# Purfleet–Bluelands, Greenlands, Esso and Botany Pits

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## Highlights

Adjacent quarries at Purfleet afford an unrivalled opportunity for the study of lateral variations in the deposits of a single Thames terrace. This complex site reveals interglacial sediments sandwiched between cold-climate gravels. The interglacial sediments have yielded an important molluscan fauna, while the gravels have been found to contain artefacts from several different Palaeolithic industries. The interglacial represented at Purfleet is believed to fall within the complex Saalian Stage, probably equating with Stage 9 of the oxygen isotope record.

## Introduction

Four adjacent quarries are included in the Purfleet GCR site (Figure 4.18), three of which are chalk pits revealing important sections in overlying Pleistocene deposits. These are, from north-east to south-west, Bluelands Quarry, Greenlands Quarry and Botany Pit. Between Botany Pit and Greenlands Quarry is a smaller gravel working, now within the confines of an oil storage depot, known as the Esso Pit. The Pleistocene sediments exposed in these pits are part of a spread of gravel, 'brickearth' and 'coombe deposits' that abuts against the northern side of the Purfleet Anticline, an east-west trending structure that causes the Upper Chalk to outcrop in a ridge between Purfleet and Grays (Geological Survey, New Series, Sheet 271; (Figure 4.1)). The deposits contain important assemblages of Palaeolithic artefacts and Mollusca (Wymer, 1968, 1985b; Palmer, 1975; Snelling, 1975; Allen, 1977; Hollin, 1977) and have also yielded pollen (Hollin, 1977).

Thames terrace deposits have been widely recognized to the south of the Purfleet Anticline, similarly banked against the Chalk. The area to the north of the Chalk ridge is now drained by the Mar Dyke, a westward-flowing tributary stream that joins the Thames at Purfleet, its valley dissecting the Pleistocene deposits on the northern side of the anticline (see (Figure 4.1)). This situation has led to speculation that the latter, which include the deposits exposed in the Purfleet quarries, were laid down by the Mar Dyke (Dewey *et al.,* 1924; Wymer, 1968, 1985b; Palmer, 1975). Recent reconstructions of Lower Thames palaeodrainage do not support this view (Bridgland, 1988a). The Purfleet sediments are now considered to occupy a sinuous abandoned section of the main Lower Thames valley and to be part of the Lynch Hill/Corbets Tey Formation, of mid-Saalian age (Bridgland, 1988a; Gibbard *et al.,* 1988; Chapter 1).

## Description

The Pleistocene deposits to the north and north-east of Purfleet seem to have been largely overlooked in early descriptions of the area, which tended to concentrate on the gravels and brickearths on the southern side of the Purfleet Anticline (for example, Whitaker, 1889; Hinton and Kennard, 1900; see below, Globe Pit). The Purfleet deposits, preserved on either side of the Mar Dyke valley (Figure 4.1), are aggraded to *c.* 15 m O.D. and therefore form part of the 'Middle Terrace', as recognized in early work in the Lower Thames (see above, Introduction to this chapter). They were mapped by the Geological Survey (New Series, Sheet 271) as 'Taplow Gravel', but were interpreted by Dewey *et al.* (1924) as Mar Dyke sediments.

It is uncertain when these deposits were first quarried, but detailed research in the area began in the early 1960s, when Botany Chalk Pit was extended. The discovery of large numbers of flint artefacts in the overlying sand and gravel led to the publication of a description by Wymer (1968). He noted that the gravel was current-bedded and that it passed laterally into 'coombe rock' in the southern part of the pit. In the eastern face, now graded, the gravel could be seen banked against Chalk containing bands of flint nodules. The gravel immediately adjacent to this rising bank of Chalk contains one of the richest concentrations of worked flint in the British Palaeolithic (Wymer, 1968; A.J.R. Snelling, pers. comm.). The assemblage from Botany Pit includes hand-axes, chopper-cores of Clactonian type and 'proto-tortoise cores', the latter suggesting an early use of Levallois technique (Wymer, 1968, 1985b). Wymer (1985b, p. 313) suggested that the natural outcrop of flint nodules in the ancient river bank at Botany Pit had been exploited as 'a Palaeolithic flint quarry where the flint was knapped on the spot and selected pieces taken away'. He thought that the wealth of available raw material may have given rise to the early use of the extravagant Levallois technique (described in Chapter 1). Roe (1968b) classified only a small proportion (0.8%) of the flakes from Botany Pit as Levalloisian. Sections visible in this pit during the 1970s were recorded by Podmore (1976), Shephard (1976) and Lonsdale (1978).

It is uncertain when the smaller gravel working known as the Esso Pit was excavated, as no published descriptions have been found. A small-scale exploratory excavation here in 1986 by the author and N.D.W. Davey revealed deposits comparable to those in nearby Botany Pit, although Chalk-bearing gravel was encountered ((Figure 4.19) and (Table 4.2)), similar to the deposits associated with the shelly sediments in Greenlands and Bluelands Quarries (Figure 4.20). The section proved to be rich in Palaeolithic artefacts; several flakes and a core were recovered from an exposure 5 m high and 1–2 m wide, with minimal disturbance of *in situ* material. These were largely undiagnostic, although a probable hand-axe finishing flake was included. Amongst a number of unstratified finds was a flake indicative of Levallois technology, with a 'faceted butt' (archaeological determinations by P. Harding).

Greenlands Quarry was also opened in the early 1960s, the resultant exposures revealing the existence of rich shell beds. The section at Greenlands and the fauna from these beds were described by Snelling (1975), who recorded over 25 ft (7.5 m) of Pleistocene deposits overlying Chalk and Chalk rubble in the north face (Figure 4.20). The lower 4 m of these sediments are dominated, above a basal gravel (0.5 m), by shelly clays and sands, the best-preserved molluscan remains coming from the upper, more sandy half of these lower beds. Above the shelly beds, alternating gravels and clays form the remainder of the sequence. Snelling listed 27 molluscan species from the Greenlands shell beds (all but seven of them aquatic), together with mammal bones and teeth, including straight-tusked elephant (*Palaeoloxodon antiquus*), bison and indeterminate small rodents. The molluscan assemblage includes the aquatic snail *Belgrandia marginata* (Michard) in great abundance; *Bithynia tentaculata* is also common, as are the bivalves *Pisidium amnicum* (Müller), *P. supinum, P. benslowanum* (Sheppard) and *Corbicula fluminalis.* Later descriptions of the sediments here, and in the adjacent Bluelands Quarry, were provided by Palmer (1975), Hollin (1977), Lonsdale (1978) and Wymer (1985b).

Palmer (1975) discovered Palaeolithic material in both Greenlands and Bluelands Quarries; she assembled a mixed collection of scrapers, flakes and cores, principally from Bluelands. Palmer interpreted this assemblage as 'Middle Acheulian', with a considerable Clactonian element, much of which was rolled and therefore possibly reworked from earlier deposits. Some Levallois influence was observed, but Palmer considered the assemblage to differ significantly from the proto-Levallois material from Botany Pit. Wymer (1985b) suggested that three different industries were included in the collections assembled by Palmer, possibly reflecting a stratigraphical sequence of Clactonian, Acheulian and Levallois occupations (see below).

Observations by Hollin (1971, 1977) broadly confirmed earlier descriptions, although he noted that Snelling's main shell-bearing bed occupies a channel cut into more argillaceous, laminated deposits. He attributed the latter to deposition in an intertidal environment. Hollin also described an upper sand body at Purfleet, directly overlying a Chalk platform at 14 m O.D. The existence of this deposit, which has the appearance, in Hollin's section, of a separate higher terrace remnant, has not been confirmed by recent investigations (P. Allen, pers. comm.).

From the various descriptions of the Purfleet sections, the following generalized sequence can be reconstructed (see also (Figure 4.20), which indicates approximate thicknesses):

5. Colluvium and possible loessic material (disturbed), not part of the fluvial sequence.
4. A sequence of gravels, sands and silts with subordinate planar-bedded clay. The gravel and sand were attributed to braided-river deposition by Hollin (1977). Wymer (1985b) has suggested that Clactonian and Acheulian artefacts occur in the lower part of this sequence, with Levallois artefacts near the top. This bed overlies the interglacial beds (1–3) at Bluelands and Greenlands. Snelling (1975) suggested that the gravel containing Levallois material at Botany Pit is the equivalent of this unit. This view is in keeping with Wymer's (1985b) observation that the basal gravel at Botany Pit contains (Acheulian) hand-axes.

