Hornchurch Railway Cutting

[TQ 547 874]

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Highlights

This locality demonstrates the maximum southern limit of the Anglian ice sheets. At Hornchurch a remnant of Anglian till is overlain by a post-diversion Thames gravel. This gravel is part of the highest terrace of the Lower Thames, a fact that implies that the terrace sequence in this part of the valley is entirely of post-diversion (late Anglian/post-Anglian) age.

Introduction

Sections at Hornchurch showing chalky till overlain by Thames terrace gravel have been famous since the last century, when the original descriptions were written (Holmes, 1892a, 1892b, 1892c). The stratigraphical importance of these sections, created during construction of the Romford to Upminster railway line, has long been recognized. The sequence in the Hornchurch–Romford district is unique, in the Lower Thames valley, in that terrace deposits there are in contact with Anglian glacigenic sediments. The superposition of the Boyn Hill/Orsett Heath Gravel above till at Hornchurch has formed a principal basis for considering the entire Lower Thames terrace system to be later than the main glaciation of eastern England (Whitaker, 1889; Holmes, 1892a, 1893; Wooldridge, 1957), although this was once a controversial interpretation (Hinton, 1910, 1926a; Kennard, 1916; Woodward *et al.,* 1922). Hornchurch is the southernmost locality at which the 'Chalky Till' of East Anglia has been recognized.

Description

The GCR site is part of a railway cutting excavated in the 1890s through a ridge of gravel-capped land running north-eastwards from the parish church at Hornchurch. When newly excavated, a section here [TQ 547 874], up to 8 m deep and 600 m long, showed *c.* 5 m of till overlain by sand and gravel (Figure 4.4). The till was observed over a distance of *c.* 300 m in the central part of the cutting; it appeared to occupy a depression in the London Clay, as the sand and gravel directly overlay London Clay to the north-west and south-east of the till outcrop (Holmes, 1892a, 1892b, 1892c, 1893, 1894; (Figure 4.4)). At the Romford end of the same railway line a second cutting [TQ 525 887] also showed till between the London Clay and Thames gravel, in this case associated with 'dark silt' deposits, interbedded with sand and pebbles (Holmes, 1894).

The gravel overlying the till at the original railway cutting site was included by Dines and Edmunds (1925) in the Boyn Hill Terrace of the Thames. On their Geological Survey map of the Romford area (New Series, Sheet 257), a tongue of Boyn Hill Gravel is shown running northeastwards from the church [TQ 544 870], across the railway cutting site, and terminating *c.* 200 m to the north-east, where a strip of boulder clay continues the northward trend of the gravel (Figure 4.1). This strip of dissected 'drift' seems to form an erosional terrace on the western side of the Ingrebourne valley, whereas the 'boulder clay' and brickearth of the Upminster district form a complementary feature on the eastern side of the valley (Pocock, 1903; New Series Sheet 257; (Figure 4.1)).

Attempts to locate till beneath the thickest part of the Orsett Heath Gravel at Hornchurch, exposed in a pit near the church [TQ 544 868], revealed only London Clay bedrock, although chalky till was reported when an electricity substation was built in part of this pit (Anon., 1982b). A section was therefore cleared in the railway cutting in 1983 (Anon., 1984a), revealing the sequence illustrated in (Figure 4.5) and (Figure 4.6). The land surface at this, the GCR site (*c.* 33 m above O.D.), is clearly erosional, so that the full thickness of the Orsett Heath Gravel is not preserved. However, 4 m of bedded gravel, considerably disturbed by an ice-wedge cast, was exposed above 3 m of till (Figure 4.5) and (Figure 4.6). Clast-lithological analysis of the gravel shows it to be typical of Lower Thames deposits upstream from the Darent confluence (Table 4.2), thus supporting its attribution to the Orsett Heath Formation. The lowest 1.5 m of the till in this exposure was unweathered; above this it was oxidized, with the top 0.1–0.3 m also decalcified.

