Chapter 7 The palaeobotany of the Palaeocene and Palaeocene–Eocene transitional strata in Great Britain

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Introduction

The Palaeocene Epoch and Palaeocene–Eocene transition was a time of climatic warmth with polar broad-leaved deciduous forests extending high into the Arctic Circle (Wolfe, 1977, 1985; Basinger *et al. ,* 1994). The palaeobotanical evidence shows variations in vegetation through this interval. During deposition of the Woolwich Formation and Reading Formation, southern Britain supported freshwater mires and relatively low-diversity (cf. Eocene plant diversity), often patchy, forest–woodland with deciduous flowering plants together with more warm-loving elements (Collinson and Hooker, 1987; Collinson, 2000a). Similar deciduous flowering plants were associated with more conifers and ferns at Ardtun in the North (Boulter and Kva■ek, 1989). In the latest part of this interval (Oldhaven Beds and division A1 of the London Clay Formation of King, 1981) the floras indicate the early development of vegetation similar to modern tropical rain forests that became fully established in the Eocene Epoch (Collinson, 1983b, 2000a). These floras are the earliest recognizably 'modern' examples from this country. There are none of the groups normally associated with the Mesozoic Era, such as the bennettites, caytonias and cycads (the latter have survived to the present day, but there is no post-Mesozoic macrofossil record of them from Britain).

History of research

Until recently, there has been relatively little interest in the Palaeocene palaeobotany of southern Britain, mainly because there is little good exposure. There are records of silicified pine cones (Prestwich, 1854; Gardner, 18831886a; Chandler, 1961a) and fern stems (Carruthers, 1870b, 1872; Kidston and Gwynne-Vaughan, 1907; Chandler, 1961a) from the Thanet Formation at Herne Bay. Ward (1978) and Collinson (pers. obs.) have reported fruits from these deposits, including several distinctive but as yet unidentified forms, and Collinson *et al.* (1985) described numerous megaspores. Crawley (in press) has revised the wood from these deposits.

The overlying Reading Formation suffers from generally poor exposure, which has limited the amount of palaeobotanical work done here. Occasional records from temporary exposures mainly in the London and Reading areas demonstrated the presence of leaf beds (e.g. Hooker, 1854), while fruits and seeds were described by Chandler (1961a), who also reviewed the earlier history of palaeobotanical research on these beds. However, the full potential of the Reading Formation was not established until the work by Crane, especially at Cold Ash near Newbury (see the Cold Ash GCR site report for details of the relevant publications). More recently, a diverse fruit and seed flora has been described from Felpham in West Sussex by Collinson (in Bone, 1986).

The youngest floras covered in this chapter originate from the Oldhaven Beds and the A1 division of the London Clay. Johnson (1901) was the first to report the presence of fossil fruits and seeds in these beds but there were no detailed records of the species present until Chandler (1961a, 1964) studied the Herne Bay and Walton-on-the-Naze floras. Brett (1972) described wood fossils from Harwich.

The Ardtun flora from Mull in Scotland is far more remote from centres of population and might well have gone unnoticed were it not for the local landowner (the Duke of Argyll) being a geologist and, at one time, the President of the Geological Society of London. He had the resources to arrange for extensive collecting at the site during the early 19th century, and later encouraged further collecting by the well-known palaeobotanist Gardner (1887a). Nevertheless, the palaeobotany at Ardtun remained largely unpublished until very recently, when Boulter and Kva■ek (1989) produced the first monograph, based partly on an unpublished manuscript by Seward and Edwards. Boulter and Kva■ek (1989) also give a comprehensive review of the history of work at Ardtun.

Palaeogeographical setting

The palaeogeography of early Tertiary times in the Northern Hemisphere shared many similarities with the geography of the present day (Figure 7.1). However, during most of the Palaeocene Epoch, there was a land connection between Europe and North America allowing plant migration. The North Atlantic started to 'open up' in late Palaeocene times, inducing an area of extensive igneous activity known as the 'Brito-Arctic Igneous Province' (BIP), which acted as a partial barrier to plant migration (Boulter and Kva■ek, 1989).

In southern Britain, Palaeocene and Palaeocene–Eocene transition deposits mainly occur in two areas known as the 'London Basin' and the 'Hampshire Basin'. These are purely structural basins, and these two areas were originally part of the same depositional basin that covered much of the present-day North Sea, Belgium, north-east France and south-east England (Figure 7.2). It was predominantly a shallow marine basin with mainly mud deposition, but with alluvial-plain deposits forming on the western margins.