3. A channel cut into (2), filled with sand and silt, with a very large comminuted shell component (interglacial species). It also contains articulated bivalve specimens. It is preserved only in the Bluelands and Greenlands sections.
2. Laminated sand, silt and clay (brickearth), containing Mollusca, ostracods and pollen (interglacial species). The fossiliferous bed is restricted to Bluelands and Greenlands, but similar deposits, although without fossils, have been recorded in the Esso Pit and in Botany Pit (now destroyed). Without biostratigraphical control, it would be unwise to correlate these with bed 2, however.
1. Sandy gravel with Chalk and calcareous concretions, containing Mollusca (interglacial species). This bed contains Clacton-ian artefacts, some in sharp condition (Wymer, 1985b). Palmer (1975) distinguished a very sandy and calcareous upper division and a coarse lower division within this unit, the Mollusca apparently occurring in the former.
Chalk rubble (above solid Chalk).

The fossiliferous beds 1–3 represent interglacial conditions. They are, however, of limited lateral extent; in their absence, the basal (unfossiliferous) part of bed 1 would be indistinguishable from bed 4 (except, perhaps, from their Palaeolithic contents).

## Interpretation

As noted above, Dewey *et al.* (1924) and Wymer (1968) attributed the Purfleet deposits to the Mar Dyke, because they occupy the valley of that tributary rather than the main river. Palmer (1975) recorded the elevation of the Chalk surface in the area of Bluelands and Greenlands Quarries in some detail and concluded that the Pleistocene deposits occupied a channel with an approximate north-east to south-west alignment. She carried out a fabric study, measuring gravel clast imbrication, which indicated deposition by water flowing towards the south-west (Figure 4.18). On the basis of this analysis, she too suggested that the gravels were deposited by the Mar Dyke. Palaeocurrent evidence from the Esso Pit, obtained during the 1986 investigation by measuring foreset orientations, confirms a broadly westward flow direction (Figure 4.18). The results of clast-lithological analysis show the deposits here to be typical of Lower Thames gravels upstream from the Darent confluence (Table 4.2). This is not entirely incompatible with a Mar Dyke origin, since that stream would largely have been reworking Thames sediments, but some dilution by rounded flint pebbles from the Palaeogene outcrop to the north (and, secondarily, from earlier Pleistocene deposits derived from this) might be expected in gravel laid down by the tributary (see below).

The distribution of the Corbets Tey Gravel (mapped by the Geological Survey as 'Taplow Gravel'), in which the Purfleet sediments are included, suggests that the Lower Thames followed a markedly sinuous course in the Ockendon–Grays area at the time that this formation was deposited ((Figure 4.1) and (Figure 4.18)B; Bridgland, 1988a). The relations between the Corbets Tey Formation and higher ground to the north, east and south, which constrains the reconstruction of the Corbets Tey floodplain, reveal the extent of this sinuosity. When this deposit was aggrading, the river, flowing eastwards from London, turned sharply to the south-west in the Ockendon area, flowed in that direction as far as Purfleet, then swung southwards through a gap in the Chalk of the Purfleet Anticline, ultimately to resume its eastward heading ((Figure 4.18)B). This interpretation explains why the Corbets Tey Gravel between Ockendon and Purfleet occupies the Mar Dyke valley and why it is banked against the northern side of the Chalk ridge at Purfleet: it is apparent that the Mar Dyke tributary has adopted this abandoned part of the early, sinuous Thames valley. An explanation is also provided for the palaeocurrent data from Purfleet, which records the westward flow between the two 18O.D.g; bends in the valley (Figure 4.18). In support of this interpretation is the fact that the wide and almost continuous belt of Corbets Tey Gravel between Ilford and Ockendon, clearly forming a terrace of the Thames, cannot be traced eastwards beyond Ockendon, as a higher area of bedrock stands in the way. Furthermore, the Mar Dyke valley upstream from the Corbets Tey Gravel outcrop is entirely devoid of gravel; there is nothing to indicate that this stream is of sufficient antiquity to have deposited any part of the Purfleet sequence and no evidence that it ever laid down substantial pre-Holocene sediments.

Deposits ascribed to a north-bank tributary of the Thames, perhaps ancestral to the Mar Dyke, were described by Hinton and Kennard (1900); this description probably pertains to the deposits located at around TQ 610 790 (Figure 4.21). These deposits occupy a 'col' to the north of Grays that separates two spreads of Orsett Heath Gravel capping the ridge formed by the Purfleet Anticline. Brickearth has been mapped here (Geological Survey, Sheet 271; (Figure 4.21)), presumably corresponding to loams and clays described in the upper part of the Hinton and Kennard section. Beneath this material was up to 2 m of gravel, largely composed of rounded flint pebbles (from the Palaeogene), but with some subangular flint. Rocks foreign to the area, of the type that characterize the Lower Thames gravels, were conspicuously scarce. The sequence fills a north–south-trending channel cut into the Thanet Sand (Hinton and Kennard, 1900). These deposits, of uncertain age, are clearly very different to the gravels (including those at Purfleet) that occupy the sinuous Thames course described above; this fact lends support to the argument that the Purfleet deposits are products of the main river.

Hollin (1971, 1977) ascribed laminated silts in the lower part of the Greenlands succession (bed 2) to an intertidal environment, suggesting that this part of the Lower Thames was within the estuarine zone at the time of their deposition. However, Robinson (in Hollin, 1977) recorded various freshwater ostracods from these laminated deposits, although specimens of *Cyprideis torosa* (Jones) from the later shelly channel-fill (bed 3) show the tuberculate ornament that this species develops in brackish conditions. Allen (1977) recorded further evidence for deposition in a slightly brackish environment, in the form of ostracods and foraminifera from a shelly seam within the laminated beds at Greenlands Quarry (bed 2). This seam also yielded the remains of insectivores, rodents, amphibians and fish (Palmer, 1975; Allen, 1977). A herpetofauna from the site has been recorded recently by Holman and Clayden (1988).

### Stratigraphy and correlation

Very different stratigraphical interpretations of the Purfleet locality have been put forward, depending on whether terrace stratigraphy, archaeology or palaeontology have been given priority as evidence for relative dating. From the molluscan evidence, Snelling (1975) concluded that the interglacial deposits at Greenlands were of Hoxnian age. This view was based principally on the occurrence of the freshwater snail *Valvata antiqua* (Morris), not known from post-Hoxnian sediments (Castell, in Snelling, 1975). However, he observed that the deposits appeared to belong to the same terrace as the gravel at Botany Pit, which had yielded an abundant Proto-Levallois industry that he was reluctant to accept as of Hoxnian age. He therefore suggested that the upper (post-interglacial) part of the Greenlands sequence and the Palaeolithic gravel at Botany Pit were lateral equivalents and that they were of post-Hoxnian age.

Palmer (1975) likened the Palaeolithic assemblage from Bluelands Quarry to the Acheulian industry in the Middle Gravel at Swanscombe, thus supporting correlation with the Hoxnian. In a reappraisal of Palmer's findings, Wymer (1985b) concluded that three separate Palaeolithic industries were represented amongst her collection. He recognized Clactonian elements, generally somewhat abraded, from within and immediately above the shelly deposits (in beds 1–3 and in the lower part of 4). In the latter context (lower bed 4), he also recognized abraded Acheulian material. A Levallois flake was attributed to the highest gravel layer (upper bed 4) (Figure 4.20). In a similar reappraisal of the records of finds in Botany Pit, Wymer (1985b) noted that sharp hand-axes occurred at the base of the gravel there, immediately above the Chalk. He suggested that these pre-date the Levalloisian material from the site. Thus there is archaeological support for the correlation of the gravel at Botany Pit with bed 4 of the general Purfleet sequence, in which Levallois artefacts also appear in the upper levels. This concurs with Snelling's (1975) suggestion that the Levallois material post-dates the interglacial beds. The implication that Palaeolithic assemblages may occur in a meaningful stratigraphical sequence in the Corbets Tey Gravel is potentially of great significance (see below, Globe Pit).

Hollin (in Palmer, 1975; Hollin, 1977) collected pollen samples from the laminated deposits (bed 2) in Greenlands Quarry, but obtained well-preserved material at only four levels. Analysis of these pointed to pollen biozone II of an interglacial, but the assemblage was insufficiently distinctive to allow correlation with either of the two post-Anglian temperate stages recognized in Britain at that time, the Hoxnian and the Ipswichian. However, Allen (in Hollin, 1977) considered that the occurrence, at Purfleet, of the bivalves *Unio* sp. and *Corbicula fluminalis* so early in an interglacial (biozone II) was suggestive of the Ipswichian rather than the Hoxnian. Hollin was inclined to accept this view rather than Castell's interpretation of the assemblage as Hoxnian (see above). Hollin suggested that the laminated deposits represented an estuarine phase resulting from a rapid rise in sea level in response to an Antarctic ice surge during the Ipswichian Stage.

Allen (1977) recognized that problems exist in ascribing the Purfleet sediments to either the Hoxnian or the Ipswichian Stage. He observed that if the deposits were Hoxnian, the Mollusca would indicate a late part of the interglacial (largely on the basis of a comparison with Swanscombe, where *Corbicula fluminalis* is absent from the early part of the sequence — see above, Swanscombe); this is contrary to the palynological evidence, which implies that biozone II, the early temperate phase, is represented. Conversely, Allen regarded the elevation of the deposits as too high, in comparison with Ipswichian sites elsewhere in the Lower Thames, for correlation with that stage. He suggested that 'the deposits aggraded during another interglacial between the Hoxnian and the Ipswichian' (Allen, 1977, p. 3).