Interpretation

Holmes (1892a, 1892b, 1893, 1894) believed that the gravel overlying the till at Hornchurch belonged to the oldest terrace of the Lower Thames valley. He therefore concluded that the fluvial drifts of the area were entirely 'post■glacial'. This interpretation was generally accepted, although some workers preferred to place the 'Chalky Boulder Clay' of south-eastern Britain later than the 'High Terrace' of the Thames (Hinton, 1910, 1926a; Kennard, 1916; Woodward *et al.,* 1922). Kennard (1916) was perhaps the staunchest opponent of Holmes's interpretation. He believed the Lower Thames and its tributaries to be of 'pre-glacial' age and considered the gravel above the Hornchurch till to be the product of 'a tributary stream, possibly the Ingrebourne, or … not a river gravel at all' (Kennard, 1916, p. 264). According to Preece (1990a), Kennard's view reflected his strong monoglacialist convictions; the evidence from Hornchurch was of fundamental importance in the replacement, during the early decades of this century, of a monoglacial interpretation of the Pleistocene by one involving multiple glacials and interglacials.

Holmes also noted that the till at Hornchurch, only *c.* 80 ft (25 m) above O.D., is considerably lower than the general level of similar deposits to the north (see (Figure 5.1)). He considered that the deposit occupied a valley or hollow and, following a suggestion by Monckton (in discussion of Holmes, 1892a), concluded that a valley system had existed in the area prior to the arrival of the ice (Holmes, 1893). The later discovery of till at Romford (above), at a similar elevation to the Hornchurch remnant, indicated to Holmes (1894) that the glacial deposits were laid down over a valley floor of considerable width. This led him to suggest that there existed a major valley running north of the present Thames and passing out to sea via the Blackwater estuary. He later developed this idea further, attributing this hypothetical valley to a 'Romford River' (Holmes, 1896).

This hypothetical phase of fluvial development, presumed to pre-date the deposition of any of the terrace gravels of the Lower Thames, became widely accepted by later writers as an early course of the river (Saner and Wooldridge, 1929; Baker and Jones, 1980; Baker, 1983), but recent work in the area through which it was thought to have passed has yielded no evidence for drainage by the Thames or any other river (Bridgland, 1986c). On the contrary, studies of the fluvial deposits of eastern and southern Essex suggest that any precursor of the modern Lower Thames was a minor tributary of the Medway, occupying much the same geographical area as the present river between Dartford and Southend (Bridgland, 1980, 1983a, 1988a). The 'Romford River' lowland can be interpreted as a classic example of 'inverted relief, since it represents an interfluve area between the pre-and post-diversion courses of the Thames. In contrast to the areas to the north and south, there were no early gravels on this interfluve, so the non-resistant London Clay was therefore afforded no protection from erosion during the latter part of the Pleistocene (Bridgland, 1986c).

(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.

Gravel	**Site**	**Sample**	**Teriary**	**Nodular**	**Total**	**(1) Chalk**	**Gnsd chert**	**Total**	**Quartz**	**Quartzite**	**Carb chert**	**Rhax chert**	**Igneous**	**Total**	**Ratio (qtz:qtzt)**	**Total count**	**National Grid Reference**
East Tilbury Marshes Gr.	E.Tilhury 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]
	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 Gravel	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]

	('Floor') *11.2–16*	*1 D*	*50.2*	*19.6*	*95.7*	(*03*)	*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*	
		113*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 Gravel	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]
		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*	*230*	*1277*	
	Belhus 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 575 811]
	Belhus 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	IA	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*	
		113	47.7	18.1	95.0	(37.3)	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*	*1.7*	*1.1*	*0.3*	*03*	*5.3*	*2.08*	*1138*	
Orsett Heath Gravel	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]
	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]

