriptions of some of the fossils in his monographs on Palaeogene ferns and conifers (Gardner and von Ettingshausen, 1879–1882; Gardner 18831886a). However, Gardner did not complete or publish his work on the angiosperm fruits and seeds, which form the bulk of these floras.

Also working on the Bembridge Marls sites was a local amateur geologist, James A'Court Smith, who accumulated a large assemblage of both plant and animal (especially insect) fossils from these strata during the mid-19th century. These eventually found their way to the British Museum (Natural History) in London, where they were published in the first comprehensive review of the flora as a catalogue of the collection (Chandler, 1925–1926). During the early 20th century, the Hordle flora was investigated by Clement Reid. He was a geologist with the British Geological Survey, who had spent much time mapping the Tertiary deposits of southern England, and in the process had accumulated a large collection of plant fossils. However, his premature death in 1916 meant that he published little of the results of this work, other than a study on the charophytes (Reid and Groves, 1921). Describing the bulk of his collection fell to his wife Eleanor, who published a monograph with her student Marjorie Chandler (Reid and Chandler, 1926).

Interest in these later Eocene and Oligocene floras then went into decline, as the far more diverse London Clay flora drew the attention of British Tertiary palaeobotanists, especially Chandler (see previous chapter). Nevertheless, Chandler continued to collect and study these younger floras, both at the two well-known sites and at other sites along the coast of southern England. The fossils mostly went to the British Museum (Natural History) and it was through that institution that Chandler published a series of definitive monographs that dealt largely with the post-Lutetian floras (Chandler, 1961a, 1962, 1963b, 1964; a fourth supplement was published posthumously — Chandler, 1978). There were also numerous shorter papers in the *Bulletin of the British Museum (Natural History*), dealing with particular taxa and some of the smaller floras (Chandler, 1955, 1960, 1961b, 1961c, 1963a).

Subsequent work on these floras has been mainly by Margaret Collinson. Following the completion of a doctorate thesis (Collinson, 1978a), a number of papers were published dealing with the taxonomy of some of the plant fossils found here, especially of the aquatic plants that dominate the stratigraphically higher floras (Collinson, 1978b, 1980a,b, 1982a, 1983a; see also Fowler, 1975). The palaeoecology of these floras was studied by a detailed examination of the relationship between the provenance of the fossils and the sedimentology (Collinson, 1983a, 1996b; Collinson *et al.,* 1993a; Hooker *et al.,* 1995). From this work came a model of vegetation change occurring in southern Britain during middle and late Palaeogene times (Collinson *et al.,* 1981; Collinson and Hooker, 1987; Collinson, 1990b).

In addition to the sites covered in this chapter, a notable post-Lutetian flora has been reported from the Oligocene Bovey Tracey lignites in Devon (Heer, 1862; Chandler, 1957). This material was obtained from ball-clay workings that are no longer active. There have been other temporary workings in this area that have yielded sometimes well-preserved floras and it is always worth monitoring such sites for evidence of this important flora. There are also numerous post-Lutetian palynological sites in the Britain, many reviewed by Boulter (in Curry *et al.,* 1978) but these lie outside of the scope of this volume.

Knowledge of the Neogene vegetation of Britain has only really come to light in recent years. The only notable macrofossils of this age, from Derbyshire, were discovered following work by the British Geological Survey (Chaloner, 1961) and have been the subject of detailed description by Boulter (1969, 1970, 1971a,b, 1974) and Boulter and Chaloner (1970). The only other Neogene macrofloras were reported by Reid (1920b) from possible Pliocene fissure deposits from County Durham, although West (1968) considers them to be Pleistocene in age.

Palaeogeographical setting

The geography of the post-Lutetian world did not differ significantly from that of early Eocene times. However, there was no longer a land bridge linking North America with Europe, and the vegetation of the two continents thus became further differentiated.

