British Tertiary Stratigraphy

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Chapter 4

London Basin: western localities

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INTRODUCTION

The Palaeogene strata to the west of London range from the Upnor Formation and Reading Formation of the Lambeth Group, formerly the Woolwich and Reading Formation, through the 'Tilehurst Member' of the Harwich Formation and the London Clay to the Virginia Water Formation and the younger strata still referred to as the 'Bagshot Beds'. At one time, the areal extent of the Palaeogene was considerably greater than at present. Remnants of this wider development are to be found in the many outliers on the Chalk of the Chiltern Hills (Figure 3.2).

Exposures are now few in number. Three stratigraphically significant Palaeogene sites in the area are included in tne GCR. The junction with the Chalk, together with a thin sequence of marine and fluvial Lambeth Group strata can be examined at Pincent's Kiln. At Harefield, a slightly thicker sequence includes fossiliferous basal London Clay, whilst at Bolter End an unusual pebble suite in the Reading Formation provides some insight into the nature of the contemporary hinterland. The GCR site at Cold Ash Quarry, near Newbury, is predominantly a fossil plant site and is covered in the *Mesozoic to Tertiary Palaeobotany* GCR volume (Cleal and Thomas, in prep.).

In the site descriptions below, following the usage by earlier workers, some traditional stratigraphical terminology is used in addition to that recently introduced by Ellison *et al.* (1994).

HAREFIELD, MIDDLESEX (TQ 050898)

Highlights

This site has contributed to an understanding of 'Reading Beds'-type Palaeocene deposits as well as being a rare occurrence in the western London Basin of where the latter is seen to rest unconformably on the Chalk. Harefield has also been the major source in the 20th century of fossils from the 'London Clay Basement Bed'.

Introduction

The 'Cement Works Pit' or 'Great Pit' at Harefield (TQ 050898; Figure 4.1) has been of interest to geologists since the latter part of the 19th century. Whilst the thickness of the Palaeogene strata present is uncertain, up to 15 m of Palaeogene strata have been recorded, including the 'Reading Beds' development of the Woolwich and Reading Formation, the Oldhaven Formation and the London Clay. The first of these rests unconformably on the Upper Cretaceous Chalk.

In the latter part of the 19th century, Whitaker (1864, 1889) referred to the site in his extensive work on the London Basin, whilst in the Beaconsfield Sheet Memoir, Sherlock and Noble (1922) described it as an 'excellent section'. Since these early times, it has continued to be of both palaeontological and stratigraphical interest. Visits by the Geologists' Association include

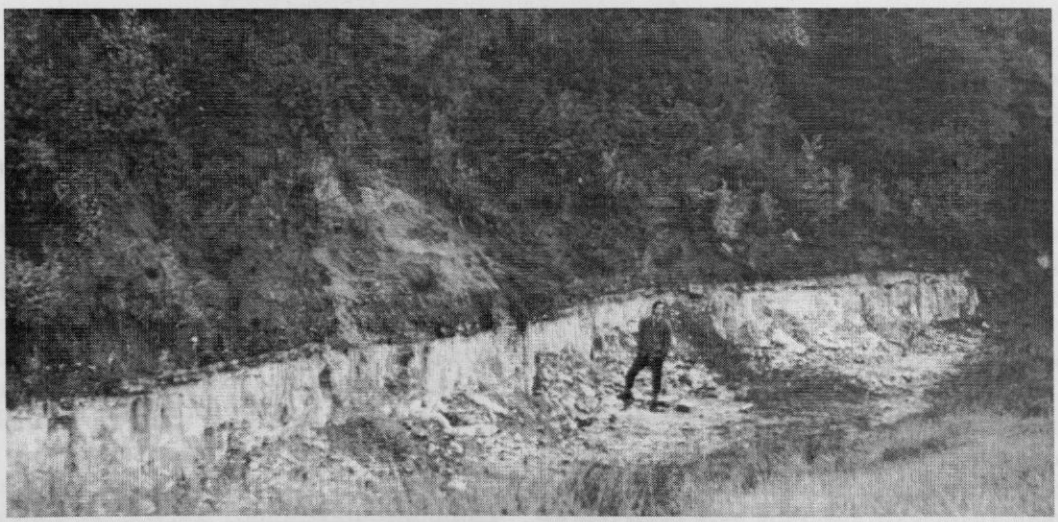

Figure 4.1 Harefield, Middlesex. Lambeth Group, showing flint gravel of the Upnor Formation resting unconformably on the Upper Cretaceous Chalk. Photograph (courtesy of English Nature) taken in 1974.

meetings reported by De Sales (1914), and Wooldridge and Wrigley (1929), whilst those by the Tertiary Research Group were recorded by Cooper and James (1975) and Cooper (1976a).