	Homchurch 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)	IA *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]
	71.2–16	*2 D*	*28.0*	*3.6*	*91.3*		*1.1*	*1.2*	*3.9*	*23*	*0.6*	*0.2*	*0.5*	*7.4*	*1.73*	*665*	
Swanscombe Lower Middle Gravel	Bamfield 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]
	11.2–16	*1 D*	*50.9*	*5.3*	*89.9*		*2.1*	*23*	*4.4*	*2.0*	*0.8*		*0.1*	*7.7*	*2.21*	*1703*	
		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*	*1 785*	
Swanscombe Lower Gravel	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]
	11.2–16	*3 D*	*36.5*	*5.9*	*89.0*	(*0.1*)	*2.5*	*2.7*	*4.0*	*2.9*	*0.5*	*0.1*	*0.1*	*8.3*	*1.90*	*1391*	
		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 Belhus 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.

Calculations in this table and in (Table 5.2) and (Table 5.5) are based on the durable content only. Non-durables such as London Clay pebbles, clay ironstones, fragments of septaria and even Chalk, are highly localized in their occurrence and are excluded because they inhibit comparison of widespread gravel characteristics. Space does not permit the inclusion of all available data. Where the addition of the flint, southern and exotic totals falls short of 100%, the occurrence of other local material is indicated, predominantly sarsen. Extra material in the southern category comprises Greensand sandstones and (where not shown separately) Hastings Beds sandstones, siltstones and ironstones. Extra material in the exotic category comprises arkosic sandstones, unidentified cherts and (where not shown separately) igneous rocks. Note that: the Tertiary flint category comprises rounded pebbles (sometimes subsequently broken) reworked from the Palaeogene; Gnsd = Greensand; Carb chert = Carboniferous/Palaeozoic chert; Rhax = *Rhaxella;* the igneous category includes metamorphic rocks (very rarely encountered); the quartzite category includes durable sandstones.

By the beginning of the present century the Hornchurch cuttings were no longer available for study, but attention moved to the opposite side of the Ingrebourne valley when till was discovered beneath brickearth deposits near Upminster, *c.* 2 km to the north-east of the Hornchurch site (Pocock, 1903). The Upminster brickyards exposed over 7 m of horizontally bedded brickearth with occasional seams of gravel (Dalton, 1890; Pocock, 1903; Woodward, 1904). This deposit was laminated in its lower part, the laminations showing contortions, leading Pocock (1903, p. 200) to suggest that the sediment had been disturbed 'by ice-floes'. These contortions, and the association with till, suggested to Pocock that the brickearth was a glacial-lake deposit. Woodward went further and, believing that the ice had reached the Grays area and caused disturbances there in the Chalk, suggested that 'the waters of the Thames Valley were pounded up by an icy dam' (Woodward, 1904, pp. 483–484).

Warren (1912) supported theories of lake development in association with the glaciation of the Hornchurch area. He claimed that the Hornchurch–Romford till probably rested on an overdeepened lake bottom, since it was unlikely that the whole Thames valley had been excavated at that time to the depth of the Hornchurch deposits. The same author later recorded new sections near Hornchurch, opened up on either side of the Ingrebourne valley during the construction of the Southend Arterial Road (A127), showing till overlain by laminated silts that he interpreted as lacustrine (Warren, 1924a). In the eastern section [TQ 565 890], Palaeolithic artefacts were found in gravel and sand interbedded with the silts (Dines and Edmunds, 1925; Dewey, 1930, 1932; Warren, 1942; Wymer, 1968, 1985b), interpreted by Warren (1942) as a product of the Ingrebourne. According to Dewey (1932), some of these artefacts suggested the use of the Levallois technique. There is little indication that artefacts have been recovered from the gravel overlying the till at Hornchurch (see, however, Wymer (1985b, p. 297)), although Palaeolithic material is widespread in the Boyn Hill/Orsett Heath Gravel. Dines and Edmunds (1925) described both of the Arterial Road sections in some detail, recording several steep-sided channels about 2 m deep filled with chalky till. They suggested (1925, p. 32) that these occurrences of till represented 'remnants of a spread which filled a valley now occupied by the Ingrebourne river', as previously envisaged by Woodward (1909; Woodward *et al.,* 1922).