Stratigraphical background

Most of the sites dealt with in this chapter occur in south-eastern England. We have in part adopted the Ellison *et al.* (1994) lithostratigraphical classification of these strata (Figure 7.3) as this is used in the *British Tertiary Stratigraphy* GCR volume (Daley and Batson, 1999). The lower part of the sequence is divided into four major units: the basal Thanet Formation, the Upnor Formation, and the overlying Woolwich Reading formations. These are in turn overlain by what King (1981) termed the A1 division of the London Clay Formation (i.e. the Harwich, Swanscombe and Harefield Members as well as the Oldhaven Beds and the Blackheath Beds). Ellison *et al.* (1994) applied the name 'Harwich Formation' to these lowest members of the London Clay Formation. However, this interval as interpreted by Ellison *et al.* includes a wide variety of lithologies, and is in essence a time-slice rather than a true lithostratigraphical unit (Ward, 1995; Hooker, 1998, explanation to fig. 20.1). In this account, we have therefore retained the older lithostratigraphical nomenclature for discussion of these floras, as this serves to emphasize the different lithologies and hence different facies, which were key factors in ensuring different palaeoenvironments were included in the GCR network.

The chronostratigraphy of the lower Palaeogene has been somewhat problematic (Curry *et al.,* 1978), but, in the scheme currently accepted by the Internation Union of Geological Sciences (IUGS), the Palaeocene Series is divided into three stages, the Danian, Selandian and Thanetian. The Thanet Formation belongs to the Thanetian and is Palaeocene (Berggren and Aubry, 1998). The Woolwich Formation and Reading Formation and all succeeding strata beneath the A2 division of the London Clay Formation (King, 1981) fall within the Palaeocene–Eocene boundary interval currently under discussion by the International Geological Correlation Programme (IGCP 308) (Berggren and Aubry, 1998). These strata are treated here as Palaeocene–Eocene transitional interval. The London Clay division A2 and above are Eocene in age (Berggren and Aubry, 1998). The Ardtun flora has been dated as earliest Ypresian on palynological evidence (Jolley, 1997), but also falls within the disputed Palaeocene–Eocene boundary interval currently under discussion.

At the time that the present volume was going to press, the Palaeogene subcommission of the International Commission on Stratigraphy (ICS) voted to place the Palaeocene–Ecoene boundary at the base of the Carbon Isotope Excursion (CIE), which occurs within lower Reading Mottled Clay (see summary in Collinson, 2000a). This means that the Oldhaven Beds at Herne Bay and the London Clay division A1 at Harwich and Walton are Eocene in age (since they are stratigraphically higher than the Reading Formation) and the Upnor Formation at Herne Bay is Palaeocene in age. The Felpham strata are judged to be Eocene in age (Collinson, 2000a). However, the correlation of the CIE to the sites at Harefield, Pincent's Kiln and Cold Ash is uncertain, so these are best treated as Palaeocene–Eocene transition.

Palaeocene and Palaeocene–Eocene transitional vegetation

In Britain, there appears to be a marked change between the Mesozoic, gymnosperm-dominated floras and the Tertiary angiosperm-dominated floras. However, this is mainly a function of the major break in the palaeobotanical record between the Wealden floras (the youngest-known Mesozoic plants) and the Thanet Formation floras (the oldest-known Tertiary plants), representing some 50 Ma. Most of the intervening time is represented by either marine deposits (mainly

the Chalk), or the pre-Thanetian unconformity. Where there is a more continuous record, such as North America, we see a more gradual transition between the two types of flora (Lidgard and Crane, 1990).

The Cretaceous–Tertiary (K/T) 'extinction' event seems to have been much less marked for plants than for animals. While there is evidence of significant perturbation of the vegetation at the K/T boundary, most notably the presence of widespread wildfire followed by a marked increase in ferns (Wolfe, 1991), plant life seems to have relatively quickly recovered and there were few major taxonomic extinctions (Boulter *et al.,* 1988). The bennettites and caytonias did not survive into the Tertiary, but they were already rapidly declining in Late Cretaceous times and the K/T event may have done little more than act as a *coup de grace.* Among the angiosperms, a second radiation and modernization seems to have taken place after the K/T event, where partially reconstructed whole plants and individual organs are very similar to, or indistinguishable from, those of living genera (Collinson, 1990a, 2000b).

