Brimpton Gravel Pit

[SU 568 651]

D.R. Bridgland

Highlights

Faunal and floral remains from silts and organic muds within the gravel sequence at this site provide unique but controversial evidence for reconstructing Middle and/or Late Pleistocene conditions in Britain. Although it has been argued that the biostratigraphical evidence here shows two interstadial and three stadial phases within the Devensian Stage, much of the sequence may prove to be pre-Devensian in age.

Introduction

Brimpton Gravel Pit, Berkshire, was operational during the late 1970s and early 1980s. It exploited the Thatcham Terrace deposits of the tributary Kennet valley (Chartres *et al*., 1976). It is a site of major importance for Upper Pleistocene (possibly upper Middle Pleistocene) stratigraphy and palaeoclimatic reconstruction in Britain. Beds of silts and organic muds within a gravel sequence here provide a biostratigraphical record of two interstadial periods and at least three stadials (Bryant and Holyoak, 1980; Bryant *et al.,* 1983).

This is the type locality of the Brimpton Interstadial, as yet unknown elsewhere in Britain. Bryant *et al.* (1983) attributed the entire Brimpton sequence to the Devensian Stage, regarding the Brimpton Interstadial as a temperate interlude intermediate between the Chelford and Upton Warren interstadials within the British sequence. This view, based on biostratigraphical correlation between sediments at Brimpton and the Chelford type locality, is challenged here on the grounds that terrace correlation between the Thames and Kennet valleys implies that a pre-Devensian age for part of the Brimpton sequence is also possible.

Description

The Brimpton site is located on a low gravel-covered interfluve between the valleys of the Kennet and its tributary, the River Enborne (Figure 3.1). The original land surface at the site was 6–7 m above the Kennet floodplain, forming part of a terrace feature that continues westwards (upstream) in the Kennet valley and southwards into the Enborne valley. This feature is the Thatcham Terrace of Chartres *et al.* (1976), which appears to be a continuation, in the Kennet valley, of the Taplow Terrace as recognized in the Reading area (see above, Fern House Pit; (Figure 3.3)).

The sediments at Brimpton were progressively exposed as the working face moved westwards, between late 1979 and early 1982. At no time was the complete stratigraphical sequence visible. The deepest part of the pit coincided with a depression in the London Clay, *c.* 10 m deep and filled with bedded gravel. The available sections suggested this to be an enclosed basin, possibly representing a scour-hollow excavated at the confluence of the Kennet and Enborne rivers (Bryant *et al.,* 1983).

Lenses and more widespread bands of clay, silt and sand occur throughout the gravel sequence at Brimpton, with clasts of these lithologies occurring in the uppermost 3 m. The matrix of the upper 1–3 m of the gravels contains significant silt and clay, whereas these are generally scarcer in the matrix of the lower gravels. The division between upper (silty) gravels and lower (sandy) gravels is indistinct in some places but sharp in others, often cutting across bedding structures.

Persistent searching in the less oxidized of various clay units within the gravel sequence yielded pollen and Mollusca from numerous levels, as well as plant macrofossils and beetles from a few (Bryant *et al.,* 1983). A sequence of alternating woodland and open-country assemblages was recognized, providing the basis for a biostratigraphical subdivision of the Brimpton sediments. From the palynological succession Bryant *et al.* (1983) deduced that a complex sequence of climatic fluctuations, which they regarded as stadials and interstadials, was represented.

(Table 3.4) Stratigraphy of the Thatcham Terrace deposits at Brimpton (after Bryant *et al.,* 1983).

Lithology	*** — Local pollen zones**	**Interpretation/age**
1. Upper silty gravels	F — Non-arboreal pollen	Cold (stadial) late mid-Devensian (^{14}C 27,400 ± 1250 BP (BM-1638))
2. Lower sandy gravels	E — *Gramineae–Betula–Pinus*	Brimpton Interstadial
	D — Cyperaceae–Betula	Cold (stadial)
	C — *Betula–Pinus–Picea*	Chelford Interstadial
	B — Non-arboreal pollen	Cold (stadial)
	A — Non-arboreal *pollen–Betula–Pinus*	Late Ipswichian or Wretton Interstadial

The sequence of fossiliferous beds or lenses, all separated one from another by gravel beds, is as shown in (Table 3.4) (interpretations follow Bryant *et al.,* 1983; see also (Figure 3.19)). The earliest stratigraphical level from which botanical evidence was obtained (A, (Figure 3.19) and (Figure 3.20)) yielded a pollen assemblage with birch (11%), pine (16%), willow (9%) and occasional oak and spruce. Local grassland was suggested by abundant pollen of Gramineae (25%) and occasional grains from grassland herbs. Heathland, waterside and aquatic species were also represented in an assemblage suggestive of temperate (interstadial or late interglacial) conditions. There was support for this interpretation from a plant macrofossil assemblage that included pine and various herb remains. The occurrence of a single fruit of hornbeam (*Carpinus*), an indicator of fully interglacial conditions, was attributed to reworking, as this species was not represented amongst the pollen spectra (Bryant *et al.,* 1983). This level also produced 15 aquatic and four terrestrial molluscan species, including *Vallonia pulchella* (Müller), *Trichia hispida* and *Pisidium supinum* (Schmidt), all of which are regarded as thermophilous taxa in the British Devensian. Their presence, and the overall richness of the fauna, lend support to the interpretation, based on the palaeobotany, of this level as temperate (Bryant *et al.,* 1983).

The second level from which evidence was obtained (B, (Figure 3.19)) was a silty bar-top drape. This yielded pollen, comprising 55–62% Cyperaceae, 5–10% Gramineae and less than 3% tree pollen (Figure 3.20). Bryant *et al.* (1983) regarded this assemblage as indicative of the typical open vegetation of full stadial conditions, with trees largely absent. They claimed support for this interpretation from an impoverished molluscan fauna, also obtained from this level, comprising three freshwater species (*Anisus leucostoma* (Millet), *Lymnaea peregra* (Müller) and *Pisidium nitidum*) and three terrestrial species, all of which today tolerate arctic conditions.