Zeuner (1945, p. 155) claimed that the Hornchurch till lies on what he termed the 'Boyn Hill bench', meaning the erosion surface beneath the Boyn Hill/Orsett Heath Gravel (formed by the downcutting phase separating this from the preceding Black Park Formation). Zeuner recognized that the earliest occupation by the river of the Lower Thames valley coincided with his 'Kingston Leaf, later redefined as the Black Park Terrace (Wooldridge and Linton, 1955; Gibbard, 1979), and not with the Boyn Hill Terrace. His interpretation of the Hornchurch site therefore implied that the diversion of the Thames into its modern valley and the formation of the Kingston Leaf (Black Park) aggradation both pre-dated the Hornchurch glaciation. Zeuner, in fact, favoured river capture as the mechanism for the diversion of the Thames, not glacial intervention.

Wooldridge (1957) remapped the deposits of the Hornchurch area and concluded that the till was part of a dissected lobe that descends into the Ingrebourne valley from the plateau to the north, reflecting the former presence of a tongue of ice 'of glacier-like dimensions' (1957, p. 13). Wooldridge suggested a correlation between the till at Hornchurch and the Maldon Till of Clayton (1957), on the basis that both are confined to valley floors (see Chapter 5, Maldon). He suggested that these low-level tills could be equated with the Lowestoft Till of Suffolk, implying an Anglian age. Wooldridge considered that the major part of the excavation of the Lower Thames valley had occurred since the emplacement of the till, thus removing any evidence for the latter having extended further southwards. Wooldridge also suggested a correlation between the excavation of the valley in which the Hornchurch till was deposited and the erosion of the Clacton Channel. He followed King and Oakley (1936), however, in referring the erosion of the Clacton Channel to their 'Inter-Boyn Hill Erosion Stage'; he thus implied, indirectly, that the lowest 'Boyn Hill' deposits at Swanscombe were older than the till at Hornchurch, an interpretation that would seem to assign the Hornchurch glaciation to the mid-Hoxnian (interglacial) Stage — clearly an untenable view.

Ideas that a major valley system existed in the Lower Thames region prior to the Hornchurch glaciation, as implied by Zeuner (1945) and Wooldridge (1957), cast doubt on the theory that the diversion of the Thames was brought about by the glaciation of its former, more northerly route. In recent years, however, work in the Vale of St Albans has confirmed the role of Anglian Stage ice sheets in this diversion event (Gibbard, 1974, 1977, 1979; Chapter 3). Gibbard (1979) also demonstrated that the Black Park Gravel, which he assigned to the late Anglian, is the oldest Thames formation in the new valley through London. Later work has confirmed the Anglian age of the Black Park Formation and has suggested that it was emplaced, at least in part, while ice still occupied parts of the London Basin (Gibbard, 1983, 1985; Cheshire, 1986a; Chapter 3, Part 2).

The reopening of the section in the Hornchurch railway cutting, as part of the GCR programme (Anon., 1984a), allowed confirmation of the sequence described by Holmes and the application of modern analytical techniques to the deposits exposed. Sedimentological and chemical analyses of the till (C.A. Whiteman, pers. comm.) have shown that it comprises 65–77% clay (with subordinate silt), up to 25% sand and up to 10% gravel, the latter dominated by Chalk (40–65%) and flint (12–35%). Limestones, calcareous fossils and non-durable igneous rocks are also present. Fabric data show preferred east-west clast orientations, interpreted by Whiteman as transverse to ice flow, which he considered to be from the north. He interpreted similar fabrics in the lower till of the Chelmsford area in the same way. This fabric data, together with the colour and chemical composition of the deposit, led Whiteman to correlate the till at Hornchurch with his Newney Green Member of the Lowestoft Formation (Whiteman, 1990; Allen *et al.,* 1991; Chapter 5, Newney Green). Cheshire (1986a), however, correlated the till at Hornchurch with his Stortford Till, which was formed by the second of four separate ice advances into Hertfordshire and south Essex, all part of the Anglian (Lowestoft) glaciation (see Chapter 3 and (Figure 3.10)E).