The Palaeocene world is divided into four major palaeofloristic zones: the Holarctic, Tropical, Notal and Australian Palaeokingdoms ((Figure 7.1); Akhmetyev, 1987). Britain belongs to the first of these. Two palaeoareas are recognized within the Holarctic. The Boreal Palaeoarea includes Canada, northern Britain, Scandinavia and much of Russia. The vegetation represented by this phytochorion consisted typically of deciduous conifers such as the redwood family (Taxodiaceae) and broad-leafed deciduous angiosperms of the subclass Hamamelidae (e.g. plane tree, walnut tree, beech and birch families). Despite such high latitudes, the vegetation seems to have had essentially temperate affinities and the adoption of deciduousness was more a matter of restricted light levels than low temperatures. The British Boreal floras belong to a distinct palaeoprovince, known as the Brito-Arctic Igneous Palaeoprovince (sometimes alternatively called the 'Thulean'), which reflects the extreme conditions that developed as a result of the volcanicity resulting from the opening of the North Atlantic (Boulter and Kva■ek, 1989).

Southern Britain, in contrast, belongs to the Tethyan Palaeoarea, which also extended over most of the USA, southern and central Europe, Kazakhstan, Central Asia and China. Southern Britain at this time supported a mixed vegetation, with freshwater mires and forest-woodland containing families that today are typically found in temperate latitudes (plane-tree, walnut-tree, birch and katsura-tree families) and subtropical to tropical latitudes (palms, frankincense, tea, icacina, moonseed, grape and squash families) (Collinson and Hooker, 1987; Collinson, 2000a). The vegetation towards the end of the interval covered in this chapter (A1 division of the London Clay, Oldhaven Beds) became very similar to that of the overlying Eocene Series (Collinson, 1983b). A distinctive flora characterizes the slightly older 'late Palaeocene' thermal maximum (Collinson, 2000a).

Palaeobotanical sites in the Palaeocene and Palaeocene–Eocene transition of Britain

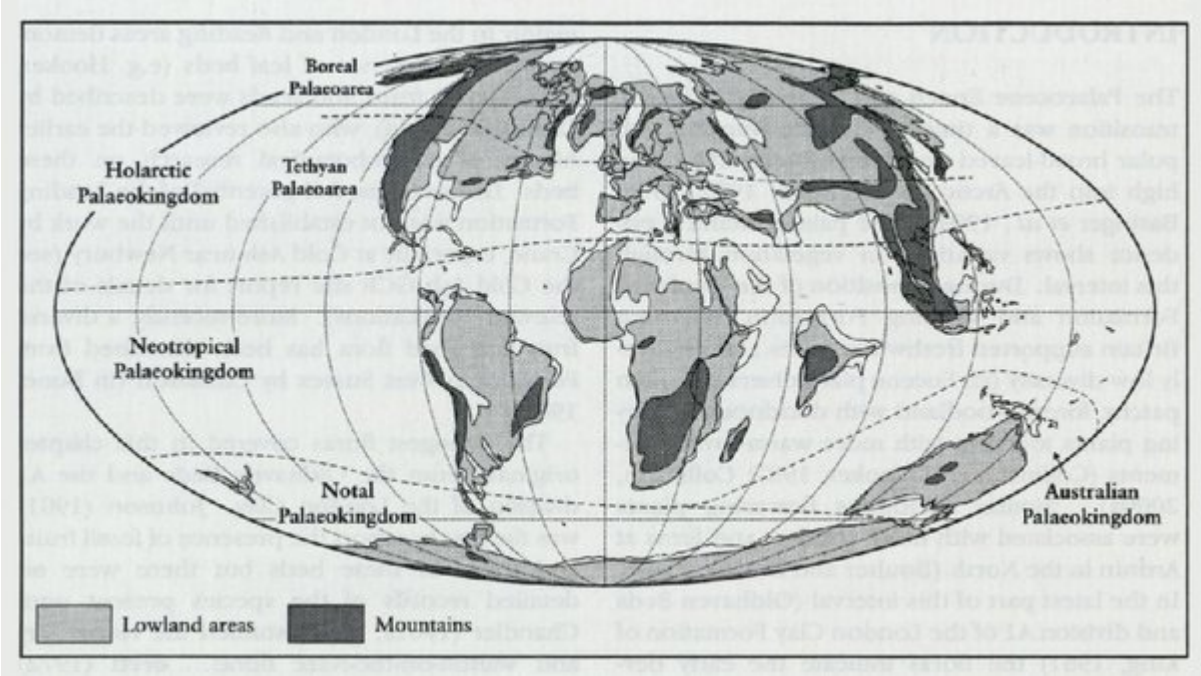
These palaeobotanical sites can be broadly divided into four categories. The first includes floras from the Thanet Formation of southern England. Plant remains are generally rare in these deposits and only one site, Herne Bay, has yielded a sufficiently diverse assemblage to merit selection as a GCR site. Herne Bay has also yielded a few plants (Ward, 1978) from the Upnor Formation, in the lowest part of the Palaeocene–Eocene transitional interval (Berggren and Aubry, 1998).