Preece (1988) has contributed recently to this debate. He noted the occurrence at Greenlands of the large freshwater mussel *Margaritifera auricularia* (Spengler), which is only recorded from one other British interglacial site, namely the well-known Ipswichian deposits of Trafalgar Square. Despite this and other similarities, he pointed out that the molluscan faunas of Trafalgar Square and Purfleet show 'some striking differences' (Preece, 1988, p. 51). Preece cited, as an example, the absence of *C. fluminalis* at Trafalgar Square, in sediments that appear to derive from a similar depositional environment to that represented at Purfleet, where the species is abundant. The potential stratigraphical significance of this species, and in particular the theory that it was absent from Britain during the Ipswichian Stage (*sensu* Trafalgar Square), has been discussed in Chapter 2 (see Stanton Harcourt and Magdalen Grove).

Bridgland (1983a, 1988a) offered a reappraisal of Lower Thames terrace stratigraphy based on the traditional method of recognizing the products of the various individual terrace aggradations from their distribution and elevation. He correlated the deposits at Purfleet with the Lynch Hill/Corbets Tey Formation of the Thames and demonstrated that they were laid down by the main river, not the Mar Dyke tributary (see above). This correlation implies a mid-Saalian age (Table 4.1) and (Table 1.1). Despite this, Gibbard *et al.* (1988) preferred to assign the Purfleet sediments to the Mar Dyke, believing them to relate to the infilling of this tributary valley during an Ipswichian high sea-level phase. In this difference of opinions, palaeogeographical reconstructions and age determinations are closely interrelated. Bridgland (1983a, 1988a) showed that the Thames, after depositing the Taplow/Corbets Tey Gravel in what is now the Mar Dyke valley, had abandoned this course by the late Saalian Stage, when the Mucking Gravel was laid down. Therefore, if the Purfleet interglacial deposits are Ipswichian, they must be the product of the Mar Dyke and not the Thames; conversely, if they were deposited by the Thames, they must be pre-Ipswichian. Comparison with the north-bank tributary gravels that were described by Hinton and Kennard (1900; see above), strongly suggests that the Purfleet deposits are of Thames origin, which, as pointed out above, carries the implication of a pre-Ipswichian age for the interglacial beds at Bluelands and Greenlands Quarries.

A further indication of the age of the Purfleet deposits has been obtained by the amino acid analysis of shells from the locality. The results of preliminary work of this type suggested that specimens of *C. fluminalis* from Purfleet (which gave D-alloisoleucine L-isoleucine ratios of between 0.33 and 0.39) were the oldest of any from the Lower Thames, including examples from the Swanscombe Middle Gravel and from Stoke Newington (Miller *et al.,* 1979). These findings have been broadly confirmed by Bowen *et al.* (1989), who published a ratio of 0.34 (± 0.24) based on two *Bithynia* shells from Purfleet. The large standard deviation of the latter ratio, however, suggests that it could be imprecise. Bowen *et al.* also published an updated *Corbicula* ratio of 0.38 (± 0.07) from the shelly gravel at Greenlands and Bluelands. These ratios are comparable with results from sites attributed to the Cromerian Stage (Bowen *et al.,* 1989). These data must be misleading, since the deposits cannot pre-date the diversion of the Thames into the valley through London (and Purfleet) during the Anglian Stage. These high amino acid ratios may, however, lend support to the view that the Purfleet deposits are of pre-Ipswichian age, since shells from sites attributed to that stage (Trafalgar Square and Bobbitshole, for example) have given uniformly low ratios, in the range 0.09 to 0.13 (Bowen *et al.,* 1989).

From an examination of the various published descriptions and discussions of the Purfleet sediments, it is apparent that they have been correlated with practically every other interglacial site in the Lower Thames at one time or another. Those who favoured an older, Hoxnian age have suggested correlation with the Swanscombe Middle Gravel (Palmer, 1975), but those favouring an Ipswichian age have broadly linked the site with Ilford, Aveley, West Thurrock, Crayford and even Trafalgar Square (Hollin, 1977; Gibbard *et al.,* 1988), despite the fact that the Purfleet deposits form part of a different, higher terrace to all of these (Figure 4.3).

There are, however, other interglacial sediments associated with the Corbets Tey Gravel, at Grays and Little Thurrock (see below, Globe Pit), at Belhus Park (Wymer, 1985b) and near the type locality at Corbets Tey (Ward, 1984). It is also likely that the complex of sites at Stoke Newington, discovered in the last century (Smith, 1883, 1894; Wymer, 1968; Kerney, 1971; Harding and Gibbard, 1984), belong to the Lynch Hill/Corbets Tey Formation. Amino acid ratios from specimens of *Corbicula* from Stoke Newington and Hackney support a correlation with Grays (Miller *et al.,* 1979), although similar ratios were also obtained from Swanscombe, considered here to be older. All the above sites, perhaps significantly, have yielded *Corbicula fluminalis.*

A borehole at Corbets Tey [TQ 550 850] produced a very similar molluscan fauna to that from Greenlands, as well as plant, ostracod, small vertebrate and insect remains (Ward, 1984). The presence of the gastropod *Hydrobia* cf. *ventrosa* (Montagu) and the ostracod *Cyprideis torosa* provides evidence for estuarine or brackish conditions (Ward, 1984). Old records (in Wymer, 1985b) of a gravel pit at Gerpins [TQ 555 840], 1 km to the south-west, appear to describe organic deposits containing wood beneath 8 m of sand belonging to the Corbets Tey Formation. A correlation of these deposits with that at Belhus Park, 3.5 km further to the south-east, was suggested by Wymer (1985b). Eight hand-axes are recorded from Gerpins Pit (Wymer, 1985b), possibly representing a lateral equivalent of the assemblage from Purfleet. The Corbets Tey, Gerpins Pit and Belhus Park sites are associated with a major channel feature within the Corbets Tey Gravel outcrop, revealed by borehole data (P.L. Gibbard, pers. comm.). According to Gibbard, this channel is excavated through the Corbets Tey Gravel and was filled during the Ipswichian Stage by Mar Dyke depos its. However, at Belhus Park the interglacial sediments were seen to be sandwiched between gravels, both apparently of Corbets Tey type. The upper gravel, in addition to containing a full suite of Thames far-travelled lithologies (Table 4.2), also yielded a number of Palaeolithic artefacts, some in very sharp condition (Wymer, 1985b). According to Wymer, these artefacts, Acheulian hand-axes and cleavers, 'cannot have been derived from any earlier deposit and must be contemporary with the aggradation that produced the gravel overlying the organic deposit' (1985b, p. 314). Artefacts of this type would be out of place in a post-Ipswichian context (see Wymer, 1988). It is therefore considered likely that the interglacial sediments at Belhus Park are pre-Ipswichian Thames deposits. Further evidence in support of this view has recently come to light, from amino acid analyses of shells from the Belhus Park interglacial deposits (Bowen, 1991; see below).

In the revised stratigraphical scheme for the Thames terrace system presented in Chapter 1, the interglacial represented within the Lynch Hill/Corbets Tey Formation is correlated with Oxygen Isotope Stage 9 (Table 1.1). The Purfleet sediments provide important evidence with regard to this interpretation. Despite many suggestions that they are Hoxnian, they have been differentiated from that stage, as represented at Swanscombe, on the basis of differences in the molluscan faunas from the two sites and their comparison with the record for vegetational history during the Hoxnian, derived from the Clacton sequence (Allen, 1977; see above, Swanscombe). An Ipswichian (*sensu* Trafalgar Square) age, still favoured by some authors (Gibbard *et al.,* 1988), may be ruled out by the presence of *Corbicula fluminalis,* which appears to have been absent from the Thames valley during that stage (Chapter 2, Stanton

Harcourt and Magdalen Grove). Notwithstanding these biostratigraphical arguments, sediments that are attributed to these two established stages form part of different terrace formations to that (the Wolvercote/Lynch Hill/Corbets Tey Formation) recognized at Purfleet (Table 1.1). Terrace stratigraphy, taken in isolation, suggests correlation of the Purfleet interglacial sediments with those at Wolvercote, Stoke Newington, and Grays and Little Thurrock (Table 1.1). The same line of evidence suggests that all these were laid down during the second of four post-Anglian interglacials (Figure 4.3); the correlation of the Anglian with Oxygen Isotope Stage 12 therefore points to a Stage 9 age for the Purfleet deposits and their correlatives (see Chapter 1 and (Table 1.1)). Recently, amino acid ratios have been obtained from shells from the interglacial deposits at Belhus Park, described above. These ratios (0.26) support the correlation with Stage 9 (Bowen, 1991). The corroboration (or otherwise) of the above correlations, on biostratigraphical grounds or from additional amino acid analyses, must await further research on these various deposits.