Analysis of the clast composition of the overlying gravel (Bridgland, 1988a) supports its interpretation as a mainstream Thames deposit (Table 4.2); it was included by Bridgland (1988a) and Gibbard *et al.* (1988) in the Orsett Heath Gravel. As the latter is correlated with the Boyn Hill Formation of the Middle Thames, this confirms the attribution of the gravel at Hornchurch to this terrace (the former 'High Terrace' of the Lower Thames). This is not the oldest terrace in the post-diversion Thames valley; as stated above, it has been demonstrated that the Black Park Gravel is the earliest post-diversion formation. The recognition of the Black Park Formation in the Lower Thames is, however, controversial (see below, Wansunt Pit).

Many previous authors have noted that the Hornchurch till lies significantly lower than the general level of the Anglian glacial sediments of southern East Anglia and, as stated, this led to suggestions that a valley system existed in the Hornchurch area prior to the glaciation (Holmes, 1892b, 1893; Woodward, 1909; Woodward *et al.,* 1922; Dines and Edmunds, 1925; Warren, 1942; Wooldridge, 1957). The low altitude of the Hornchurch till, overlying London Clay at 25 m O.D., poses problems for Lower Thames stratigraphy and for the reconstruction of chronological events following the diversion of the river. According to Gibbard (1979), the downstream correlative of the earliest post-diversion formation, the Black Park Gravel, has a base level of *c.* 38 m O.D. in the Dartford area (his Dartford Heath Gravel), which was at least 10 km downstream from Hornchurch along the route taken by the pre-Mucking Gravel Thames (see (Figure 4.1)). The aggradation of this formation is considered to have been coeval, at least in part, with the continued glaciation of the Vale of St Albans (see Chapter 3, Part 2). However, the altitude of the till at Hornchurch suggests that the valley system there had already been excavated to over 12 m below the supposed Black Park base level (at Dartford) at the time of the ice advance (the Stortford Till advance of Cheshire, 1986a). This is difficult to reconcile with the correlation of the Black Park and Dartford Heath gravels, which has long been a subject of debate (see below, Wansunt Pit). It must be stated at this juncture that the elevation of glacial sediments is of no stratigraphical significance unless they are interbedded with fluviatile or marine deposits; glaciers can erode and infill closed hollows of very large dimensions, which can be well below the level of other contemporaneous sediments. It is therefore possible that the till at Hornchurch was deposited in an overdeepened hollow (as suggested by Warren (1917, 1924a)) or a 'tunnel-valley'. However, neither of these explanations seems likely given the location so close to the limit of what appears to have been a narrow lobe of ice. Moreover, there is further evidence that a valley system was deeply excavated in the Lower Thames by Late Anglian times, from projections of the Westmill Upper Gravel from the Vale of St Albans southwards down the Lea valley (Cheshire, 1983c, 1986a). This gravel, contemporaneous with the later part of the glaciation of the Hertford area and charged with its outwash (Chapter 3, Part 2), has a steep downstream gradient, indicating that its base level would have been as low as 35 m O.D. when it joined the Lower Thames valley and around 30 m O.D. by the Hornchurch area — 8 m below the base of the Dartford Heath Gravel some 10 km further downstream (see (Figure 4.7)).