At a slightly higher stratigraphical level, unoxidized clay/silt bar-top drapes and/or small channel-fills were found to contain abundant well-preserved pollen (C, and C_2, (Figure 3.19) and (Figure 3.20)). Of these, C_2 also yielded plant macrofossils and molluscs, whereas C, yielded nine species of Coleoptera. These levels were dominated by tree pollen (62–76%), principally birch and pine, both also represented amongst the macrofossils. Spruce formed an abundant element of the latter, but only 1–4% of the pollen. As this tree is not a high pollen producer, these facts suggest that it was an important species in local forests at the time of deposition. Occasional grains of oak and alder were also encountered. The remainder of the plant community appears to have included both shade-tolerant (forest) and open-habitat taxa, the latter possibly growing close to the river. The freshwater molluscan fauna was similar to that from the previous level (B), but the land fauna was significantly different and highly distinctive. It included the boreal forest snail *Discus ruderatus* (Férussac), only previously recorded from interglacials in Britain, and a species found only in interglacials and in the Late Devensian, *Nesovitrea hammonis* (Ströns). Although these snails extend today into the Arctic region, their presence was seen by Bryant *et al.* (1983) to provide some support for the palaeobotanical evidence for climatic amelioration at this level. Further support for this view came from the beetles, which were considered indicative of an environment similar to central and southern Fennoscandia at the present time, with much colder winters and slightly cooler summers than are currently experienced in southern Britain.

The fourth pollen-bearing level (D, (Figure 3.19) and (Figure 3.20)), another set of bar-top drapes, yielded sparse pollen dominated by non-arboreal types. This material actually comes from seven samples at slightly different stratigraphical levels, but their similarity suggests that they represent the same biozone, one characterized by open-vegetation species (Bryant *et al.,* 1983). This interpretation is supported by the limited molluscan fauna from the same levels, comprising taxa tolerant of arctic conditions (such as *Columella columella* and *Pupilla muscorum*), all known from Devensian stadial sediments.

The fifth fossiliferous level to be recognized was represented in silt drapes and channel-fills within the remainder of the lower sandy gravel at Brimpton (E, (Figure 3.19)). Tree pollen was markedly and consistently more abundant in these silts than in level D, although the overall assemblage is suggestive of a combination of open habitats and birch–pine woodland (Figure 3.20). This evidence for a further temperate interval is supported by a diverse molluscan assemblage that includes taxa characteristic of shallow water bodies with plentiful vegetation (*Valvata cristata* (Müller) and *Anisus leucostoma*).

Finally, pollen and plant macrofossils occur at a number of different levels within the upper silty gravel, in lenses and clasts of fine-grained sediment. Some of these are richly fossiliferous and have yielded notably varied macrofossil floras as well as pollen, mollusc and beetle remains. The pollen and plant macrofossils point to open, treeless conditions with northern and arctic–alpine species well represented. Molluscs likewise suggest stadial conditions, with a preponderance of open-habitat terrestrial species such as *P. muscorum.* With the exception of a small sample from the highest levels (see below), all the molluscs present have modern ranges extending into the Arctic and all are known from stadial deposits in Britain. Certain samples within the upper silty gravel yielded insect remains, including a wide range of beetles. Amongst these, those species that have restricted climatic ranges suggest temperatures colder than at present (*Amara quenseli* (Schoenberr), *A. torrida* (Panzer), *Otiorhynchus nodosus* (Müller), *Notaris aethiops* and *Tachinus jacuticus* Poppius), although with little indication of the degree of severity (Bryant *et al.,* 1983).

Radiocarbon dating of willow twigs from near the base of the upper silty gravel (F, and F_2, (Figure 3.19)) has indicated ages of 29,500 ± 460 years BP and 26,340 ± 1210 years BP, respectively (mid-Late Devensian). This is the only geochronometrical dating evidence from the site, the attribution of the lower sandy gravel to the Devensian relying on the recognition, from faunal similarities, of the Chelford Interstadial within the Brimpton sequence.

Interpretation

The significance of the Brimpton site stems from the complex biostratigraphy that has been demonstrated, largely on the basis of palynology, from the sequence there. Six pollen assemblages have been recognized at different stratigraphical levels (see above; (Figure 3.19) and (Figure 3.20)). Bryant *et al.* (1983) regarded the *Betula–Pinus–Picea* pollen assemblage (C, (Figure 3.19) and (Figure 3.20)) as equivalent to the Early Devensian Chelford Interstadial; pollen spectra from this level at Brimpton resemble those from the Chelford type locality (Simpson and West, 1958). This correlation is supported by the presence of macrofossils of Norway spruce (*Picea abies* (L.) Karsten) at both sites. If this correlation is accepted, the implication is that the lower temperate levels at Brimpton (A, (Figure 3.19 and (Figure 3.20)) represent either the latter part of the Ipswichian Stage or an earlier, pre-Chelford, Devensian interstadial. The higher temperate horizon (E, (Figure 3.19) and (Figure 3.20)) does not resemble the mid-Devensian Upton Warren Interstadial of Coope (Coope *et al.,* 1961) in its floral and faunal content, particularly since trees appear to have been present, whereas they are unknown from deposits of Upton Warren age. For this reason, level E was attributed to a hitherto unrecognized interstadial within the Devensian, named after the site at Brimpton (Bryant *et al.,* 1983). Deposits of Chelford Interstadial age have been reported from only a few sites in England (Shotton, 1977), the nearest to Brimpton being at Wretton, in Norfolk (West *et al.,* 1974). None of the sites hitherto attributed to this interstadial have yielded Mollusca, so the assemblage from Brimpton is of especial interest. It includes two snail species (*Vertigo substriata* (Jeffreys) and *Discus ruderatus*) that in Britain are otherwise known only from interglacial deposits (Bryant *et al.,* 1983).