### Summary

The complex of pits at Purfleet together constitute one of the most important localities for the reconstruction of Thames drainage development. They provide evidence from every discipline of relevance to Pleistocene stratigraphy. In particular, important Palaeolithic and molluscan assemblages from different parts of the composite site provide significant stratigraphical and palaeoenvironmental evidence. The site has long been recognized as possibly representative of an undefined and unnamed temperate interval between the Hoxnian and Ipswichian. There is still considerable controversy about whether the sediments at Purfleet, which belong to the Lynch Hill/Corbets Tey Formation, represent a post-Hoxnian/pre-Ipswichian temperate episode or a partly estuarine valley-fill of Ipswichian age. There is also a closely related dispute as to whether the deposits are the product of the Thames or of the tributary Mar Dyke stream. In fact, several lines of evidence combine to suggest that the temperate deposits at Purfleet correlate with Oxygen Isotope Stage

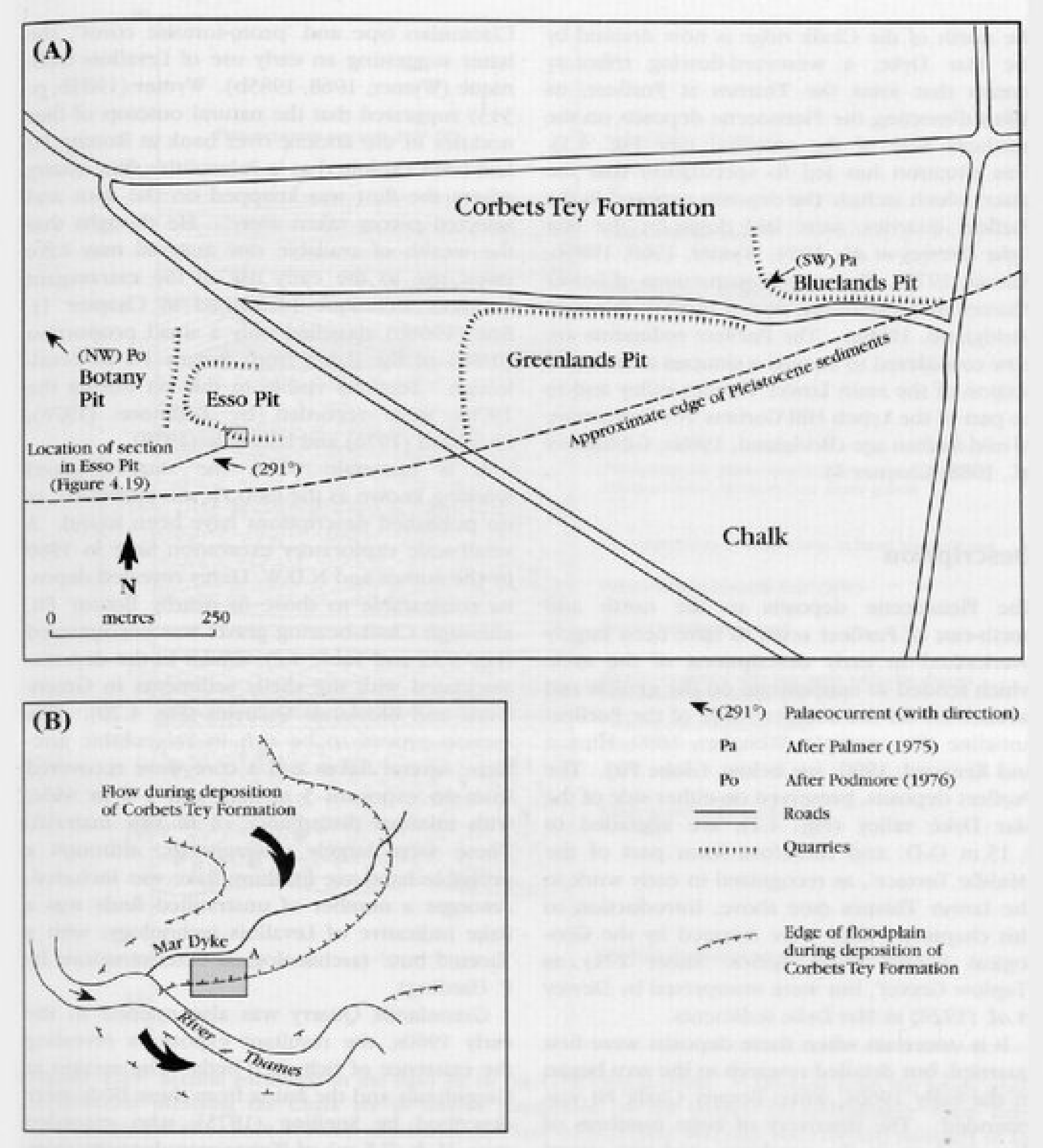
9. Phases 3 (interglacial) and 4 (post-interglacial) of the model for terrace formation (proposed in Chapter 1) are clearly well-represented at Purfleet, by the various fossiliferous sediments and the overlying gravels of bed 4 (respectively). It seems likely that the unfossiliferous lower division of bed 1, recorded by Palmer (1975), represents phase 2 of the model, therefore dating from the end of Stage 10 (the same age as the gravel at the Globe Pit site — see below). The importance of the fossiliferous beds at Purfleet is heightened by the destruction of the last remaining exposures of the Grays brickearth (see below, Globe Pit), which is also considered to have accumulated during Oxygen Isotope Stage 9.

## Conclusions

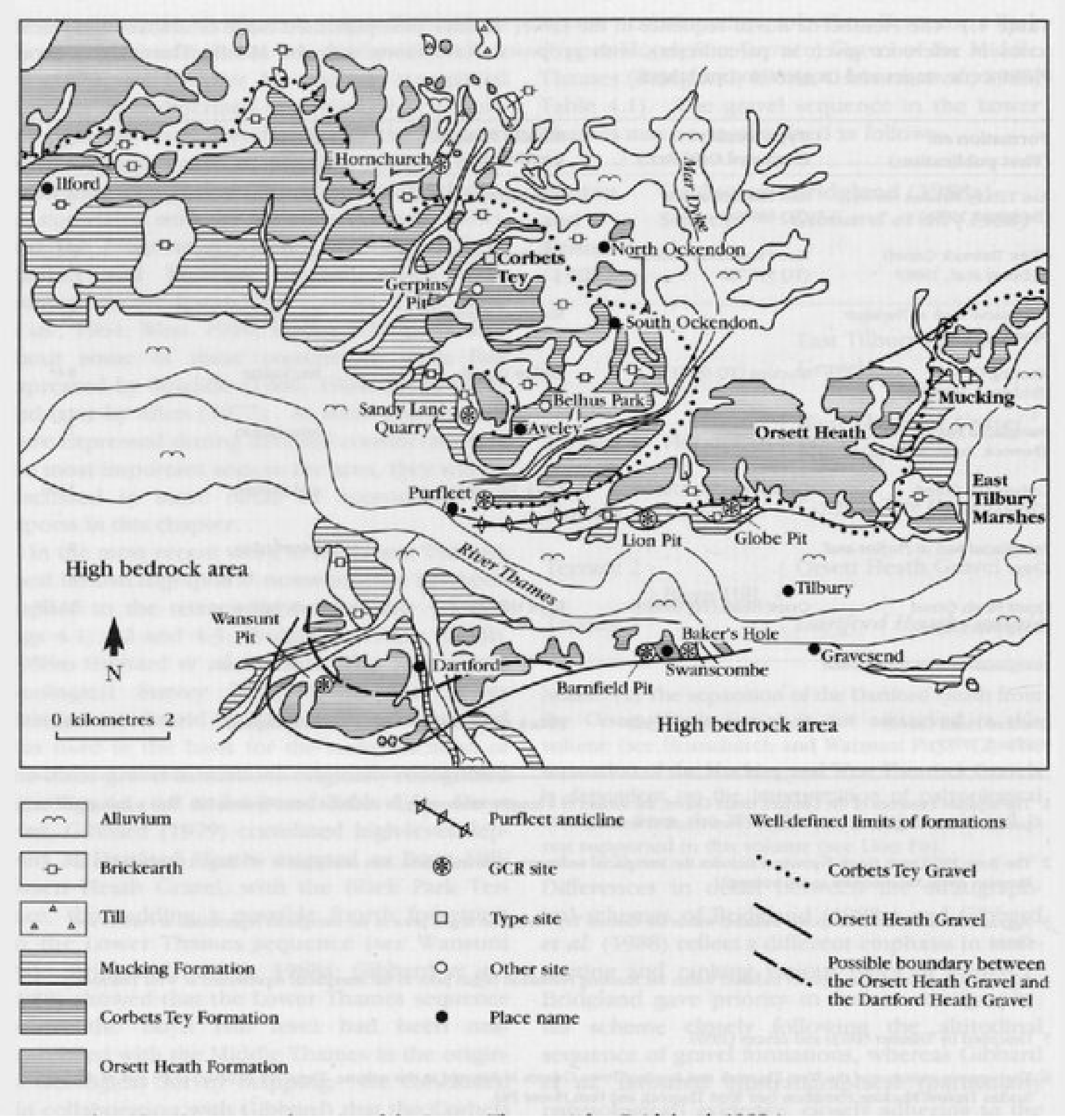
The various sections at Purfleet can be pieced together to provide a detailed record of the sediments that make up the Corbets Tey Gravel, which forms the second of the three terraces preserved on the Essex side of the Lower Thames valley. The picture that emerges is one of widespread cold-climate gravel aggradation, following the more localized deposition of fossiliferous sediments during an interglacial. The gravels contain Lower Palaeolithic (early Stone Age) flint artefacts — these are particularly abundant at the Botany and Esso Pits. The lowest gravels, beneath and/or part of the interglacial beds, contain artefacts belonging to the early and rather primitive Clactonian industry, whereas the later gravels contain the important addition of later types, including material flaked using the 'Levallois technique' (a distinctive method of flint working that produced artefacts of characteristic types). This appearance of Levallois material, implying the first use of this technique after the interglacial represented at Purfleet, is the earliest in the Lower Thames sequence and is of considerable stratigraphical importance.