Bridgland (1980, 1983a) suggested a revised Lower Thames stratigraphy, in which the surface overlain by the Hornchurch till was correlated with the Black Park 'bench', the erosion surface beneath the Black Park Gravel. This surface, equivalent to that underlying Zeuner's Kingston Leaf, appears to fall below the level of the Boyn Hill Gravel east of London (Evans, 1971; Bridgland, 1980). It was probably formed as a result of rapid downcutting by the newly diverted Thames along its adopted course. This interpretation allows the reconciliation of an Anglian age for the till at Hornchurch with the evidence for diversion of the Thames from the Vale of St Albans during the same glacial period. According to Cheshire (1986a), the Thames was diverted by the first of the four ice advances into the Vale of St Albans, whereas the till at Hornchurch represents the second advance. Thus by the time the ice reached Hornchurch, the Thames had already excavated its newly adopted valley to the base level of the Hornchurch till.

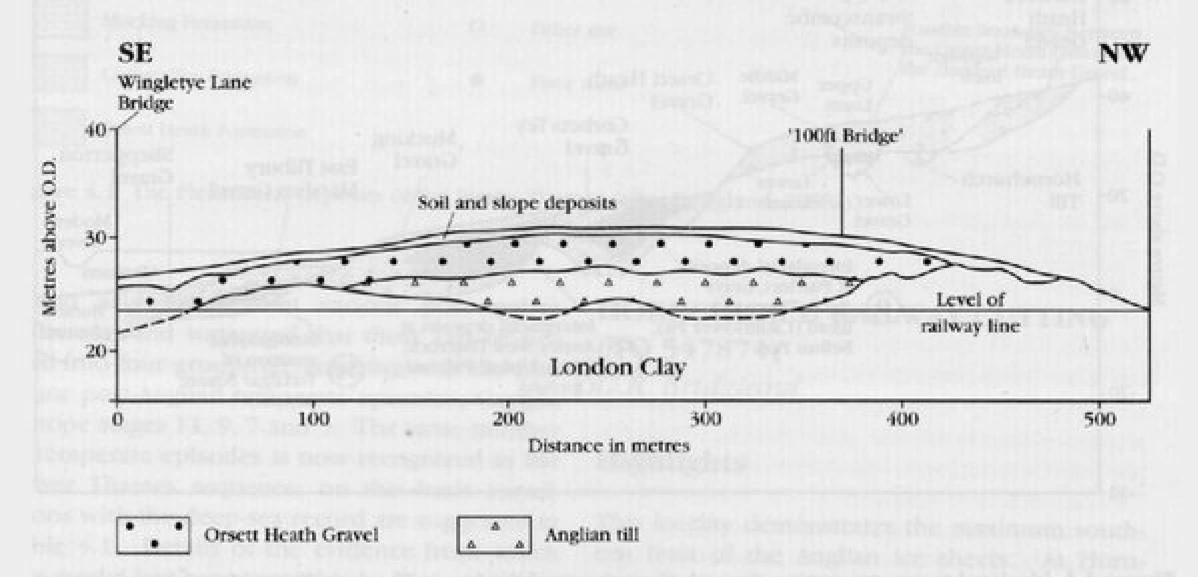
There remains a significant difficulty, however. This arises from the fact that Anglian glacial deposits and Hoxnian fluvial sediments apparently overlie the same erosion surface, 26 m above O.D. at Hornchurch and *c.* 2 3 m O.D. at Swanscombe; yet the accepted terrace stratigraphy of the Lower Thames requires the (Late Anglian) Black Park/Dartford Heath Gravel to have been aggraded to over 40 m O.D. (Figure 4.3) between the deposition of these two sets of sediments. This problem (discussed below — see Wansunt Pit) raises serious doubts about the correlation of the gravel at Dartford Heath with the Black Park Formation.