The pollen spectra attributed to the Brimpton Interstadial (level E, (Figure 3.19 and (Figure 3.20)) show appreciable frequencies of *Betula* and *Pinus* (together reaching over 30% of the total pollen), leaving little doubt that these trees were growing in the region. The land-snail fauna from this level supports this evidence for a relatively temperate climate. As well as the aquatic taxa noted above (see above, Description), the occurrence of snails *Myxas glutinosa* (Müller), *Cochlicopa lubrica* (Müller), *Vallonia pulchella* and *Trichia bispida,* as well as the general diversity of the molluscan assemblage, suggests interstadial conditions (Bryant *et al.,* 1983).

The radiocarbon dates from the upper silty gravel (*c.* 27,000 years BP — see above) suggest that it was deposited late in the Devensian Stage. Sediments of similar age have been studied at Thrapston (Bell, 1969), Beckford (Briggs *et al.,* 1975a), Brandon (Shotton, 1968) and Great Billing (Morgan, 1969). Bryant *et al.* (1983) provided a full discussion of possible correlations between the Brimpton sequence and that from the post-Eemian period on the continent, where more complete sedimentary records exist. They tentatively suggested a correlation of the Brimpton Interstadial with the continental Odderade Interstadial. However, Bowen (1989; Bowen *et al.,* 1989) has recently suggested that the Upton Warren Interstadial equates with the Odderade Interstadial, attributing both to Oxygen Isotope Substage 5a. Bowen (1989, p. 44) expressed misgivings about the evidence from Brimpton; he considered that a fluvial sequence of this type, dominated by coarse-grained sediments, would inevitably be punctuated by unconformities and that 'extensive reworking and redeposition should be expected'.

Consideration of regional stratigraphical evidence in the Middle Thames and Kennet valleys suggests that the attribution of the entire Brimpton sequence to the Devensian Stage is open to question. The distribution and elevation of the deposits at Brimpton suggest that, with a surface 7–8 m above the present-day river, they form part of the Thatcham Terrace of the Kennet and/or Enborne, as defined by Chartres *et al.* (1976). Thomas (1961) included these deposits in the Lower Taplow Terrace of the Kennet, which he correlated with the terrace of the same name in the Middle Thames valley at Reading, originally described by Sealy and Sealy (1956). The Lower Taplow Terrace at Reading was redefined by Gibbard (1985) as the Reading Town Gravel. Gibbard assigned this aggradation to the Early Devensian and suggested a correlation with the Summertown-Radley Terrace of the Upper Thames, the deposits of which (Stanton Harcourt Gravel) had also been ascribed to the Devensian (Seddon and Holyoak, 1985; Chapter 2, Stanton Harcourt and Magdalen Grove). These various terrace correlations, which would appear to be in close agreement with the supposed Dev-ensian age of the Brimpton deposits, are supported by the reappraisal of terrace correlation within the Thames catchment, outlined in Chapter 1.

However, there are strong grounds for attributing the deposits at Reading, correlated with the Thatcham Terrace, with the Taplow Formation (see Chapter 1 and (Figure 1.3); (Figure 3.3) and above, Fern House Pit). The Summertown-Radley aggradation has also been correlated in this volume with the Taplow Formation and is considered to have aggraded over a lengthy period between the mid-Saalian (Oxygen Isotope Stage 8) and the mid-Devensian, with only its uppermost levels typically dating from the latter stage (see Chapter 2, Stanton Harcourt and Magdalen Grove; (Figure 2.18)). The Taplow Formation downstream from Reading has been ascribed to the Saalian Stage (Chapter 1); its aggradation is thought to have spanned the period between Oxygen Isotope Stages 8 and 6 (inclusive). A later formation, the Kempton Park Gravel, occurs downstream from Reading, representing aggradation between Stage 6 and the mid-Devensian (Gibbard, 1985; see above, Fern House Pit; (Figure 2.18)). The rejuvenation during Stage 6, which separated these two formations, appears not to have occurred in the Reading area or further upstream in the Thames valley. Therefore the Taplow Formation at Reading, like the Summertown-Radley Formation of the Upper Thames, is believed to represent a considerable period of floodplain stability, from Oxygen Isotope Stage 8 to the mid-Devensian (see above, Fern House Pit).

These interpretations have important implications for the age of the deposits forming the Thatcham Terrace of the Kennet valley. The Summertown-Radley Formation provides an analogue for the Thatcham Terrace deposits; both are the upstream equivalents of the Taplow Formation of the Reading area and both lie upstream of the limit of the Stage 6 rejuvenation, when the Thames further downstream was incised to the level of the Kempton Park Gravel (see above, Fern House Pit). This comparison suggests that the Thatcham Terrace surface may overlie sediments with a considerable range of ages, from Oxygen Isotope Stage 8 to the mid-Devensian. Sediments from the earlier parts of this time interval appear to dominate the Summertown-Radley sequence, the Ipswichian Eynsham Gravel and overlying ?Devensian gravels typically being restricted to the uppermost levels of the formation (Chapter 2). The bulk of the Brimpton sequence might therefore be expected to be pre-Ipswichian, despite the similarity between faunas from some levels within it to British Devensian interstadial assemblages. It is particularly pertinent to note, at this point, that .there is very little available information about faunas and floras of Saalian Stage interstadials, which are essentially unknown in Britain and are rare in Europe as a whole. Since, by definition, such periods had relatively restricted biotas, it is likely that interstadials in different 'glacial stages' within the same part of the Pleistocene appear similar in terms of their palaeontology. The basis for the correlation of level C at Brimpton with the Chelford Interstadial may therefore require reexamination.