The age of the interglacial at Purfleet is controversial. On the basis of rather meagre pollen evidence it has been correlated with the last interglacial, only 120,000 years BP. This view is contradicted by the rich molluscan assemblage from Bluelands and Greenlands Quarries, which indicates that the sediments are older than the accepted last interglacial site at Trafalgar Square. The relations of this site to the terrace sequence in the Lower Thames suggests that the second of four post-Anglian interglacials is represented at Purfleet, implying correlation with Stage 9 of the deep-sea record and an age of around 300,000 years BP.

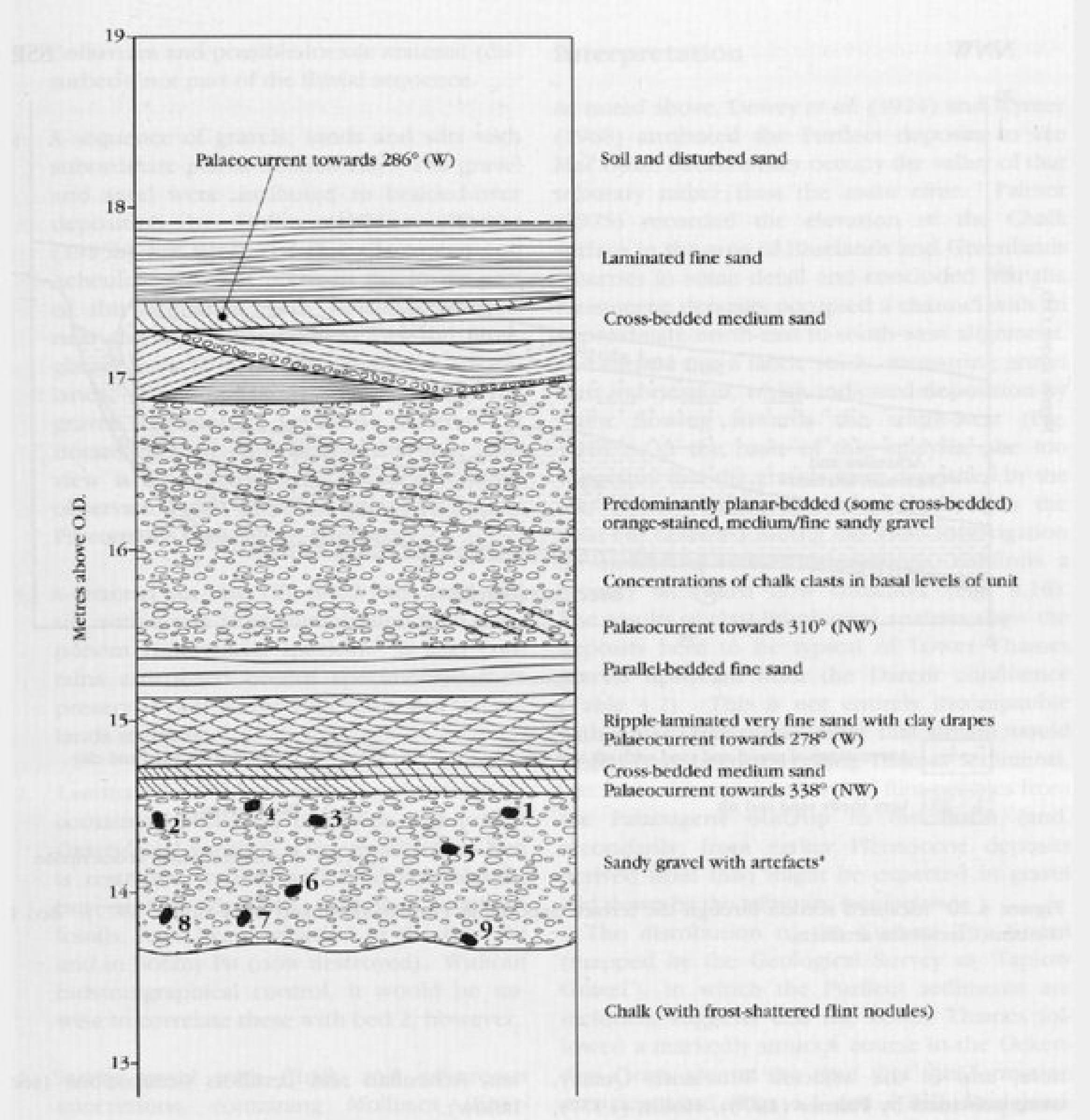
**References**




(Figure 4.18) (A) Map showing the location of the various exposures at Purfleet; (B) the extent of the Thames floodplain in the Purfleet area during the deposition of the Corbets Tey Gravel. Note that where the floodplain passed through the Chalk outcrop of the Purfleet Anticline it was considerably restricted.




*(Figure 4.1) The Pleistocene deposits of the Lower Thames (after Bridgland, 1988a).*




*(Figure 4.19) Section excavated in the Esso Pit by the GCR Unit in 1986. * Artefacts from the sandy gravel immediately overlying the Chalk are as follows (numbered on the figure): (1) undiagnostic sharp flake; (2) large preparation flake in sharp condition; (3) small cortical flake that may have formed naturally in the river's bed load; (4) undiagnostic hard-hammer flake in slightly rolled condition; (5) broken flake (the break probably occurred at the time of knapping); (6) broken unstained flake that may have formed naturally in the river's bed load; (7) core, utilizing a broken nodule — approximately four flakes have been removed by alternate flaking; (8) small sharp flake that may have formed naturally in the river's bed load; (9) a sharp flake, thick in section (particularly towards the distal end), with semi-converging scars on the dorsal surface — flakes of this type are produced during the shaping of hand-axes. Other material was found elsewhere at the site. The collection has been lodged with the British Museum. Archaeological determinations by P. Harding.*