Both body fossil organisms and trace fossils have attracted the attention of palaeontologists over many years. Extensive fossil lists are given in Cooper and James (1975) and Cooper (1976a), whilst earlier palaeontological references include those by Wrigley (1929) and Curry (1959). Stratigraphical descriptions include the brief account in Sherlock and Noble (1922) and a description of the lower part of the Reading Beds by Cooper (1976a) and of the London Clay by the same author (1982, unpublished and produced for the Geologists' Association field meeting of 21 February, 1982) and Cooper and James (1975). The stratigraphical significance of the site is further discussed in Hester (1965), Cooper (1976a) and King (1981), whilst more recently it was sampled by Townsend and Hailwood (1985) as part of their broader research into Palaeogene magnetostratigraphical correlation in south-eastern England. More recently, new lithostratigraphical terminology has been introduced by Ellison *et al.* (1994) (see below for details).

This site was also independently selected for its fossil plant content, a more detailed account of which can be found in the GCR series volume *Mesozoic to Tertiary Palaeobotany of Great Britain* (Cleal and Thomas, in prep.).

Description

The Harefield site is important for various reasons. One is that it is an example of the very few remaining localities in the western part of the London Basin where the Palaeogene may be seen resting on the Chalk. The burrowed surface of unconformity has interested palaeontologists since the 19th century, with the burrow (*Terebella harefieldensis*) named after this locality by White (1923).

Lithological succession

Flint gravel at the base is followed by a succession of muds, silts and sands, concretionary in places. Almost 15 m of Lambeth Group and succeeding Thames Group strata have been reported from this site, although relatively recent accounts do not confirm this and it is possible that the total thickness may be somewhat less (Figure 4.2, after King, 1981; Cooper, 1976a).

Stratigraphy

Above the unconformity, around 1 m of flint gravel represents a particularly coarse development of the Bottom Bed of the Woolwich and Reading Formation, which, following Ellison *et al.* (1994), is now known as the Upnor Formation of the Lambeth Group. No modern accounts refer to the total thickness of the latter, though early reports (e.g. Sherlock and Noble, 1922, p. 28) indicated something over 10 m. Glauconitic sediments immediately above the basal gravel (Cooper, 1976a) should perhaps be assigned to the Upnor Formation, with the remainder of the Lambeth Group succession considered to be part of the Reading Formation of Ellison *et al.* (1994).

The succeeding strata have proved to be of considerable stratigraphical and palaeontological interest. Traditionally regarded as the 'London Clay Basement Bed', all but the uppermost part was redefined by Cooper (1976a) as the Harefield Member, with the northern part of this section as stratotype. Subsequently, King (1981, pp. 16–18) defined the Oldhaven Formation, subsuming most of the 'London Clay Basement Bed'. This formation is represented at Harefield by King's Tilehurst Member for which the section is one of two hypostratotypes (but see later discussion). The latter was considered by Ellison *et al.* (1994) to comprise part of their Harwich Formation.

Magnetostratigraphy

In relatively recent years, the stratigraphical significance of the site has been re-emphasized by Townsend and Hailwood (1985). They recognized that the Woolwich and Reading Formation and most of the overlying Oldhaven and London Clay strata accumulated during periods of reverse polarity. However, the basal unit of the Oldhaven Formation (Unit 2 of Cooper, 1976a, p. 35) shows normal polarity and has been referred to by Townsend and Hailwood (1985) as the Harefield normal magnetozone.