The only part of the Brimpton sequence for which geochronometric dates indicative of the Devensian Stage have been obtained is the upper silty gravel. The radiocarbon dates from this upper division indicate that the lower sandy gravel was laid down prior to the mid-Devensian. It is possible, however, that the upper division is significantly later than the lower deposits; it may even represent the addition of a mid-Devensian Enborne gravel to a sequence of older Kennet sediments. Bryant *et al.* (1983) suggested that the change from (lower) sandy to (upper) silty gravel resulted from an increase in the deposition of fine sediment as the river aggraded to the highest levels of the floodplain. Chartres (1981), however, showed that loessic silt had been incorporated in the upper levels of the terrace gravels in the Kennet valley by pedogenic activity; the matrix of the upper gravel at Brimpton might therefore be of a similar origin, particularly since its lower limit appears to be independent of the sedimentary bedding (see above, Description). Chartres described a mechanism whereby this loessic silt was restricted to a distinct upper layer: he thought that a clayey illuvial horizon, developed by soil-forming processes prior to loess accumulation, had acted as a barrier to downward movement of silt. An upper silty layer was thus recognized by Chartres (1980, 1984) on the Thatcham Terrace at Thatcham and attributed by him to post-depositional (pedogenic) modification of the original fluvial sediments. However, although the Brimpton site is also on the Thatcham Terrace and an upper silty division has been recognized there, no illuvial clay layer has been observed at the top of the lower gravel. The question of whether the upper silty gravel at Brimpton is of sedimentary or pedogenic origin therefore remains open.

Study of soil profiles on the Kennet terrace gravels may nevertheless provide information of significance to the dating of the Brimpton sediments. Work of this type has revealed differences in levels of complexity between subsoil horizons on different terraces within the Kennet system, with the highest and oldest terraces having the most complex soils (Chartres et al, 1976; Chartres, 1980, 1984; see above, Hamstead Marshall). Chartres did not work at the Brimpton site, but studied the upper levels in the same terrace formation at Thatcham, some 6 km upstream. Micromorphological analyses of samples from Thatcham revealed evidence for complex soil formation over at least one full climatic cycle (Chartres, 1980, 1984). Within the lower part of the soil profile, Chartres recognized concentrations of yellow illuvial clay (argillans), which he attributed to soil formation under temperate conditions. These clays had been disrupted and incorporated into the matrix as a result of disturbance of the soil structure by cryoturbation, under periglacial conditions (in a similar way to the disruption of presumably older red argillans in soils developed on the higher Kennet gravels, such as those at Hamstead Marshall — see above). This interpretation implies that the illuviation phase that produced the yellow argillans was followed by at least one periglacial episode and therefore must have occurred prior to the Holocene. Thus, the Thatcham Terrace surface must have been in existence during a pre-Holocene temperate episode. Chartres duly ascribed the phase of yellow-clay illuviation at Thatcham to the Ipswichian interglacial. In contrast to the evidence from the Thatcham Terrace, no disrupted argillans were observed in soils developed on the lowest terrace in the Kennet sequence, the Beenham Grange Terrace. The implication of this is that no pre-Holocene temperate-climate soil formation has affected this terrace, which fully accords with its correlation with the Late Devensian Shepperton Gravel of the Middle Thames. Chartres's observations led him to propose that pedological evidence from the various Kennet terraces provided a stratigraphical framework, with larger numbers of climatic cycles represented in the soils on higher terraces. His view that soils on the Thatcham Terrace incorporate relict Ipswichian features lends support for the proposal (above) that this aggradation is largely pre-Devensian in age.

Thus two opposing interpretations of the deposits at Brimpton have emerged. The first, that proposed in the original report on the site by Bryant *et al.* (1983), considers them to be Devensian (with possible Ipswichian remnants at the base of the sequence). The second, influenced by regional stratigraphy and by arguments for a more complex Pleistocene record, holds that the deposits may span a longer period and may be dominantly, if not wholly, of pre-Devensian age. The argument between these opposing views hinges largely on the correlation between the Chelford Interstadial and level C at Brimpton. This correlation is based on a sequence of five pollen counts from level C, which indicated a similar floral assemblage to that at Chelford. However, as has been noted above, interstadial assemblages are relatively impoverished and non-distinctive, and little is known about the characteristics of pre-Devensian interstadials. Given the contrary evidence from terrace stratigraphy, supported by pedological studies, the validity of this correlation must be questioned. The radiocarbon dates from Brimpton only indicate a Devensian age for the upper gravel; they have no bearing on the age of the largest part of the sequence. There may in any case be grounds for doubting the accuracy of these dates; the soil evidence, already described, appears to indicate a pre-Ipswichian age for the entire Thatcham Terrace sequence at Thatcham. An assessment of the soil at the top of the Brimpton sequence is clearly desirable, as are further attempts to determine the ages of the various deposits. Amino acid analyses of mollusc shells from the sequence might provide important geochronological evidence of this kind.

The Brimpton pit, with its succession of alternating cold- and temperate-climate deposits, is clearly a stratigraphical site of considerable importance. If its attribution to the Devensian Stage is correct, the site must represent one of the most complete Lower and Middle Devensian sequences in Britain. Comparable sites at Wretton (West *et al.,* 1974) and Four Ashes (Morgan, 1973; Shotton, 1977) have deposits of presumed Chelford Interstadial age, but fossil molluscan faunas are absent. The Brimpton Interstadial temperate episode has been recognized at no other site. The occurrence of molluscan and insect faunas at Brimpton, together with considerable palaeobotanical evidence, also makes this a site of considerable interest.