| Gravel | Site | Sample | Flint: Tertiary | Flint: Nodular | Flint: Total | Chalk: (1)Chalk | Southern: Gnsd chert | Southern: Total | Exotics: Quartz | Exotics: Quartzite | Exotics: Carb chert | Exotics: Rhax chert | Exotics: Igneous | Exotics: Total | Ratio (qz:qzt) | Total count | National Grid Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **East Tilbury** | E.Tilbury Mshs | 1 D | 58.9 | 9.9 | 96.2 | | 0.9 | 1.1 | 0.9 | 0.7 | 0.5 | 0.3 | 0.3 | 2.7 | 1.40 | 745 | TQ 6880 7843 |
| **Marshes Gr.** | *11.2-16* | *1 D* | *49.5* | *6.6* | *92.2* | | *1.5* | *1.6* | *3.2* | *1.4* | *0.6* | *0.2* | *0.1* | *6.1* | *2.21* | *979* | |
| **Mucking** | Lion Pit - lwr gravel | 1 D | 47.8 | 35.9 | 97.5 | (1.1) | 0.7 | 0.7 | 0.7 | 1.1 | | | | 1.8 | 0.67 | 276 | TQ 5978 7821 |
| **Gravel** | ('floor') *11.2-16* | *1 D* | *50.2* | *19.6* | *95.7* | *(0.3)* | *0.6* | *0.6* | *1.8* | *0.9* | *0.6* | | *0.3* | *3.7* | *2.00* | *327* | |
| | upper gravel (2) | 2 D | 67.1 | 5.9 | 95.3 | | 0.8 | 0.8 | | 3.5 | | | | 3.9 | | 255 | TQ 5978 7809 |
| | *11.2-16* | *2 D* | *59.4* | *3.2* | *94.2* | | *1.1* | *1.1* | *1.9* | *1.5* | *0.4* | *0.4* | | *4.7* | *1.29* | *465* | |
| | Mucking | 1A D | 64.0 | 9.3 | 97.0 | | 1.1 | 1.1 | 0.9 | 0.6 | | 0.1 | | 1.8 | 1.50 | 708 | TQ 6892 8154 |
| | *11.2-16* | *1A D* | *57.7* | *4.9* | *92.1* | | *1.9* | *1.9* | *3.1* | *1.2* | *1.1* | *0.2* | *0.1* | *6.0* | *2.55* | *901* | |
| | | 1B D | 37.4 | 13.3 | 92.5 | | 4.9 | 4.9 | 1.2 | 0.6 | 0.6 | 0.3 | | 2.6 | 2.00 | 345 | |
| **Corbets Tey** | Stifford | 1A | 51.6 | 8.4 | 94.0 | | 0.4 | 0.4 | 2.9 | 1.2 | 0.6 | 0.1 | 0.4 | 5.5 | 2.33 | 730 | TQ 5900 7908 |
| **Gravel** | | 1B | 52.5 | * | 92.9 | | 0.9 | 1.0 | 3.5 | 1.4 | 0.5 | 0.1 | | 5.9 | 2.46 | 918 | |
| | *11.2-16* | *1B* | *39.2* | *8.3* | *88.3* | | *1.1* | *1.4* | *6.0* | *2.6* | *1.1* | *0.2* | *0.1* | *10.3* | *2.30* | *1277* | |
| | Bellhus Park, organic bed (3) | 1 | 47.5 | 9.8 | 90.2 | (0.3) | 0.7 | 0.7 | 2.0 | 4.4 | 2.0 | 0.7 | | 9.1 | 0.46 | 297 | TQ 575811 |
| | Bellhus Park, upper gravel (3) | 1 | 49.0 | 9.7 | 93.8 | | | | 3.5 | 1.4 | 0.7 | | 0.7 | 6.2 | 2.50 | 145 | |
| | Purfleet, Esso Pit | 1A | 44.8 | 16.9 | 91.8 | | 0.5 | 0.5 | 2.5 | 3.0 | 1.6 | | | 7.4 | 0.82 | 366 | TQ 5607 7837 |
| | *11.2-16* | *1A* | *36.3* | *7.6* | *86.6* | | *1.0* | *1.1* | *3.9* | *3.7* | *3.1* | *0.5* | *0.2* | *11.7* | *1.04* | *618* | |
| | | 1B | 47.7 | 18.1 | 95.0 | (37.5) | 1.5 | 1.5 | 0.8 | 1.5 | 0.8 | 0.4 | | 3.5 | 0.50 | 260 | |
| | Globe Pit | 1 D | 57.9 | 11.2 | 93.1 | | 3.2 | 3.5 | 0.8 | 1.1 | 1.1 | 0.2 | | 3.4 | 0.71 | 653 | TQ 6251 7830 |
| | | 2 D | 50.2 | 10.5 | 93.2 | | 3.1 | 3.1 | 1.3 | 0.7 | 0.7 | 0.8 | | 3.7 | 2.00 | 617 | TQ 6251 7828 |
| | *11.2-16* | *2 D* | *40.7* | *5.4* | *90.5* | | *4.4* | *4.7* | *2.1* | *0.8* | *1.2* | *0.2* | *0.1* | *4.5* | *2.73* | *1456* | |
| | | 3 D | 64.6 | 8.9 | 94.4 | | 2.4 | 2.4 | 1.5 | 1.0 | 0.4 | | | 3.2 | 1.40 | 463 | TQ 6251 7827 |
| | Barvills Fm Pit | 1 D | 67.9 | 11.8 | 92.9 | | 3.3 | 3.3 | 1.7 | 1.1 | 0.4 | 0.1 | | 3.6 | 1.50 | 722 | TQ 6811 7774 |
| | *11.2-16* | *1 D* | *55.6* | *5.6* | *91.8* | | *2.7* | *2.9* | *2.2* | *1.1* | *1.1* | *0.3* | *0.3* | *5.3* | *2.08* | *1138* | |
| **Orsett Heath** | Hornchurch | 1 | 41.8 | 0.7 | 92.6 | | 2.3 | 2.3 | 2.0 | 1.4 | 0.6 | 0.6 | | 5.1 | 1.17 | 352 | TQ 5464 8739 |
| **Gravel** | railway cutting | 2 | 28.9 | 11.7 | 90.2 | | 1.6 | 1.9 | 1.9 | 2.3 | 1.6 | 0.9 | 0.9 | 7.9 | 0.80 | 429 | TQ 5464 8739 |
| | Hornchurch Dell | 1 | 54.0 | 7.7 | 91.7 | | 1.5 | 1.5 | 2.1 | 2.8 | 1.2 | 0.4 | | 6.7 | 0.78 | 676 | TQ 5440 8675 |
| | Globe Pit North (4) | 1A D | 41.4 | 9.0 | 90.4 | | 4.1 | 4.4 | 0.6 | 1.4 | 1.6 | 0.3 | | 5.2 | 0.40 | 365 | TQ 6245 7855 |
| | Linford | 1 D | 64.6 | 11.6 | 96.0 | | 2.2 | 2.4 | 0.7 | | 0.2 | | 0.2 | 1.7 | | 424 | TQ 6681 8028 |
| | | 2 D | 84.2 | 4.0 | 95.7 | | 1.4 | 1.6 | | 0.5 | | 0.2 | 1.2 | 2.7 | | 625 | TQ 6681 8028 |
| | *11.2-16* | *2 D* | *28.0* | *3.6* | *91.3* | | *1.1* | *1.2* | *3.9* | *2.3* | *0.6* | *0.2* | *0.5* | *7.4* | *1.73* | *665* | |
| **Swanscombe** | Barnfield Pit 1 | 1 D | 58.2 | 9.8 | 93.9 | | 0.9 | 1.2 | 2.4 | 1.8 | 0.5 | | | 4.8 | 1.37 | 1081 | TQ 5973 7430 |
| **Lower Middle** | *11.2-16* | *1 D* | *50.9* | *5.3* | *89.9* | | *2.1* | *2.3* | *4.4* | *2.0* | *0.8* | | *0.1* | *7.7* | *2.21* | *1703* | |
| **Gravel** | | 2 D | 48.5 | 12.7 | 92.7 | | 1.9 | 2.0 | 1.9 | 1.8 | 0.5 | 0.1 | 0.2 | 5.0 | 1.05 | 992 | TQ 5973 7430 |
| | *11.2-16* | *2 D* | *41.6* | *5.5* | *89.7* | | *3.0* | *3.1* | *3.5* | *1.5* | *0.5* | *0.2* | *0.2* | *6.8* | *2.42* | *1785* | |
| **Swanscombe** | Barnfield Pit | 3 D | 55.5 | 8.3 | 94.3 | | 1.0 | 1.0 | 2.3 | 1.3 | 0.5 | 0.2 | 0.1 | 4.5 | 1.75 | 931 | TQ 5974 7430 |
| **Lower** | *11.2-16* | *3 D* | *36.5* | *5.9* | *89.0* | *(9.1)* | *2.5* | *2.7* | *4.0* | *2.9* | *0.5* | *0.1* | *0.1* | *8.3* | *1.40* | *1391* | |
| **Gravel** | | 4 D | 30.5 | 11.8 | 94.1 | (0.4) | 2.7 | 2.8 | 1.1 | 0.8 | 0.4 | 0.1 | | 2.7 | 1.29 | 857 | TQ 5974 7430 |
| | *11.2-16* | *4 D* | *28.1* | *8.8* | *90.6* | *(0.3)* | *3.5* | *3.8* | *2.7* | *1.5* | *0.9* | *0.2* | | *5.6** | *1.74* | *1494* | |

* Not separately recorded

*D* (after sample number) indicates that the sample concerned came from downstream of the contemporary Darent confluence.