Palaeontology

The site has been a major source in the 20th cen-

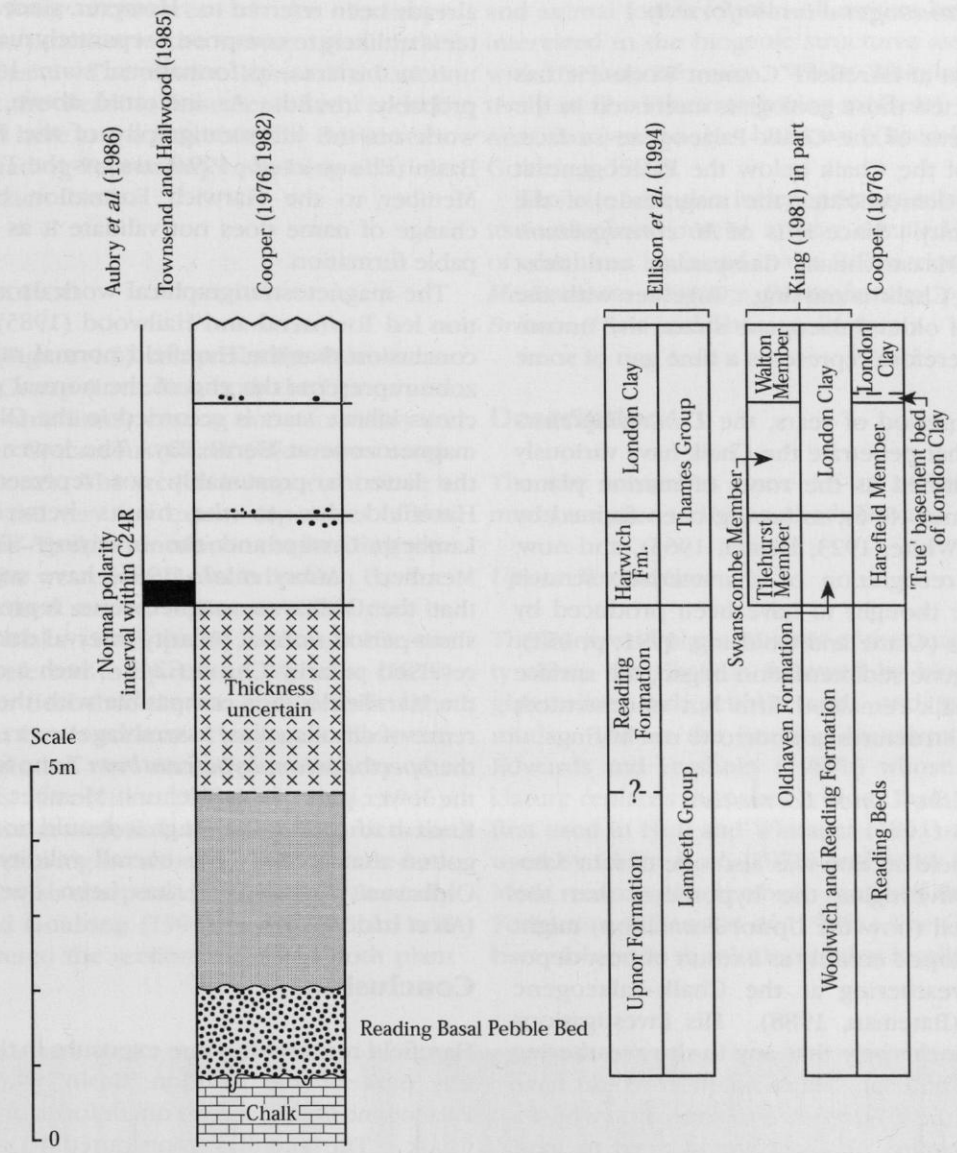

Figure 4.2 Generalized succession of the Woolwich and Reading Formation and London Clay at Harefield, Middlesex (mainly after Cooper, 1976a, 1982).

tury of 'London Clay Basement Bed' fossils (Cooper, 1982). Extensive lists compiled from various sources are given in Cooper and James (1975) and Cooper (1976a). Mollusca, both bivalves and gastropods, are most common, though also present are brachiopods (*Discinisca, Lingula*) ophiuroid ossicles, ostracods and fish remains (including otoliths, teeth and scales). A particularly palaeoecologically interesting occurrence comprises contemporaneously exposed early concretions bored by the bivalve *Martesia saxorum*, whilst also providing a substrate for the brachiopod *Discinisca* and button coral *Paracyathus*. The boring molluscs and others from different sites were described by Wrigley (1929).

Interpretation and evaluation

Although present-day exposures are not as good as they once were, this site retains its importance as one of the few remaining exposures in the western part of the London Basin.