The Hornchurch railway cutting GCR site contains an important stratigraphical reference section, illustrating the relations between Anglian till and one of the oldest gravels of the Lower Thames terrace sequence. The details of the initiation and evolution of the Thames valley through London, during and following the glaciation, are at present uncertain. Further studies are required of deposits in the critical areas on the northern side of the present valley, where glacial sediments are preserved beneath fluvial (Thames) deposits. In particular, knowledge of the precise geometry of the till remnants would be useful, as would further information about the possible lacustrine sediments at Upminster. The reference section at Hornchurch will be a starting point for further work on the Anglian glacial deposits and palaeogeography of the Lower Thames region.

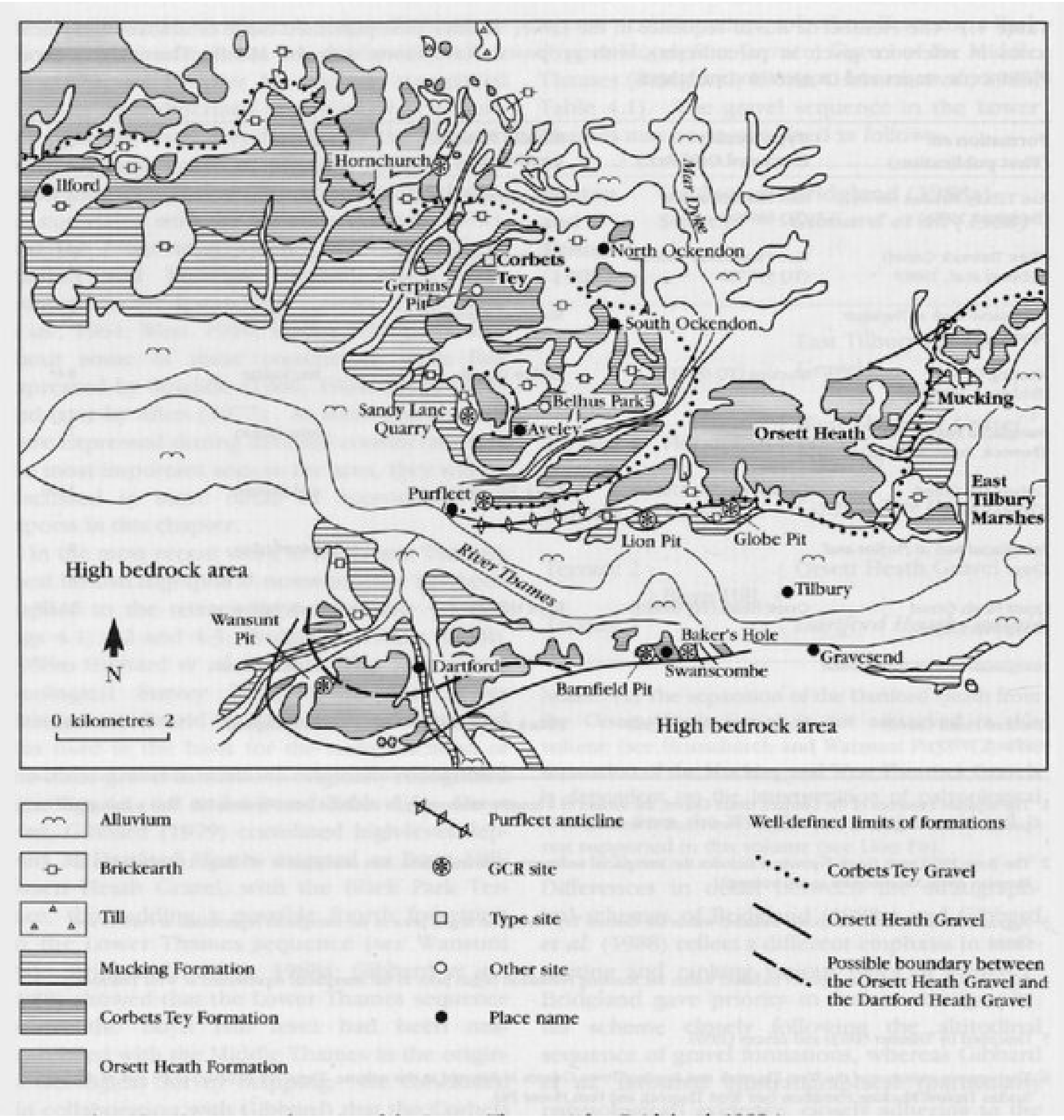
Conclusions

This locality is a unique reference site, providing important evidence that the glaciation of the North London area by East Anglian ice (during the Anglian Stage, around 450,000 years BP) occurred before the deposition of the highest terrace gravel of the Lower Thames. During this glaciation, ice sheets repeatedly invaded the old Thames valley across Hertfordshire and central Essex. Hornchurch is the most southerly point known to have been reached by these ice sheets. A narrow lobe of till (boulder clay), directly deposited