Secondly, there are sites from the middle part of the Palaeocene–Eocene transition in southern England known as the 'Reading Formation'. By far the best site for fruits and seeds in these beds is Felpham. The best 'leaf beds' (in fact lenses, also containing fruits and seeds) are at Cold Ash, while Harefield has yielded an interesting charophyte assemblage. All three have been selected as GCR sites. A fourth site, at Pincent's Kiln, has been incorporated within the GCR network, not so much for yielding a diverse flora, but because of the palaeoecological insights that it provides into the vegetation.

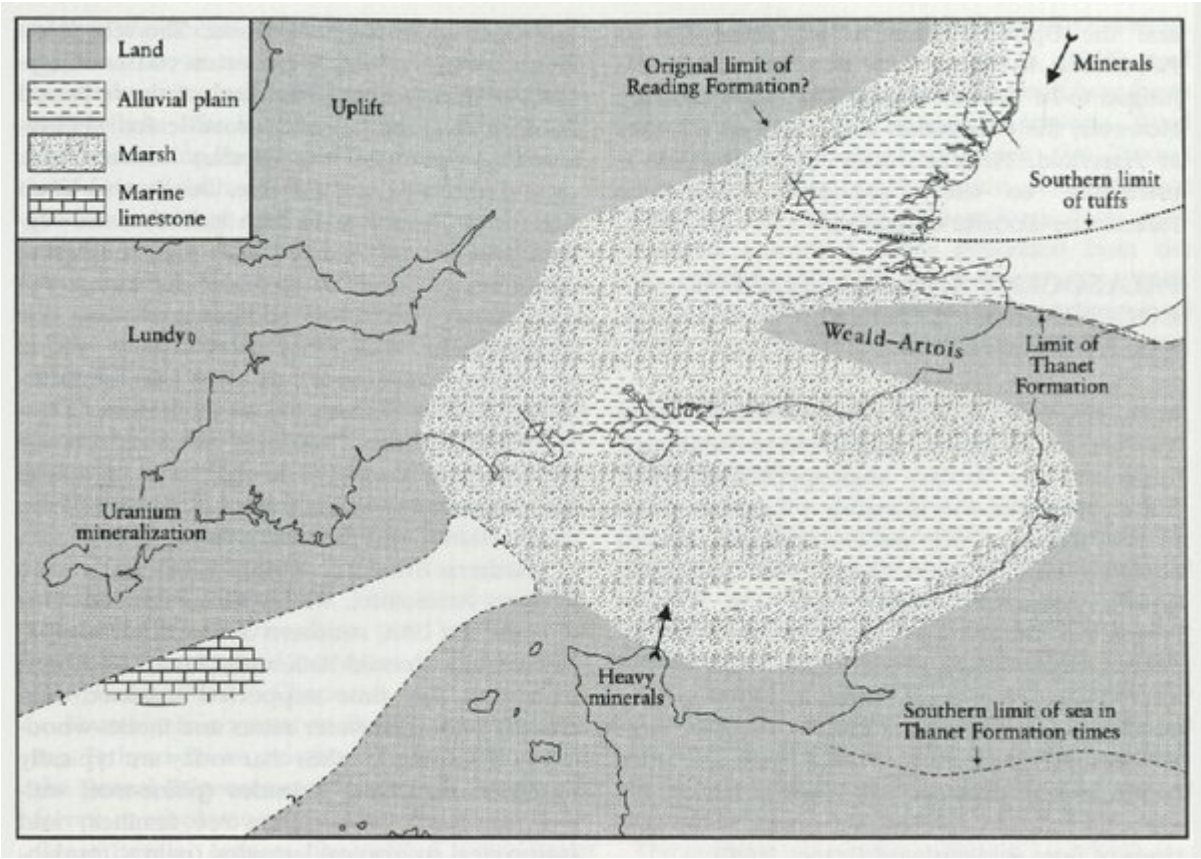
Thirdly, there are several sites that preserve floras from the latest part of the Palaeocene–Eocene transitional interval. These are the Oldhaven Beds at Herne Bay, and division A1 of the London Clay at Harwich and Walton-on-the-Naze, which are more or less of equal age (Ellison *et al.,* 1994; Ward, 1995; Hooker, 1998). Wrabness, where the flora may be from the upper A1 or lower A2 division of the London Clay, is described in Chapter 8.