The palaeogeography of post-Lutetian Britain is summarized by Murray (1992) (Figure 9.1). Britain was joined to the rest of Europe at intervals during the Tertiary via the Weald–Artois High, which extended from Kent to Belgium. There was nevertheless a broad inlet from the Atlantic extending approximately along the present-day English Channel, up to the Weald–Artois High. However, this palaeo-English Channel progressively shallowed and narrowed through middle Eocene to Oligocene times, and by the latest part of this interval there was no sedimentation taking place in areas currently occupied by land and therefore there are no land outcrops of strata of this age along the south coast of Britain.

British post-Lutetian plant-bearing deposits occur mainly in the Hampshire Basin, which was an embayment on the southern coast of England. In the London Basin, the London Clay is overlain by marine Virginia Water Formation ('Bagshot Sands'), which have yielded practically no plant macrofossils. During middle Eocene times, the Hampshire Basin was under a shallow sea, but as the palaeo-English Channel shallowed, it became filled by fluvio-deltaic sediments. The post-Lutetian geological history of the Hampshire Basin was thus one of a change from shallow-marine, to marsh, to fully terrestrial conditions.

Our knowledge of conditions in inland Britain is very limited. However, recent work on various examples of so-called 'pocket deposits' (e.g. the Brassington Formation at the Bees Nest GCR site) suggests that there was a fairly flat topography over much of England and Wales, varying in altitude by only a few tens of metres (M.C. Boulter, pers. comm.).

Stratigraphical background

The post-Lutetian deposits of the Hampshire Basin is characterized by marked lateral variation in facies, which has resulted in much confusion over the lithostratigraphical nomenclature. Since lithostratigraphy is not the main concern of this volume, we have merely attempted to remain consistent with the nomenclature used in the Tertiary stratigraphy GCR volume (Daley in Daley and Balson, 1999). In this scheme, the post-Lutetian deposits are divided into a shallow to

marginal-marine Barton Group and a brackish to non-marine Solent Group. These groups are subdivided into a number of formations and in some cases members, which are summarized in (Figure 9.2).

The Barton Group is middle Eocene in age, while the Solent Group is late Eocene to early Oligocene in age. The recognition of the Eocene–Oligiocene boundary has been the subject of much dispute (e.g. see review by Curry *et al.,* 1978, and Daley in Daley and Balson, 1999). This has been compounded by the problems of trying to identify the boundary (defined on the extinction of hantkeninid foraminifera) in the Hampshire Basin, which by that time had become non-marine. The hantkeninid extinction, and therefore the boundary, occurs within nannoplankton zone NP21. There is a record of NP19/20 in the Colwell Bay Member of the Headon Hill Formation, in Hampshire, implying that the boundary must be significantly higher (Collinson, 1992; Hooker, 1992). The Grimmertingen Sand (with NP21) is often correlated (as a transgression) with the Bembridge Oyster Bed on the Isle of Wight (base Bembridge Marls Member, Bouldnor Formation) (Hooker, 1992). The *Nematura* Band (low in the overlying Hamstead Member of the Bouldnor Formation at Hamstead, Isle of Wight) has been correlated with the *Argik Verte de Romainville* in the Paris Basin (with zone NP22) by means of dinoflagellates by Liengjaren *et al.* (1980) (see Collinson, 1992; Hooker, 1992). Zone MP21, post-Grande *Coupure* Oligocene mammals occur above the *Nematura* Band on the Isle of Wight (Hooker, 1992). A fluctuation in pollen floras, interpreted as indicative of cooling, occurs in the Paris Basin in strata that correlate with the upper Bembridge Marls and lower Hamstead Member; climatic cooling is documented in the marine realm above the hantkeninid extinction (Collinson, 1992, p. 441). Taken together, this information suggests that the boundary is low in the Bouldnor Formation in the English sequence (Collinson, 1992; Hooker, 1992). This means that the Bembridge Marls Member and the Hamstead Member below the *Nematura* Band should be treated as Eocene–Oligocene transitional strata until correlations can be refined. It is possible that the boundary could be lower in the sequence but this is judged highly improbable (Collinson, 1992; Hooker, 1992) and the Bembridge Limestone Formation is here treated as Eocene in age, as in Collinson *et al.* (1993a), Hooker *et* al. (1995) and Collinson and Hooker (2000).