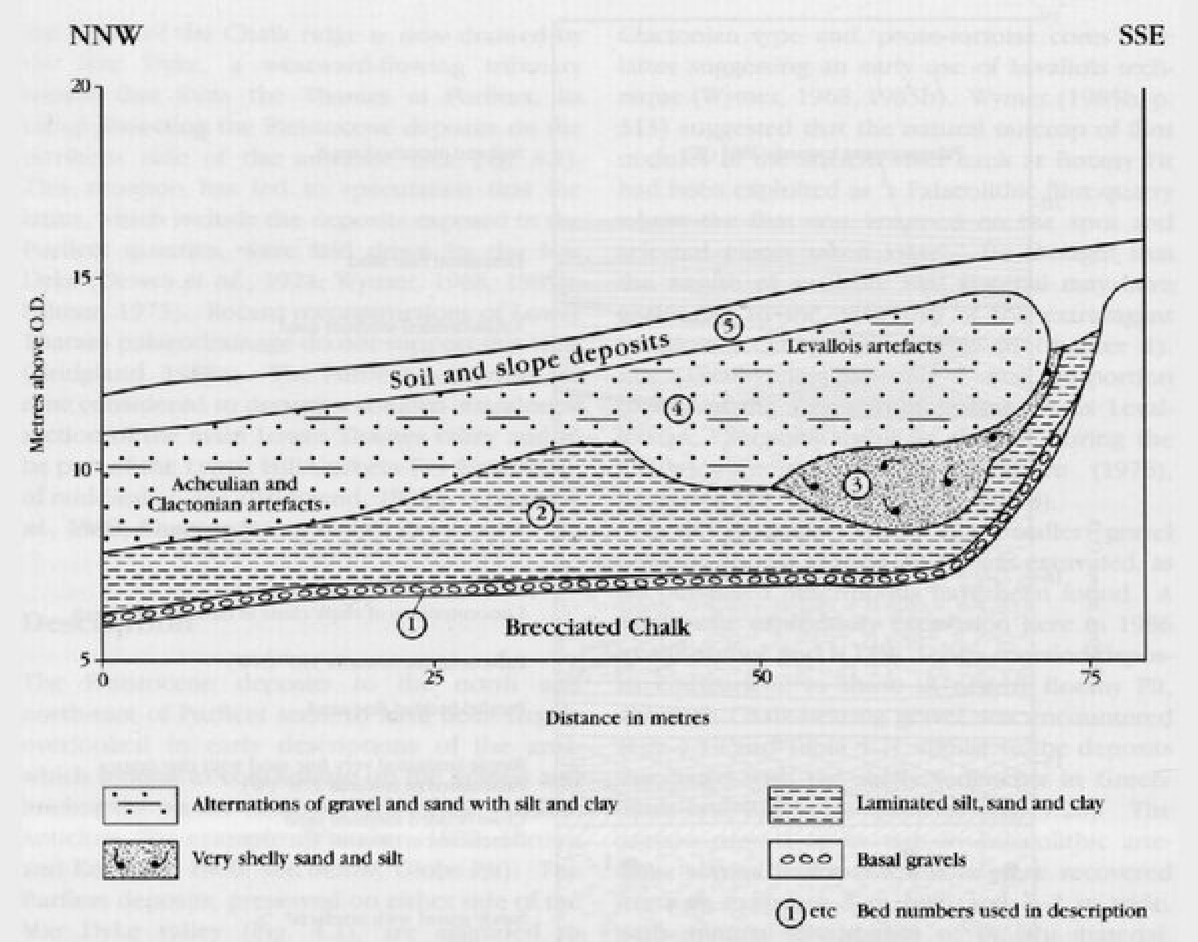
(1) -Chalk, a non-durable, is only present locally and was therefore excluded from calculations, but shown instead as a % of the total durable material.

(2) Lion Pit tramway cutting sample 2 is from the upper gravel in section 2;

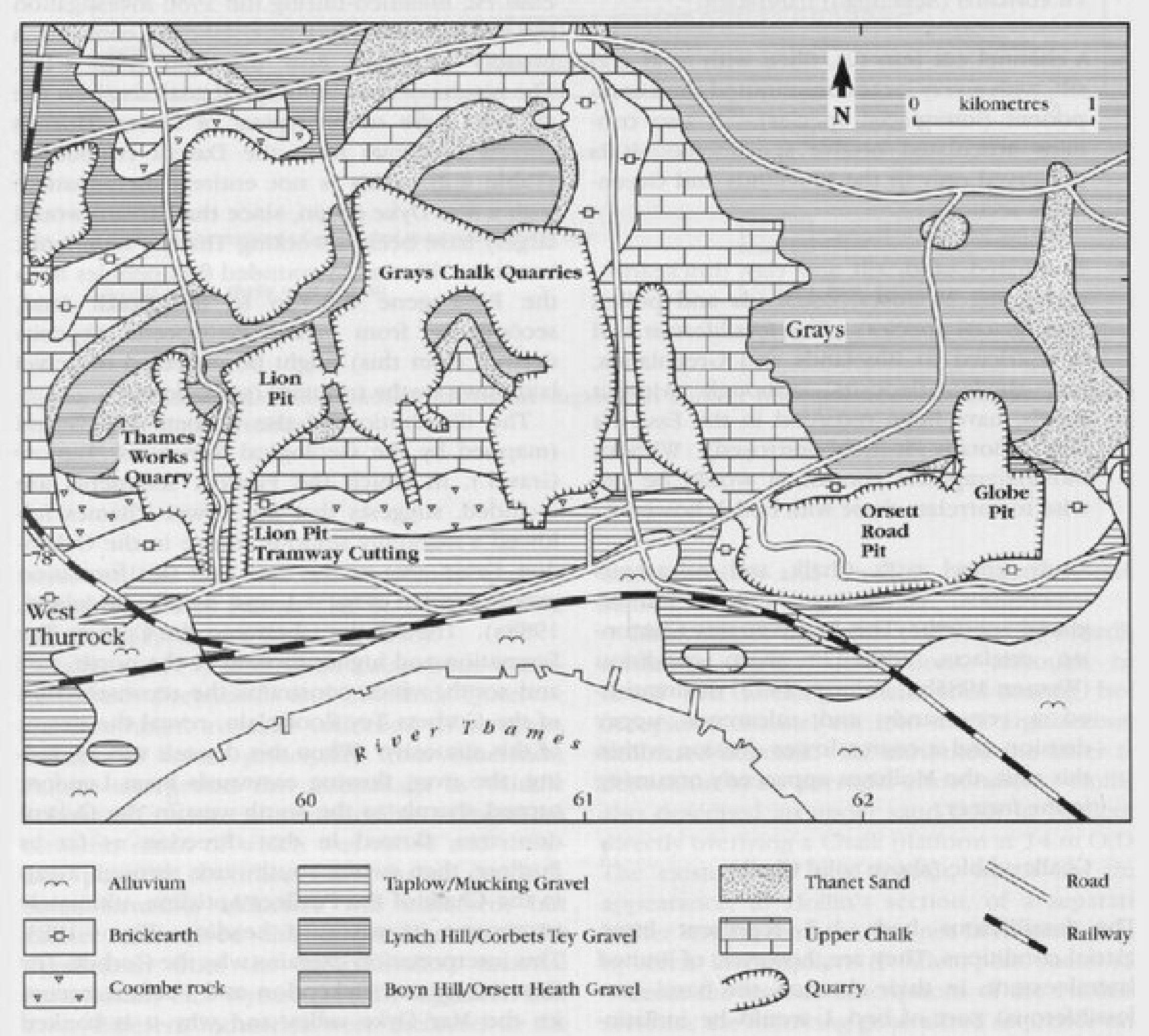
(3) The Bellhus Park samples are from the organic sediments within the Corbets Tey Formation and from the gravel overlying the organic sediments;

(4) The Globe Pit North sample is from the Orsett Heath Gravel outcrop in the northern part of the old workings, outside the GCR site.

*(Table 4.2) Clast-lithological data from the Lower Thames. All counts by the author, at 16–32 mm size range, except those in italics, which are 11.2–16 mm counts. Note that non-durables (including Chalk) are excluded from the calculations, but Chalk is shown in this table as a relative % of the total durables.*




*(Figure 4.20) Idealized section through the terrace deposits at Purfleet (modified from Hollin, 1977). Bed 1 contains Clactonian artefacts.*




*(Figure 4.21) Map showing the various sites in the Thurrock-Grays area.*

| **Formation *etc* (First publication)** | **Type locality (National Grid Ref.)** | **Middle Thames equivalent** | **Stage** | **$^{18}O$** |
|---|---|---|---|---|
| East Tilbury Marshes Gravel (Bridgland, 1983b) | East Tilbury Marshes (TQ 688784) | Kempton Park Gravel | mid to late Devensian | 6-2[7] |
| (West Thurrock Gravel) (Gibbard *et al.*, 1988)[6] | Lion Pit tramway cutting (TQ 597779) | (Reading Town Gravel)[6] | (early Devensian) | (?5d) |
| *Interglacial Beds at Trafalgar Square* | | Brentford deposits[5] | Ipswichian | 5e |
| Mucking Gravel (Bridgland, 1983b) | Mucking (TQ 689815) | Taplow Gravel | late Saalian | 8-6[4] |
| *Interglacial beds at West Thurrock, Aveley etc.* | | | Intra-Saalian | 7 |
| Corbets Tey Gravel (Gibbard, 1985) | Corbets Tey (TQ 570844) | Lynch Hill Gravel | mid-Saalian | 10-8[3] |
| *Interglacial beds at Purfleet and Grays* | | | Intra-Saalian | 9 |
| Orsett Heath Gravel (Bridgland, 1983b) | Orsett Heath (TQ 668803) | Boyn Hill Gravel | early Saalian | 12-10[2] |
| *Interglacial beds at Swanscombe* | | | Hoxnian *sensu* Swanscombe | 11[2] |
| (Dartford Heath Gravel) (Gibbard, 1979)[1] | Wansunt Pit (TQ 5147360) | (?Black Park Gravel) | (late Anglian) | (12) |

1 The separate existence of the Dartford Heath Gravel, the subject of a lengthy controversy, is doubtful (see Wansunt Pit). This is thought to be part of the late Anglian to early Saalian Orsett Heath Formation.