The sub-Palaeogene unconformity

The section at Harefield 'Cement Works Pit' has long attracted those geologists interested in the development of the Chalk–Palaeogene surface. The age of the Chalk below the Palaeogene at Harefield demonstrates the magnitude of the unconformity. Since it is of *M. coranguinum* age, the Maastrichtian, Campanian and most Santonian Chalk is missing. Together with the absence of older Palaeogene strata, the unconformity therefore represents a time gap of some 30 Ma.

Over a period of years, the *T. harefieldensis* burrows that penetrate the Chalk have variously been described as the roots of marine plants (Hudlestone, 1876), as having been formed by annelids (White, 1923; Hester, 1965), and now, with the recognition of characteristic scratch marks, are thought to have been produced by arthropods (Crane and Goldring, 1991, p. 151). As Palaeogene sedimentation began, the surface of the Chalk remained firm but uncemented; hence the structures are burrows not borings.

Origin of the Upnor Formation

The Harefield section was also one of four sampled to investigate the hypothesis that the Bottom Bed (now the Upnor Formation) might have developed entirely as a result of post-depositional weathering at the Chalk–Palaeogene interface (Bateman, 1988). His investigations proved conclusively that any in-situ weathering has been minimal. Major solution would have destroyed the *T. harefieldensis* burrows, whilst a 44 km thickness of Chalk would need to have been dissolved at Harefield to yield the quartz content of the basal conglomerate (Bateman, 1988)!

Hester (1965, p. 122) has demonstrated the very variable thickness of the Bottom Bed from the Cement Works and other pits in the Harefield area. It seems likely that this variation may reflect subsequent erosion in later 'Reading Beds' times and that this could have been a response to a fall in sea level (Crane and Goldring, 1991, p. 156).

Stratigraphy and correlation

The recognition of Harefield as a lithostratigraphical type section for the Tilehurst Member of King's (1981) Oldhaven Formation has already been referred to. However, since the latter is unlikely to comprise a separately mappable unit in this area, its formational status locally is probably invalid. As indicated above, recent work on the lithostratigraphy of the London Basin (Ellison *et al.*, 1994) assigns the Tilehurst Member to the Harwich Formation but the change of name does not validate it as a mappable formation.

The magnetostratigraphical work on the section led Townsend and Hailwood (1985) to the conclusion that the Harefield normal magnetozone represents the end of the normal polarity chron whose start is recorded in the Oldhaven magnetozone at Herne Bay. The lower part of the latter is presumably not represented at Harefield due to the hiatus between the Lambeth Group and the overlying 'Tilehurst Member'. Aubry *et al.* (1986) have suggested that the Oldhaven magnetozone represents a short-period normal polarity interval during the reversed polarity Chron C24R. Such a date for the Harefield site is compatible with the occurrence of dinoflagellate assemblages representing the *Apectodinium hypercanthum* Zone found in the lower part of the Tilehurst Member here by Knox *et al.* (1983), although it should not be forgotten that recently the overall validity of the Oldhaven magnetozone has been questioned (Ali *et al.*, 1996).

Conclusions

Harefield represents a rare exposure in the western part of the London Basin where the Palaeogene is seen to rest unconformably on the Chalk. The site has contributed to a better understanding of the nature and significance of this surface and our appreciation of the variable nature of the overlying Lambeth Group.

The site formerly attained lithostratigraphical significance through being a type locality for the Tilehurst Member of King's (1981) Oldhaven Formation, whilst it remains probably the most important site palaeontologically for this part of the Palaeogene sequence in the London Basin.

PINCENT'S KILN, THEALE, BERKSHIRE (SU 651721)

Highlights

This small section shows the Palaeocene resting unconformably on the Chalk and is one of the

few surviving exposures of the Tertiary–Cretaceous junction in the western part of the London Basin. The marine Upnor Formation (formerly the Reading Basement Bed) is well developed here and is succeeded by fluvial sediments (Reading Formation) containing a variety of plant macrofossils.

Introduction

The site (Figure 4.3) comprises the Palaeocene Lambeth Group (including both the Upnor and Reading Formations), resting unconformably on the Upper Cretaceous Chalk (*Micraster coranguinum* Zone). The section is important since it is one of the very few extant exposures of the Cretaceous–Tertiary junction in the Reading area towards the western end of the London Basin.