The Neogene 'pocket deposits' of central and northern England are all assigned to the Brassington Formation, although they do not now form a continuous sedimentary unit and thus are arguably not a mappable lithostratigraphical unit in the strict sense.

Post-Lutetian vegetation

The same major phytochoria recognized in the early Eocene strata (see previous chapter) are also present in the late Eocene and early Oligocene successions: the Holarctic, Tropical, Notal and Australian Palaeokingdoms (Akhmetyev, 1987). Southern England is in the Tethyan Palaeoarea of the Holarctic Palaeokingdom, which can be recognized over southern North America, central and southern Europe, Central Asia and Kazakhstan. However, unlike early Eocene times, there was no longer a land bridge between North America and the rest of the Tethyan Palaeoarea and consequently its fossil floras are assigned to their own palaeo-province.

During late Eocene times, marked changes appear in both the plant macrofossil and palynological record (Collinson *et al.,* 1981; Collinson and Hooker, 1987; Collinson, 1990b, 1992, 1996b). The *Nypa* palm and associated mangrove elements disappear, as does '*Scirpus*' *lakensis* (Collinson, 1996b, 2000a) and there is a progressive decline in the proportion of species indicating paratropical rain forest conditions. Instead, the plant fossil record consists mainly of the remains of aquatic and marginal aquatic vegetation such as bullrushes, leather ferns, pondweeds, water lilies, water ferns and water soldiers with rarer taxodiaceous conifers. This floral change is independent of facies change, as brackish facies (including oyster beds) and fluvio-lacustrine facies are present throughout the Palaeogene Period in southern England (Collinson, 1990b, 1996b, 2000a).

Concentrating on the aquatic plants, Collinson *et al.* (1981) were able to recognize clear vegetational changes during the second half of the Eocene Epoch, in response to climatic cooling, further supported by later work on all floral elements and mammalian faunas (Collinson and Hooker, 1987; Collinson, 1990b, 1992, 1996b, 2000a). In some parts of the British late Eocene succession there is evidence of vegetation reminiscent of the cypress swamps of North America, such as in the Headon Hill Formation at Hordle Cliffs. The dominant floral associations of the Bembridge Limestone and the Bembridge Marls (Collinson, 1983a, 1990b; Collinson and Hooker, 1987; Collinson *et al.,* 1993a), including the

bulrush–leather ferns, are also typical of the south-eastern USA today. This indicates cooler conditions than in early Eocene times, i.e. subtropical rather than tropical.

Undoubted Oligocene floras are poorly represented in Britain. Elsewhere in Europe, a change in the vegetation from evergreen subtropical to mixed evergreen and deciduous has been identified between the late Eocene and early Oligocene strata (Collinson, 1992) but the wetland vegetation in southern England was apparently little affected across the boundary (Collinson and Hooker, 1987; Collinson, 1990b, 1992). A palynological study by Machin (1971) suggested a change to vegetation favouring more temperate conditions, but Collinson (1992) concluded that the changes in Britain merely represented the culmination of those commencing in early Late Eocene times.

The limited available macrofossil evidence of British Neogene vegetation suggests it was a mixture of mainly ericaeous heaths and forests dominated by conifers, such as *Cryptomeria.* However, the palynology suggests that many angiosperms were also present in these forests and that nearly one-third belong to genera that are today restricted to tropical or subtropical environments (Boulter, 1971a,c). Thus, even towards the end of the Neogene Period, conditions were significantly warmer than they are today.