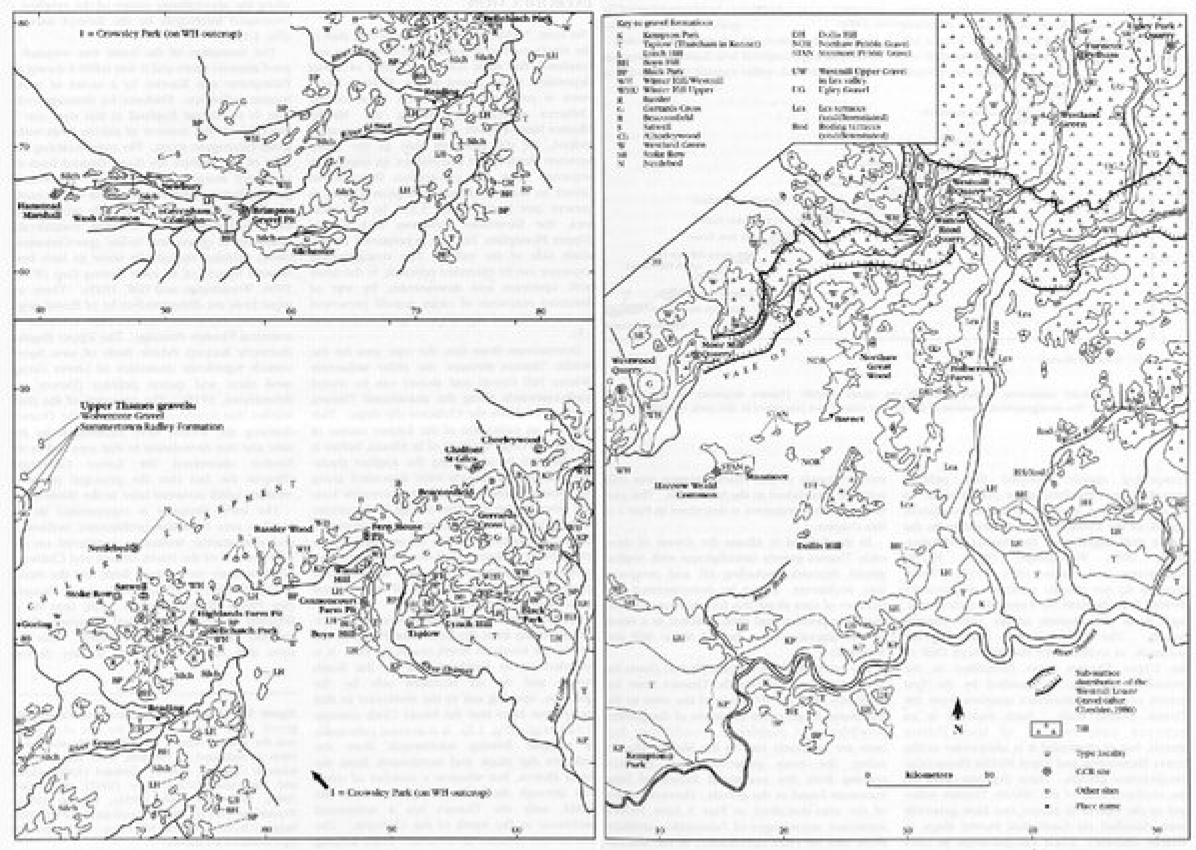
If the alternative interpretation of the Brimpton sequence as being largely of pre-Devensian age were to be proved correct, however, the importance of the site would not in any way be diminished; pre-Devensian interstadial sediments are extremely rare in Britain and no lengthy biostratigraphical record from any pre-Devensian glacial episode has so far been recognized at a single site.

Conclusions

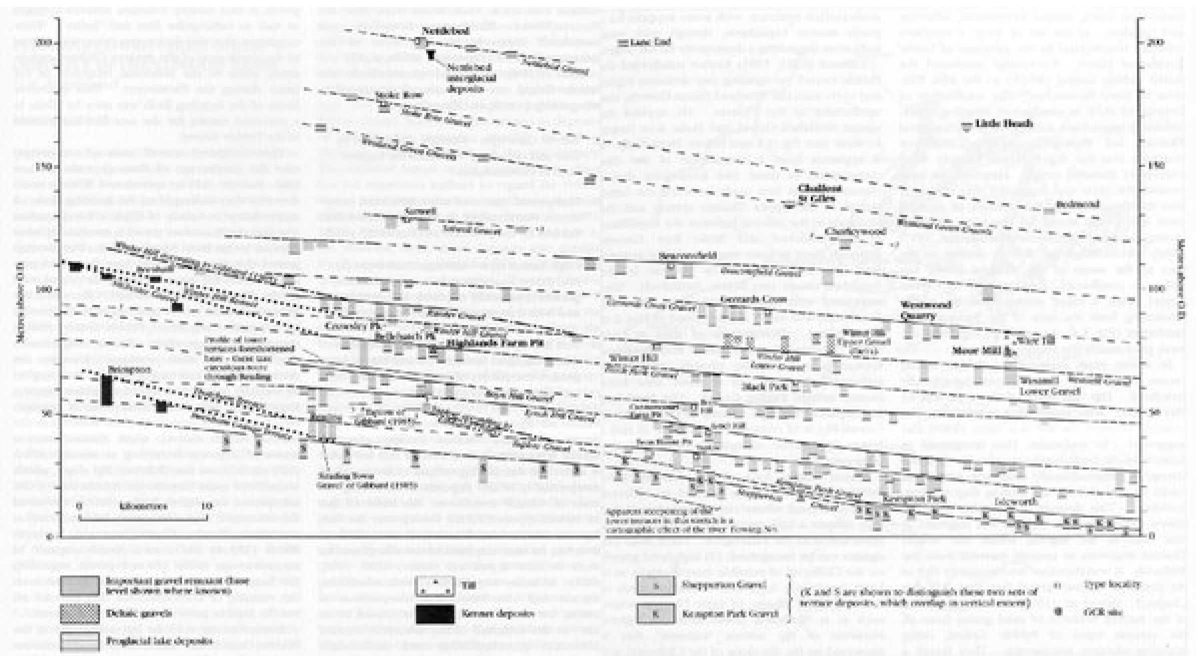
Brimpton Gravel Pit reveals unique evidence for conditions in southern England during the latter part of the Quaternary Ice Age. Here, beds of gravel deposited by the River Kennet, a tributary of the Thames, alternate with silty and organic layers containing the remains of plants (including pollen) and snails. These fossil remains allow the prevailing climatic conditions at the time of deposition to be determined. Differences between the assemblages from different levels record a sequence of three warm and three cold episodes at Brimpton. It has been suggested that the sequence of deposits here was formed during the last major cold phase of the Quaternary, between about 80,000 and 10,000 years ago, when glaciers covered much of northern Britain, but failed to reach this part of southern England.