A measured section at Pincent's Kiln may be found in Blake (1903, p. 23), although the site was not referred to by name. Whitaker (1872) had earlier described the site and identified the molluscan fossils present. The section has twice been included in excursions run by the Geologists' Association (Hawkins, 1934, 1946). In the former account, Hawkins recorded the section, referring to 'about 12 feet of dune-bedded, yellowish sharp sand' at the top. Recently, Crane and Goldring (1991) have described and re-interpreted the section and listed both plant and animal fossils found. All writers have been interested in the biogenic structures associated with the unconformity. Whilst Whitaker tentatively ascribed these to boring molluscs, they are now known to be burrows (Bromley and Goldring, 1992).

This site was also independently selected for its fossil plant content, a more detailed account of which can be found in the GCR series volume *Mesozoic to Tertiary Palaeobotany of Great Britain* (Cleal and Thomas, in prep.).

Description

The site comprises some 4.5 m of sands and muds assigned to the Lambeth Group.

Upnor Formation

The burrowed planar surface of the unconformity above the Chalk is followed by bioturbated glauconitic and pebbly sands and grey silty muds. This is the Reading Basement Bed of Edwards and Freshney (1987b) whose nomenclature replaces the term 'Bottom Bed' probably first used in Hull and Whitaker (1861) and later used by Curry *et al.* (1978) and other workers. More recently, this has been renamed the Upnor Formation (Ellison *et al.*, 1994). The Chalk has been subjected to solution so that locally there is

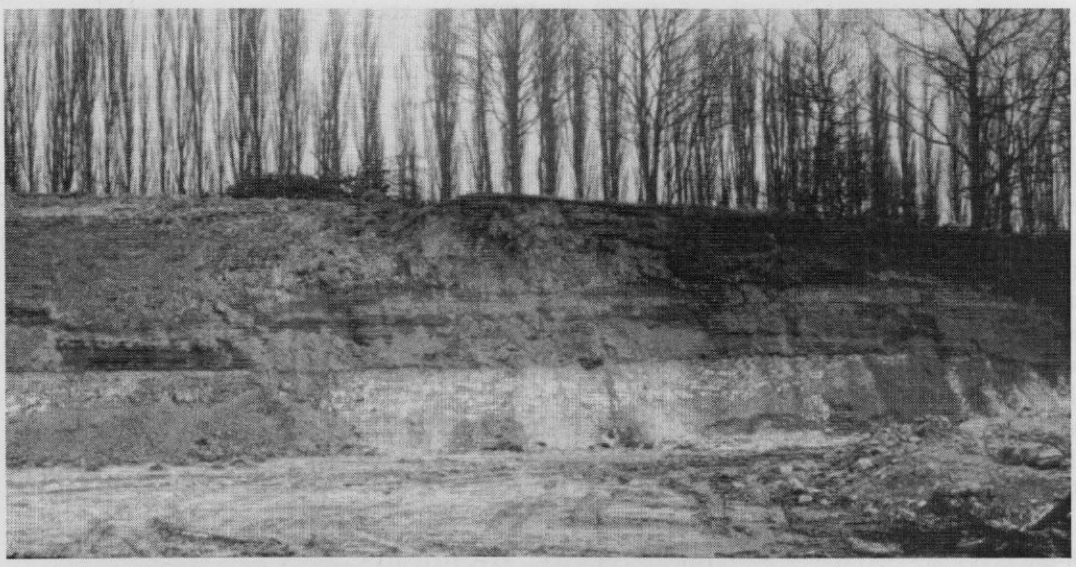

Figure 4.3 Pincent's Kiln, Theale, Berkshire, showing the Palaeogene (Lambeth Group) resting unconformably on the Upper Cretaceous Chalk. (Photograph courtesy R. Goldring, who obtained this picture in 1979 after the site had been re-excavated by NCC.)

a zone about 10 cm in thickness of concentrated burrow infills. Large flints that originally rested on the surface of the unconformity, now 'float' about 10 cm above the Chalk.

Crane and Goldring (1991) have described both the burrows and the body fossils. The former are shallow, U-shaped burrows, possibly attributable to arthropods. Of the latter, *Ostrea*, *Discinisca* and foraminifera occur in the sands, whilst the silty muds contain *Glycymeris* and *Crassatella*. Coccoliths collected by Hamilton and Hojjatzadeh (1982) suggest a correlation with nannoplankton Zone NP9 (top of the Palaeocene).