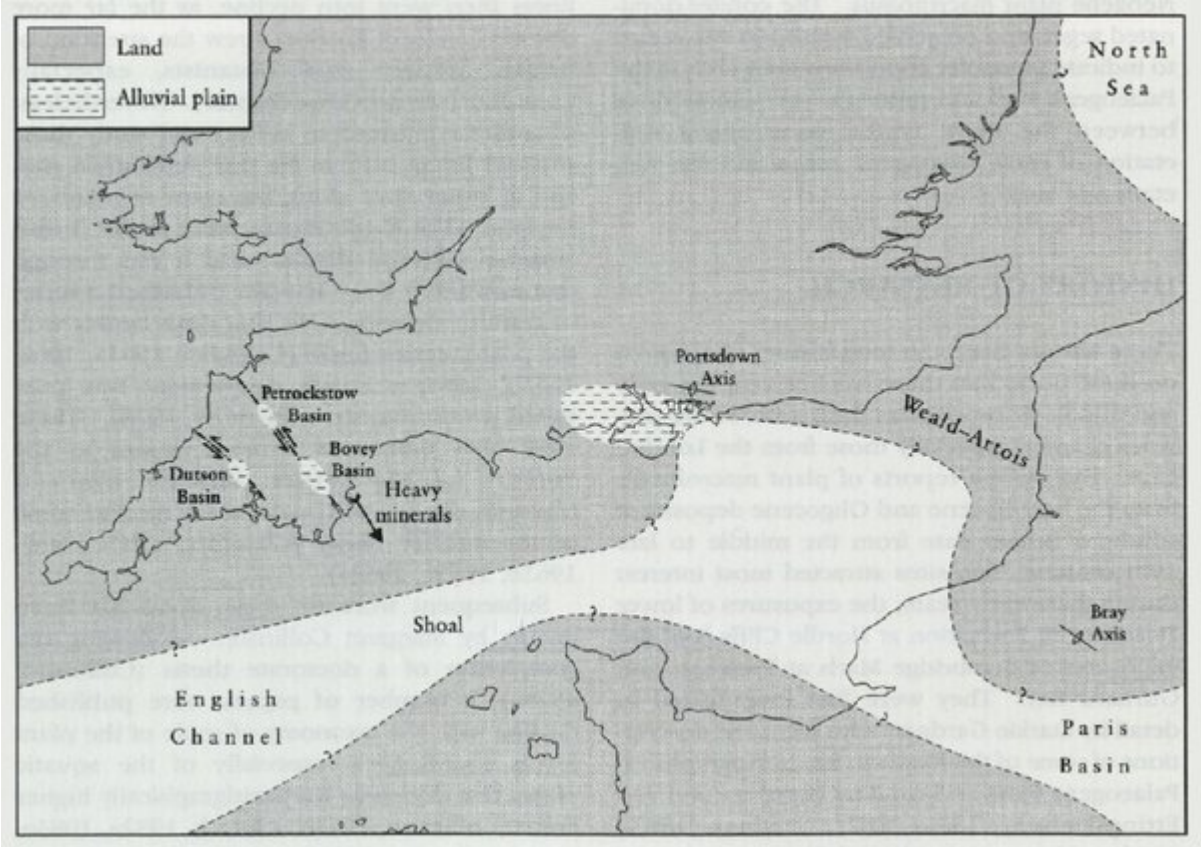
Post-Lutetian palaeobotanical sites in Britain

Post-Lutetian palaeobotanical sites in Britain fall into two categories, one of which consists of the sole Neogene palaeobotanical locality in Britain: Bees Nest. As it is the only site to yield Neogene plant macrofossils of any quantity in this country, it was almost self-selecting for the GCR.