However, the Brimpton deposits form part of a terrace of the River Kennet that is correlated with the Taplow Terrace of the main Thames. This terrace, in the Thames valley, is thought to have been formed between 250,000 and 130,000 years ago. There is some reason to suspect that the Brimpton sequence may be of a comparable antiquity, for at Thatcham there is a soil developed in the same terrace that seems to indicate deposition of the gravel prior to the last interglacial (which occurred between 130,000 and 120,000 years ago). Whatever the outcome of this controversy, it is clear that the Brimpton site exposes an important sequence of sediments laid down during a period of fluctuating climate. Very few sites in Britain reveal so complex a history of climatic change, either in the last glacial or earlier; the resolution of the question of dating the Brimpton sequence is of acute urgency. Regardless of whether the Brimpton sediments are of Devensian or Saalian age (they may even include both), the site is of major significance.'

References



(Figure 3.1) (Following two pages) Map showing the gravels of the Middle Thames, the Vale of St Albans and the Kennet valley. Compiled, with reinterpretation as indicated in the text, from the following sources: Cheshire (1986a), Gibbard (1985), Green and McGregor (1978a), Hare (1947), Hey (1965, 1980), Sealy and Sealy (1956), Thomas (1961), Wooldridge (1927a) and the Geological Survey's New Series 1:50,000 and 1:63,360 maps. GCR sites and type localities are shown.

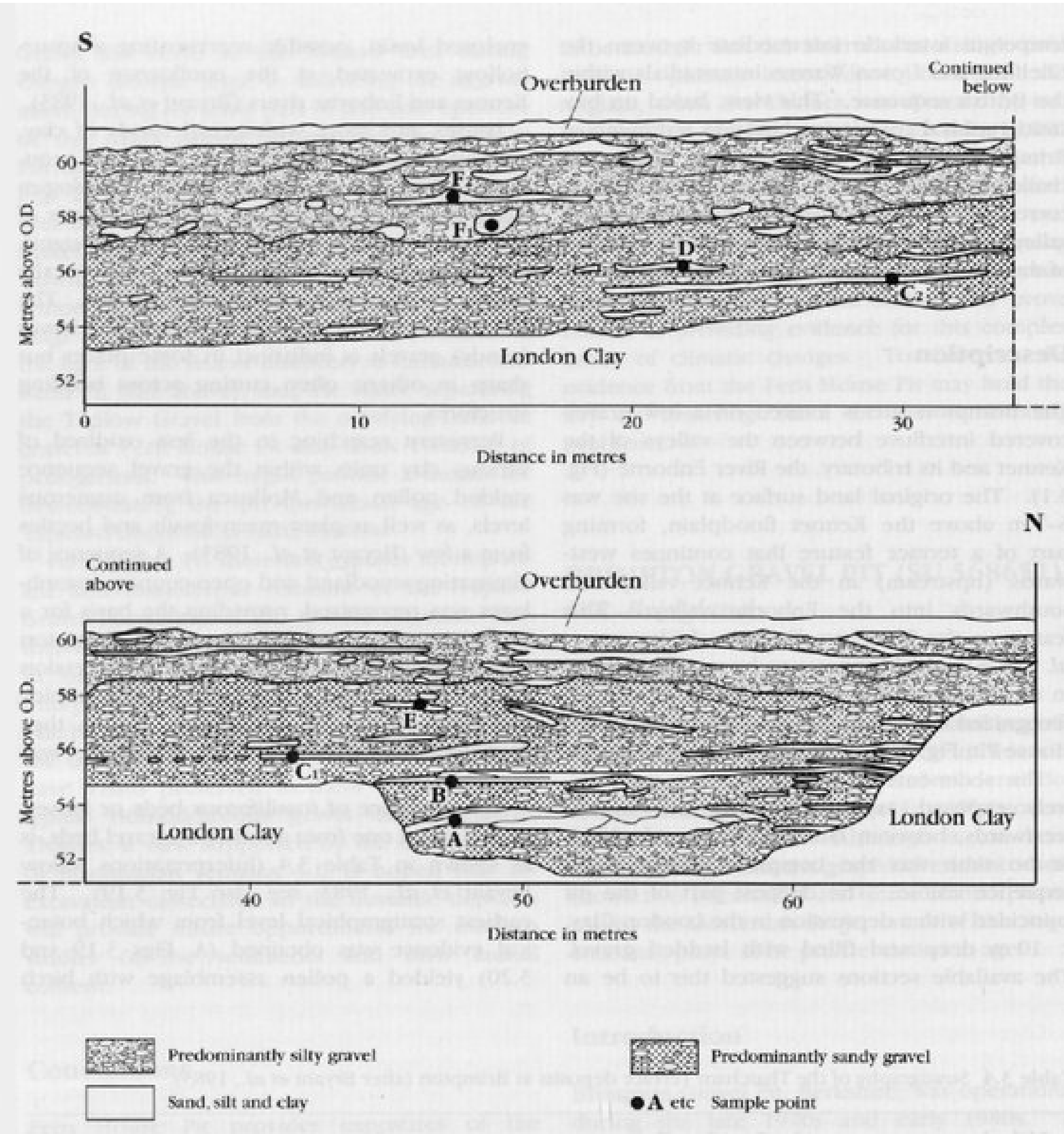


(Figure 3.3) Long-profiles of terrace formations in the Middle Thames. Compiled predominantly from data provided by Gibbard (1985), with subordinate information from Sealy and Sealy (1956) and Thomas (1961). Modifications to the source information are described in the text.