Reading Formation

The marine sediments are truncated (in places cryptically) by a channel-form structure. From the northern part of the section, Crane and Goldring (1991) described medium to coarse sands and muds, exhibiting a series of scours and fills, and containing a variety of fossil plants including leaves, fruits, seeds and megaspores. To the south, the erosion surface rises gently and the overlying sediment is mud in which leaf remains are common. These younger sediments are assignable to the Reading Formation of Ellison *et al.* (1994).

Interpretation and evaluation

The importance of the section is that it provides one of the very few exposures of the Cretaceous–Tertiary unconformity in the Reading area towards the western end of the London Basin.

The Upnor Formation (Reading Basement Bed) clearly represents a major transgressive event. It is thin here compared with the maximum thickness of around 10.7 m found in Surrey, west Middlesex and south Berkshire (see Hester, 1965, p. 121). Hester referred to the considerable variation in the thickness of the Reading Basement Bed and postulated that this might be the result of erosion and fluvial reworking, with thicker occurrences representing less-eroded 'remnants'. Crane and Goldring (1991) concluded that the Chalk was uncemented though firm at the time of the Upnor Formation transgression and that its surface was probably a submarine-planed hardground.

The sediments above the Reading Basement Bed are fluvial in origin, the sands not being aeolian as Hawkins (1946) had suggested. Perhaps, at least in part, they comprise material reworked from a formerly thicker Basement Bed. Crane and Goldring (1991) suggested that these fluvial sediments were probably laid down relatively quickly and that their truncating relationship with the underlying strata presumably reflected a sea-level fall.

Pincent's Kiln has not been designated as a stratotype but Ellison *et al.* (1994) believe that Warner's Brickworks, Knowl Hill, near Reading (although largely infilled) may be suitable for their Reading Formation. Indeed, the best exposures of this stratigraphical unit are in the Hampshire Basin. Perhaps the best of all is that in Alum Bay, Isle of Wight, which Edwards and Freshney (1987b) have designated as the Hampshire Basin hypostratotype. It should, however, be noted that their usage of the term Reading Formation includes the 'Reading Formation Basement Bed', rather than raising the latter to separate formation status (cf. Ellison *et al.*, 1994).

It may be that this albeit small section at Pincent's Kiln includes the Palaeocene–Eocene boundary. Whilst the Reading Basement Bed appears to be uppermost Palaeocene in age (NP Zone 9), Knox (1984, p. 995) has suggested that the junction of this unit and the overlying non-marine strata in the western part of the London Basin be considered to represent (somewhat arbitrarily) the NP9/10 or Palaeocene–Eocene boundary.

Conclusions

Pincent's Kiln is an important locality in that it represents one of the very few exposures of the Cretaceous–Tertiary unconformity in the western part of the London Basin. The Upnor Formation represents a major westerly transgression of the sea which reached this area towards the end of the Palaeocene (nannoplankton Zone NP9). The subsequent regression is represented by fluvial sediments with plant remains.

BOLTER END, BUCKINGHAMSHIRE (SU 799919)

Highlights

The Reading Formation at this site is distinguished by the presence of exotic pebbles in

addition to the flints found commonly elsewhere in the Palaeogene. The existence of such pebbles reflects the presence of a marginal fluvial facies and probably originated from the erosion of Lower Cretaceous and Upper Jurassic rocks outcropping to the north-west.

Introduction

The site at Bolter End (grid reference SU 799919; Figure 3.2, Figure 4.4) occurs within the Lane End Outlier (Wooldridge and Gill, 1925, fig. 10), one of a number of small outliers of Palaeogene age which rest unconformably on the dip slope of the Chalk forming the Chiltern Hills (see sheet 254 (Drift): Henley on Thames, published 1905).

Whilst some of these outliers, such as that at Lane End, include London Clay strata, most comprise 'Reading Beds' type sediments of the Woolwich and Reading Beds Formation, now renamed the Lambeth Group. The particular significance of Bolter End (and the Lane End Outlier as a whole) is that the succession has an atypical petrology (particularly with regard to pebble composition) which provides an insight into the provenance and environment of deposition of the formation in this area.