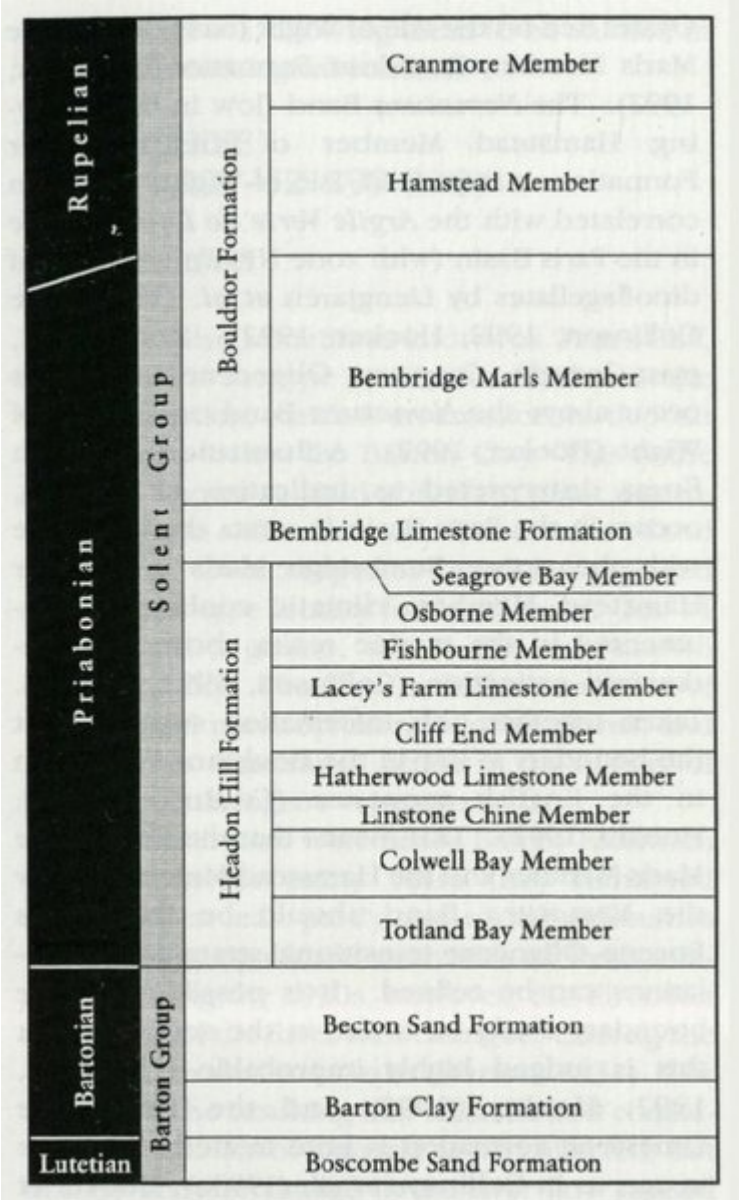
All the other sites covered in this chapter form a network within the Hampshire Basin that demonstrate the evolving vegetation from the middle of the Eocene Epoch to the early part of the Oligocene Epoch. The best sites for individual floras are in the mainly non-marine Solent group, and include the classic localities at Hordle–Beacon Cliffs (lower Headon Hill Formation) and Thorness Bay (Bembridge Limestone and lower Bouldnor Formations). These have been studied for over a century and are of international significance. They are complemented by the less well-known sites of Paddy's Gap, Hamstead Ledge and Bouldnor Cliff, which provide different insights into these same floras, the latter including the only confirmed Oligocene strata in Britain.

Many of the other sites described here have been selected to fill in the gaps between these better-known floras. Although they may not have yielded such diverse assemblages, they are nevertheless important for establishing the spatial and temporal context to give the remarkably complete history of vegetational change that can be documented in the Hampshire Basin. They include Highcliffe and Barton for the Barton Group floras; Colwell Bay and Chapel Corner for the middle and upper Headon Hill Formation floras; and Headon Hill and Totland, which provide extensive exposures of some of these plant beds, allowing them to be studied in their sedimentological context.

References



(Figure 9.1) Palaeogeography of southern England during late Eocene times. (After Murray, 1992.)



(Figure 9.2) Lithostratigraphical scheme for the middle and upper Palaeogene strata (mostly post-Lutetian) in the Hampshire Basin.