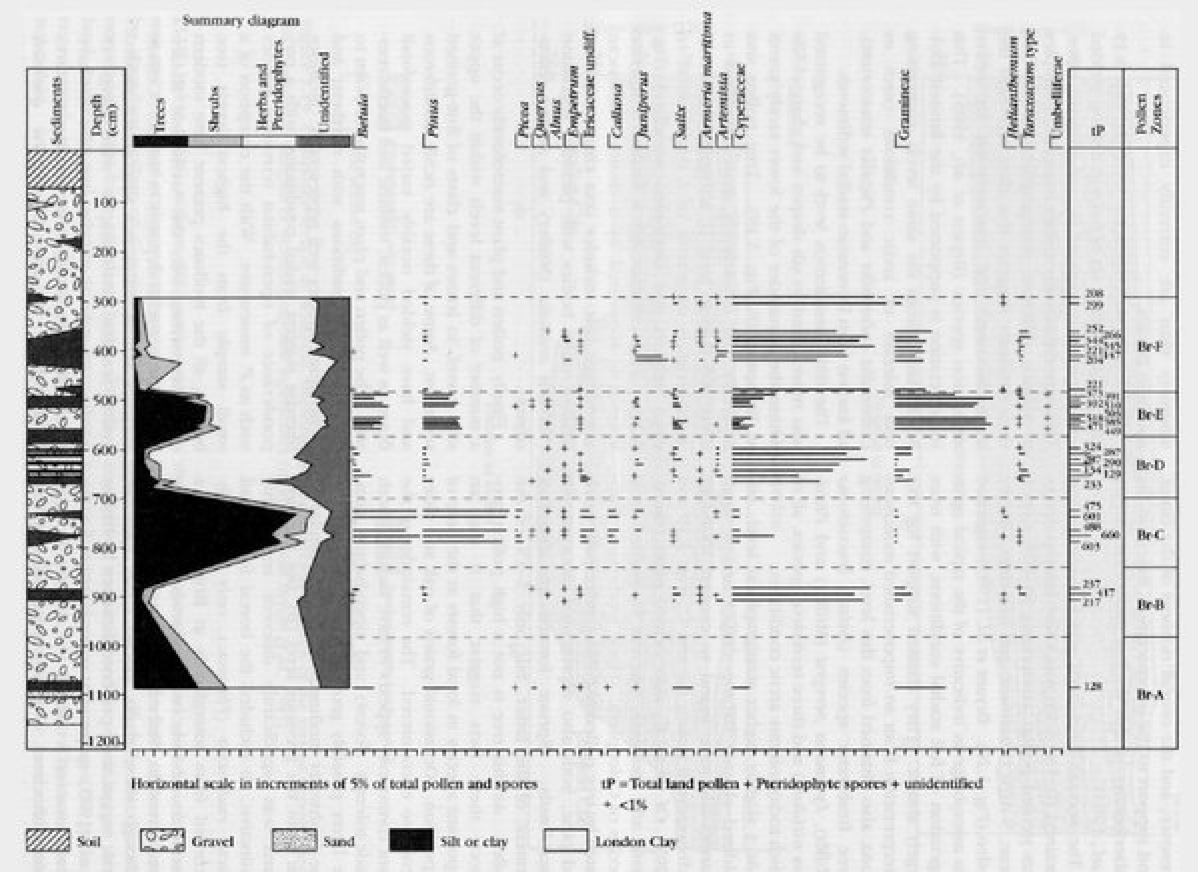
Lithology	* – Local pollen zones	Interpretation/age
1. Upper silty gravels	F – Non-arboreal pollen	Cold (stadial) late mid-Devensian (^{14}C 27,400 ± 1250 BP (BM-1638))
2. Lower sandy gravels	E – Gramineae-*Betula-Pinus*	Brimpton Interstadial
	D – Cyperaceae-*Betula*	Cold (stadial)
	C – *Betula-Pinus-Picea*	Chelford Interstadial
	B – Non-arboreal pollen	Cold (stadial)
	A – Non-arboreal pollen-*Betula-Pinus*	Late Ipswichian or Wretton Interstadial

* See Fig. 3.20; A–F also coincide with labels in Fig 3.19, which indicate sample points.

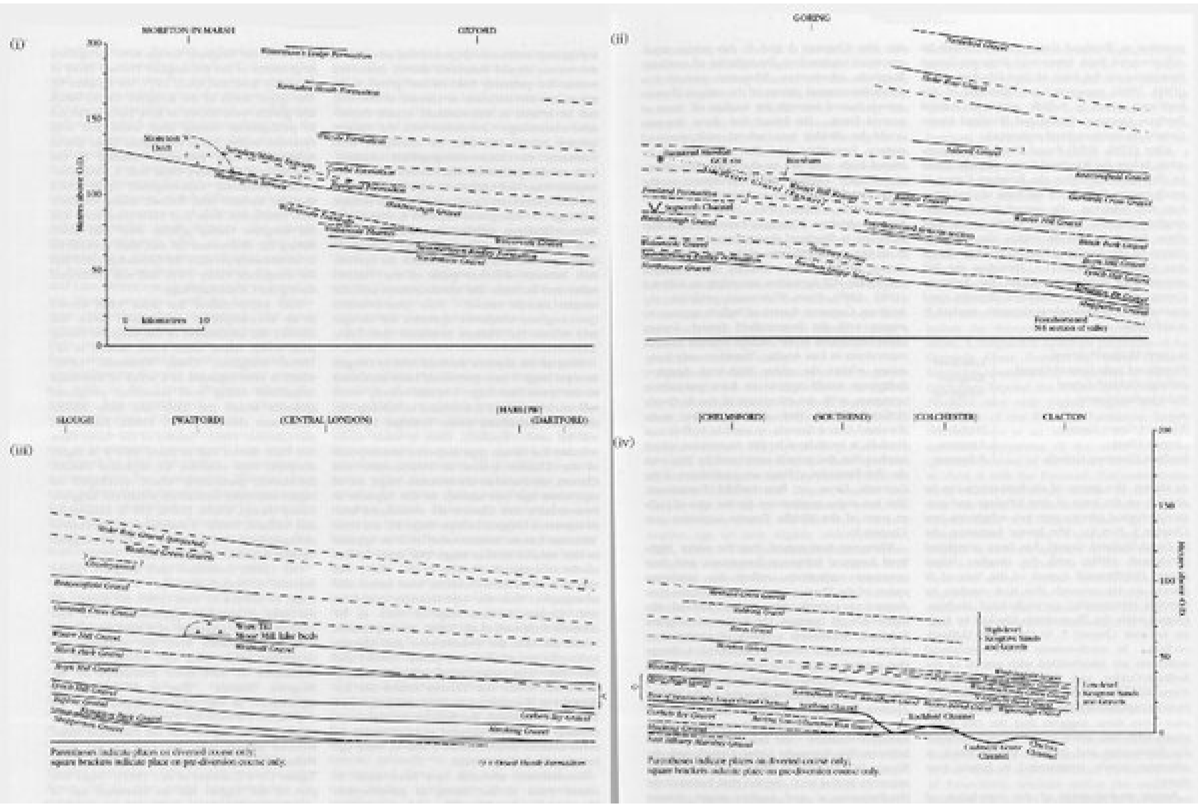
(Table 3.4) Stratigraphy of the Thatcham Terrace deposits at Brimpton (after Bryant et al., 1983).