Fourthly, in contrast to these sites representing Tethyan floras, northern Britain belongs to the Boreal Palaeoarea and preserves a quite different, mesophytic vegetation. Only one site in Great Britain, Ardtun, has yielded a significant assemblage of these Boreal floras and this has been included as the representative Hebridean site for the GCR.

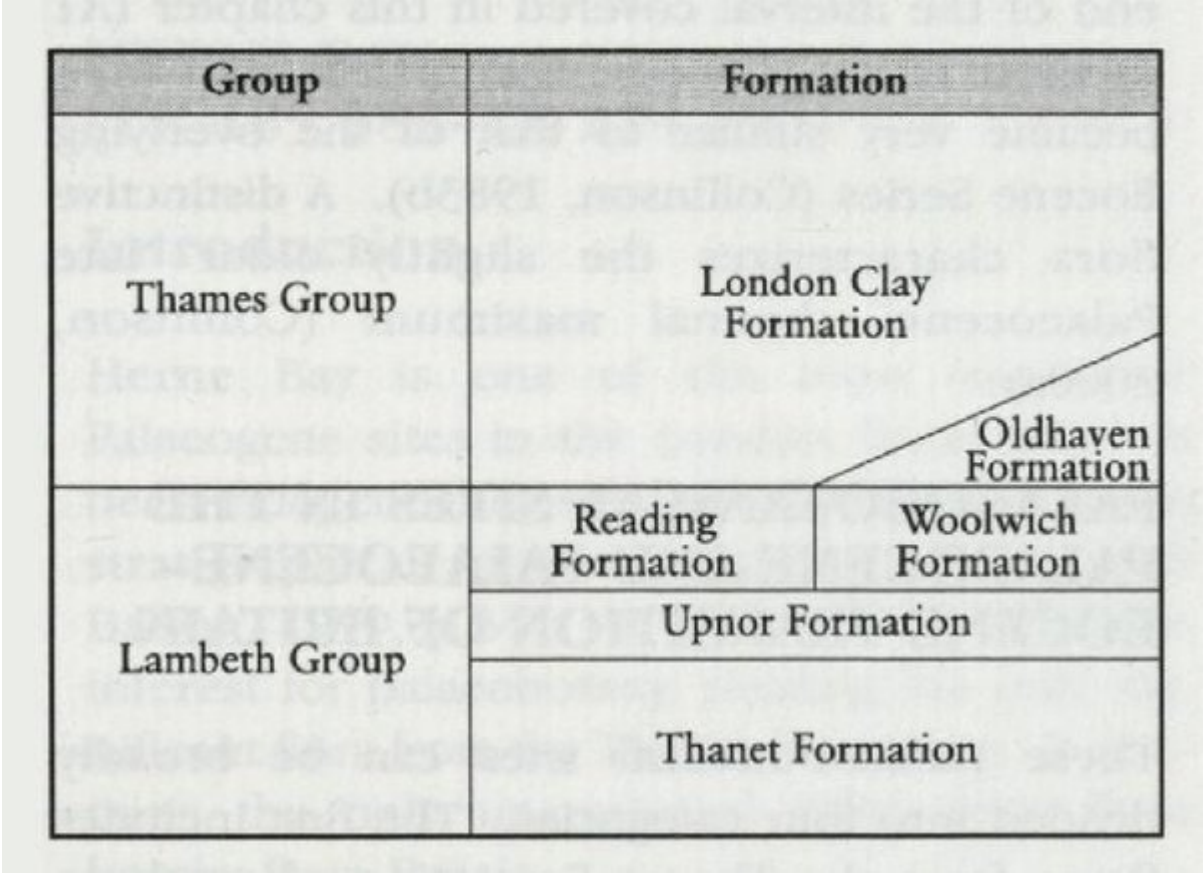
References



(Figure 7.1) Palaeogeography of the Palaeocene world, showing main areas of land and mountains. Based on Smith et al. (1994). Also shown are the main palaeofloristic areas, based on Akhmetyev (1987).



(Figure 7.2) Palaeogeography of southern England during the Palaeocene. (After Murray, 1992.)



(Figure 7.3) Lithostratigraphical classification of the Palaeocene and lower Eocene (Ypresian) deposits of the London and Hampshire basins. (Adapted from Curry et al., 1978; King,1981; and Ellison et al, 1994.)