2 The Boyn Hill/Orsett Heath Formation includes the interglacial sediments at Swanscombe, here attributed to $^{18}O$ Stage 11 (referred to as Hoxnian *sensu* Swanscombe in this volume).

3 Aggradation of the terrace deposits included within the Corbets Tey Formation began prior to the interglacial represented at Purfleet and Grays.

4 Aggradation of the terrace deposits included within the Mucking Formation began prior to the interglacial represented at West Thurrock, Aveley etc.

5 Described by Trimmer (1813) and Zeuner (1959).

6 The separate existence of the West Thurrock and Reading Town Gravels is disputed in this volume. These are believed to be part of the late Saalian Taplow/Mucking Formation (see West Thurrock and Fern House Pit).

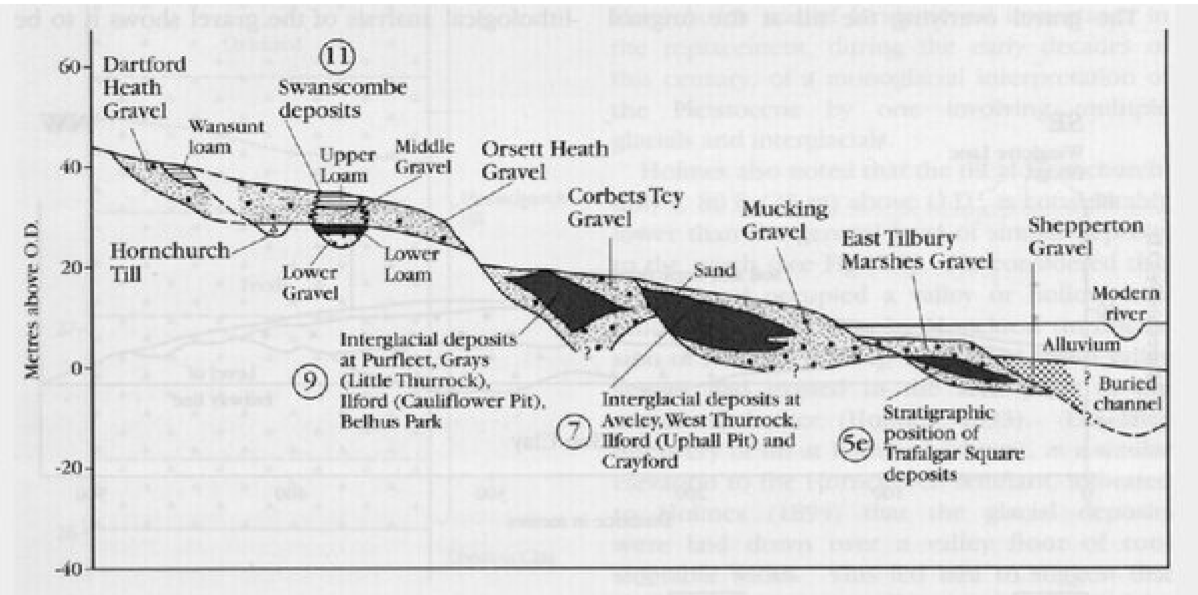
7 The Ipswichian sediments at Trafalgar Square and Brentford are regarded here as part of the Kempton Park Formation (see Chapter 3, Fern House Pit). This formation is considered to represent aggradation from the end of Stage 6 (gravel underlying the Trafalgar Square sediments, the Spring Gardens Gravel of Gibbard, 1985) to the mid-Devensian.

*(Table 4.1) The Pleistocene fluvial sequence in the Lower Thames (first published usage of lithostratigraphical terms in reference given in parentheses), with proposed correlations with the Middle Thames sequence, Pleistocene stages and oxygen isotope stages.*

| Age (in thousands of years) | Upper Thames | Middle Thames | Lower Thames | Essex | Stage | ¹⁸O |
|---|---|---|---|---|---|---|
| 10 | Recent floodplain and channel deposits. Holocene alluvium of floodplain and coast | | | | Holocene | 1 |
| 71 | Northmoor Gravel | Shepperton Gravel | Submerged | Submerged | late Devensian | 2-4 |
| | Rejuvenation event | | | | | |
| ? | | Temperate climate deposits at South Kensington (Natural History Museum), Isleworth and Kempton Park | Submerged | Submerged | early/mid Devensian? interstadial(s) | 5a &/or 5c? |
| 122 | Cold climate gravels above Eynsham Gravel | **Reading area** U. levels of Taplow Gravel; **Slough area** Kempton Park Gravel | East Tilbury Marshes Gravel | Submerged | early-mid Devensian | 5d-2 |
| 128 | Eynsham Gravel | Within Taplow Formation; Trafalgar Square and Brentford deposits | Below floodplain | Submerged | Ipswichian (sensu Trafalgar Square) | 5e |
| | Stanton Harcourt Gravel | Taplow Gravel; Basal Kempton Pk Gravel - incl. Spring Gardens Gravel of Gibbard (1985) | Basal East Tilbury Marshes Gravel | Submerged | late Saalian | 6 |
| | Rejuvenation event | | | | | |
| 186 | | Taplow Gravel | Mucking Gravel | | | |
| 245 | Stanton Harcourt Channel Deposits, interglacial Magdalen Grove, Summertown etc. | Interglacial deposits at Redlands Pit, Reading | Interglacial deposits at Aveley, Ilford (Uphall Pit), West Thurrock, Crayford and Northfleet | Submerged | Intra-Saalian temperate episode | 7 |
| | Basal Summertown-Radley Formation at some sites? | Basal Taplow Gravel? | Basal Mucking Gravel | Submerged | | |
| | Rejuvenation event | | | | mid-Saalian | 8 |
| 303 | Wolvercote Gravel at some sites? | Lynch Hill Gravel | Corbets Tey Gravel | Barling Gravel | | |
| 339 | Wolvercote Channel Deposits | | Interglacial deposits at Ilford (Cauliflower Pit), Belhus Park, Purfleet and Grays | Shoeburyness Channel interglacial deposits | Intra-Saalian temperate episode | 9 |
| | Basal Wolvercote Gravel | Basal Lynch Hill Gravel? | Basal Corbets Tey Gravel | Shoeburyness Channel - basal gravel | | |
| | Rejuvenation event | | | | early Saalian | 10 |
| | ? Moreton Drift (Arkell, 1947a) | | | | | |
| ? | Hanborough Gravel | Boyn Hill Gravel | Orsett Heath Gravel | Southchurch/Asheldham/Mersea Island/Wigborough Gravel | | |
| 423 | Reworked mammalian fauna in Hanborough Gravel | | Swanscombe deposits | Southend/Asheldham/Cudmore Grove/Clacton Channel Deposits | Hoxnian (sensu Swanscombe) | 11 |
| | Basal Hanborough Gravel? | Basal Boyn Hill Gravel? | Basal Orsett Heath Gravel (incl. Basal Gravel at Swanscombe) | Southend/Asheldham/Cudmore Grove/Clacton Channel - basal gravel | | |
| | Rejuvenation event | | | | | |
| | Freeland Formation | Black Park gravel | | | | |
| | Moreton Drift? | Anglian glacial deposits | Hornchurch Till | U. St Osyth/U. Holland Gravel | Anglian | 12 |
| 478 | Freeland Formation | Winter Hill/Westmill Gravel | Valley did not exist as a Thames course prior to this | St Osyth/Holland Formation | | |
| ? | Sugworth Channel Deposits | Rassler Gravel? | | Wivenhoe/Cooks Green Fm; Ardleigh*/St Osyth Formation; Waldringfield Gravel | Cromerian Complex | 21-13 |
| | Combe Formation | Gerrards Cross Gravel | | Bures Gravel* | Early Pleistocene | pre 21 |
| | Higher divisions of the Northern Drift Group | Beaconsfield Gravel; Satwell Gravel; gravel at Chorleywood; Westland Green Gravels; Stoke Row Gravel; Nettlebed Gravel; Nettlebed interglacial deposits | | Moreton Gravel*; Stebbing Gravel* | | |

* Nomenclature for High-level Kesgrave Subgroup in Essex follows Whiteman (1990).

(Table 1.1) Correlation of Quaternary deposits within the Thames system. Rejuvenations that have occurred since the Anglian glaciation are indicated.




(Figure 4.3) Idealized transverse section through the terraces of the Lower Thames. The odd-numbered (warm) oxygen isotope stages to which the various interglacial deposits are attributed are indicated (numbers in circles). The *stratigraphical position of the Trafalgar Square deposits is shown.*