The Lane End Outlier has attracted the interest of geologists since the 19th century. Although small in size, its significance has been discussed in some detail over the years. Sections noted by Whitaker (1872) revealed nothing abnormal in the 'Reading Beds', but the discovery of an unusual pebble suite (Jukes-Browne and White, 1908) led in time to some controversy. According to Wooldridge and Gill (1925), the outlier 'long enjoyed a certain notoriety'. Certainly it has provided a focus of interest continuing to the present day.

Early references to Lane End and the pebble suite include White (1906), Woodward (1909), Barrow (1919) and Sherlock (1924). A detailed early description was published in Jukes-Browne and White (1908). Wooldridge and Gill's (1925) comprehensive paper, following new excavations at a number of localities in the outlier, went a considerable way towards resolving outstanding disputes. Later, with the development of a number of further pits and other exposures, Wooldridge and Ewing (1935) were generally able to confirm earlier conclusions, whilst introducing extensions and corrections to their 1925 account. In recent years, detailed work on the Lane End Outlier has been limited by lack of exposures. Reference to it is, however, made by Bateman and Moffat (1987) whose broader mineralogical investigations of the Woolwich and Reading Formations continues the interest in the detrital mineralogy of Lane End discussed at some length in both Wooldridge and Gill (1925) and Wooldridge and Ewing (1935).

Figure 4.4 Bolter End, Buckinghamshire. A view of the overgrown pit in 1982. (Photograph: courtesy of English Nature.)

Description

The most useful map of the Lane End Outlier and its stratigraphical composition remains that of Wooldridge and Gill (1925, fig. 1). A complete sequence of 'Reading Beds' occurs between the Chalk and the overlying London Clay. The base of the Palaeogene dips south-eastwards at a low angle and the junction with the Chalk was formerly visible on both sides of the Fingest Road at Bolter End. The Bolter End site itself appears to correspond to the 'new sand pit' described by Wooldridge and Gill (1925, figs 13 and 14) just to the south of Bolter End Common.

Wooldridge and Gill (1925) considered the local 'Reading Beds' to be some 15–18 m thick and roughly divisible stratigraphically into two parts. A lower mottled clay, considered by Wooldridge and Ewing (1935) to be marine and unlike the 'normal' mottled clay from the formation elsewhere, reaches some 9+ m around Lane End itself, but thins to the north-west of the outlier. This may reflect overlap by, or passage into, the upper part of the formation, comprising cross-bedded sands with gravels and intraformational mud–clast breccias which provide the focus of interest and characterize the unusual nature of the outlier.

Lithology

At Boulter End, the sediments are typical of the 'upper division' of the local Reading Beds. The rudites within these comprise predominantly intraformational mud–clast breccias with some exotic pebbles or, higher up, lenticular gravels with more exotic pebbles. These pebbles, which represent the main attraction of the site, include quartz pebbles and black, polished chert/siliceous rock pebbles which earlier workers referred to as 'lydite'. From elsewhere in the outlier, (Jukes-Browne and White, 1908) had also noted quartzite and sandstone pebbles. They also referred to the variations in wear of the flints. Whilst true flint pebbles occurred, they were markedly outnumbered by subangular, little-worn flint nodules.

Stratigraphy

The nature of the strata at Boulter End (traditionally considered as 'Reading Beds') suggests that they be assigned to the Reading Formation (Lambeth Group) of Ellison *et al.* (1994).

Interpretation and evaluation

This site represents, for the Lambeth Group, a unique facies not found at any of the remaining sections of this age. However, a few years after the discovery of quartz and other exotic pebbles in the Reading Beds of the Lane End Outlier, such workers as Barrow (1919) disputed the age of the gravels in which these pebbles were found, implying a Pliocene age. Subsequently, work by Wooldridge and Gill (1925) proved beyond doubt that such pebbles occurred *in situ* in a conformable sequence below a capping of London Clay and were consequently of Reading Beds age. That quartz pebbles also occur in younger gravels locally (the 'Pebble Gravel' of the Henley-on-Thames sheet; see discussion in Wooldridge and Ewing, 1935, pp. 305–11) indicates perhaps how the earlier controversy arose.