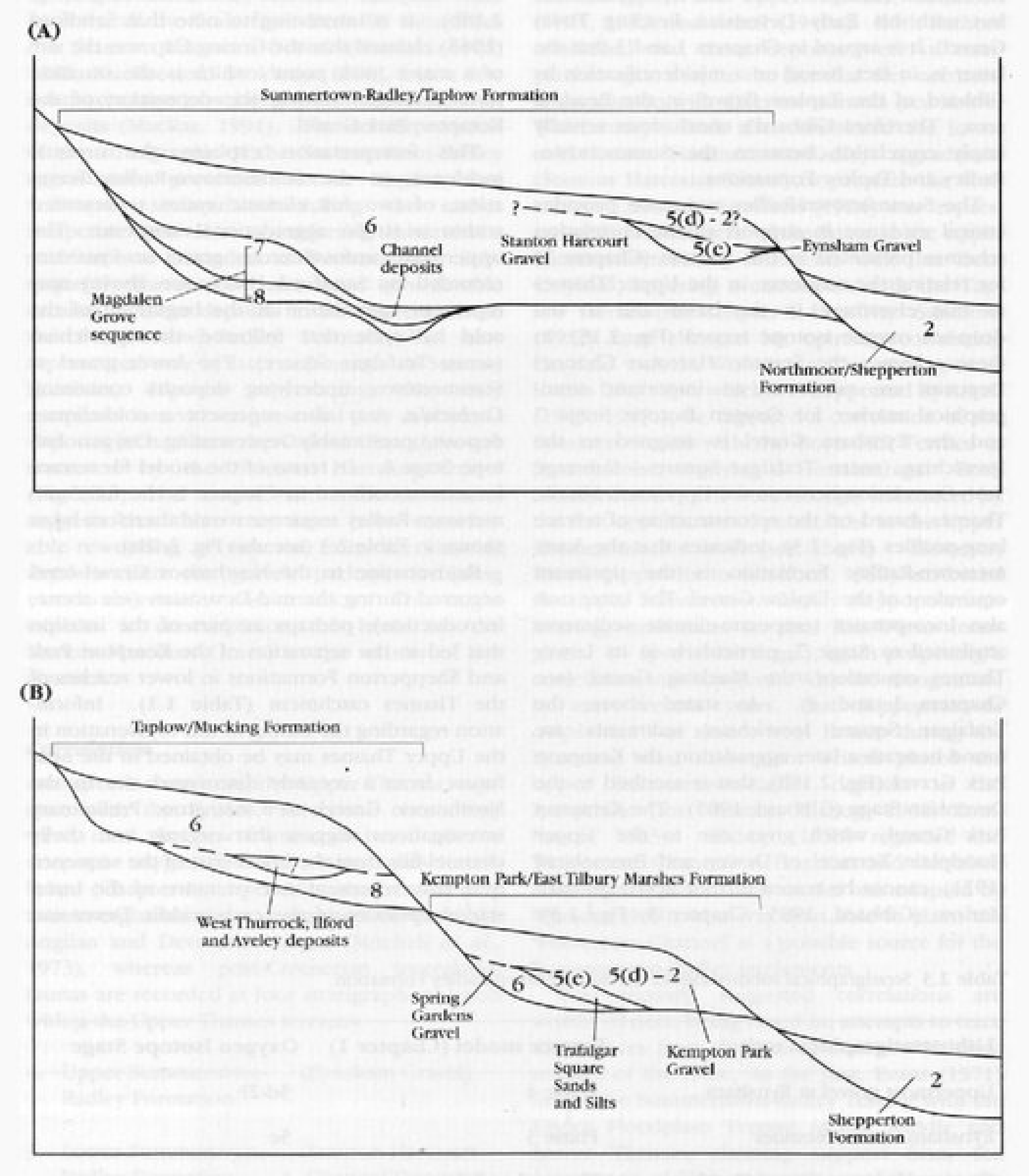
(Figure 3.19) Composite section at Brimpton, showing the stratigraphical relations of the various deposits and the locations of samples of biostratigraphical significance (modified from Bryant et al., 1983).



(Figure 3.20) Pollen from the deposits at Brimpton (after Bryant et al., 1983).



(Figure 1.3) Longitudinal profiles of Thames terrace surfaces throughout the area covered by the present volume. The main sources of information used in the compilation of this diagram are as follows: Arkell (1947a, 1947b), Briggs and Gilbertson (1973), Briggs et al. (1985), Evans (1971) and Sandford (1924, 1926) for the Upper Thames; Gibbard (1985) and Sealy and Sealy (1956) for the Middle Thames; Bridgland (1983a, 1988a) and Bridgland et al. (1993) for the Lower Thames and eastern Essex; Whiteman (1990) for central Essex.



(Figure 2.18) Comparison of terrace stratigraphy upstream (A) and downstream (B) from the limit of the Kempton Park Formation. Numbers 2-8 indicate oxygen isotope stages.