Pebble provenance

The significance of the exotic pebbles in the Reading Formation at Bolter End is considerable since there is a clear implication that by this time the extensive Chalk cover landward of the Palaeogene basin must have been breached to facilitate the erosion of older strata. Wooldridge and Gill (1925) held the view that the Lane End exotics were derived from the Lower Cretaceous and Upper Jurassic rocks exposed to the north-west. They pointed out that White considered the 'lydites' to be identical with those occurring in the Portland Beds and that northerly outcrops of the Lower Greensand contained both 'lydites' and quartz pebbles. H.B. Milner (in discussion of Wooldridge and Gill's (1925) paper, pp. 171–2) considered that the kyanites, staurolites and garnets from Lane End were like those from the Lower Greensand. That the latter might have been the source of the pebbles was supported by Wooldridge and Ewing's (1935) conclusion that the Faringdon Greensand could have provided some material. Recent work by Bateman and Moffat (1987), whilst conceding that the English Midlands provides a likely source for the exotic pebbles, concluded that the provenance of the Woolwich and Reading Formation as a whole based on detrital minerals is as yet speculative and unresolved.

Pebbles other than flint have been recorded from various outcrops on the western margins of

the Palaeogene depositional basin. A variety occur, e.g. at Blackdown and Bincombe Down in Dorset, although the strata in which these are found are somewhat younger than the Lambeth Group (see separate accounts of these sites). Hester (1965, p. 123), in fact, recorded the presence of various exotic pebbles in the formerly named Bottom Bed of the latter, but at most localities, particularly those further east, at this level and in the stratigraphically higher pebble beds referred to by Ellison (1983; cf. Blackheath Beds), the pebbles in this group are exclusively flint.

Depositional environment

The petrological distinctiveness of the Reading Formation at Bolter End, together with the mud–clast breccias which occur in a number of fluvial sequences (cf. the Wessex Formation (Wealden) of the Isle of Wight) suggests that it represents a fluvial facies of northern or north-western provenance, which does not fit comfortably into any of the six lithofacies described from the Woolwich and Reading Formation as a whole by Ellison (1983). Wooldridge and Ewing (1935, p. 302) considered it to represent a channel facies laid down by a river, which in their words was one of the 'effluents of the so-called Eocene Amazon'. Clearly, this facies contrasts with the much lower energy 'mottled clay' deposits found elsewhere.

Comparison with other localities

Although Bolter End is the only locality at which this 'marginal' fluvial facies may now be examined, an important matter for consideration is its former areal extent. Wooldridge and Gill (1925) attempted to determine this at some length. They recognized it to the west in the Nettlebed Outlier (SU 705873), but found it absent in most localities further east, including the classic Harefield site (see separate account). They did, however, refer (Wooldridge and Gill, 1925, pp. 162–3) to mud–clast breccias at a former pit at Denham (Dew's Pit) where rare 'lydites' and quartz pebbles have also been found. Following the later development of new pits, Wooldridge and Ewing (1935) reported the development of the facies from a wider area including localities such as Ayot, near Hatfield, and further west near Newbury. These authors made the point that the mud–clast aspect of the facies is more widespread than the quartzose gravels, but interestingly reported the latter from further south, near Basingstoke.

Maybe such localities represent separate channels developed on the western margins of the Lambeth Group basin of deposition. Resolving the palaeogeographical extent of the Lane End facies is inevitably diminished by the limited outcrops of the formation in such areas as the Chilterns. A possible way forward according to Wooldridge and Gill (1925) would be to map the scattered conglomeratic sarsens and quartz-bearing conglomeratic ironstones which both May and White (Jukes-Browne and White, 1908) considered might be erosional remnants of the 'Lane End facies'. To date, this has apparently not been attempted and in view of the uncertainty of their easy diagnosis, will probably not be undertaken.

Conclusions

A distinctive facies of the Woolwich and Reading Formation comprising sands with mud–clast breccias and gravels with exotic pebbles, called here the 'Lane End facies', is represented at Bolter End. This facies provides an important insight into the palaeogeographical conditions that existed towards the western margins of the basin of deposition, which extended over south-eastern England during the period of time represented by the Lambeth Group.

This facies has been recognized from some other, but unfortunately no longer exposed, sites in this part of the London Basin. It is, however, not present at all localities in this area and is absent further to the east. It appears to represent a fluvial channel development deriving material from a hinterland to the west and/or north. Whilst the presence of flint in the pebble beds indicates a predominantly Chalk provenance, the exotic pebbles clearly demonstrate that by Reading Formation times, material from below the original Chalk cover was being eroded. The possibility exists that Lower Cretaceous or even Upper Jurassic rocks were the source of such pebbles.