by the ice, now occupies the Ingrebourne valley to the north of Hornchurch, as was first discovered when the railway was constructed. The till at Hornchurch is overlain by gravel of the Boyn Hill Terrace. This juxtaposition underlines the fact that the Lower Thames came into existence only after the Anglian ice sheets blocked the old route of the river, diverting it into its modern valley through London.

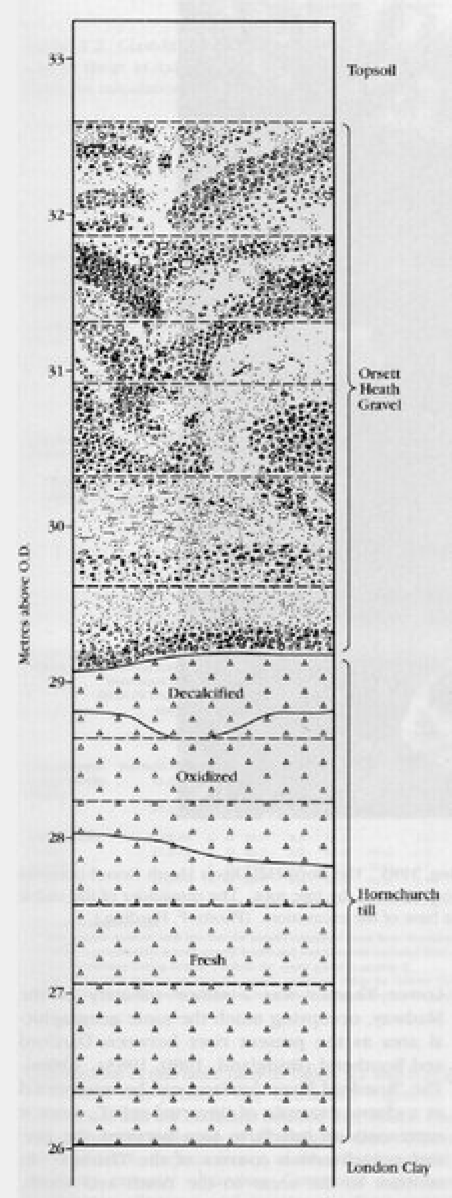
References



(Figure 4.4) Section in Hornchurch Railway Cutting, recorded during its original construction (after Holmes, 1892a).



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



(Figure 4.5) The GCR section, Hornchurch Railway Cutting, 1983. Pecked horizontal rulings denote steps in the section. The cutting side slopes at approximately 45° (see (Figure 4.6)).

(Figure 4.6) The GCR section, Hornchurch Railway Cutting, 1983. The Boyn Hill/Orsett Heath Gravel occupies the upper part of the section, its base occurring on the step beneath the tree root. The remainder of the visible section is in till, although London Clay was reached in the base of the excavation. (Photo: P. Harding.)

			Flint			Chalk	Southern		Exotics								
Gravel	Site	Sample	Tertiary	Nodular	Total	(1)Chalk	Gnsd chert	Total	Quartz	Quartzite	Carb chert	Rhax chert	Igneous	Total	Ratio (qz:qzte)	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	(37.3)	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.

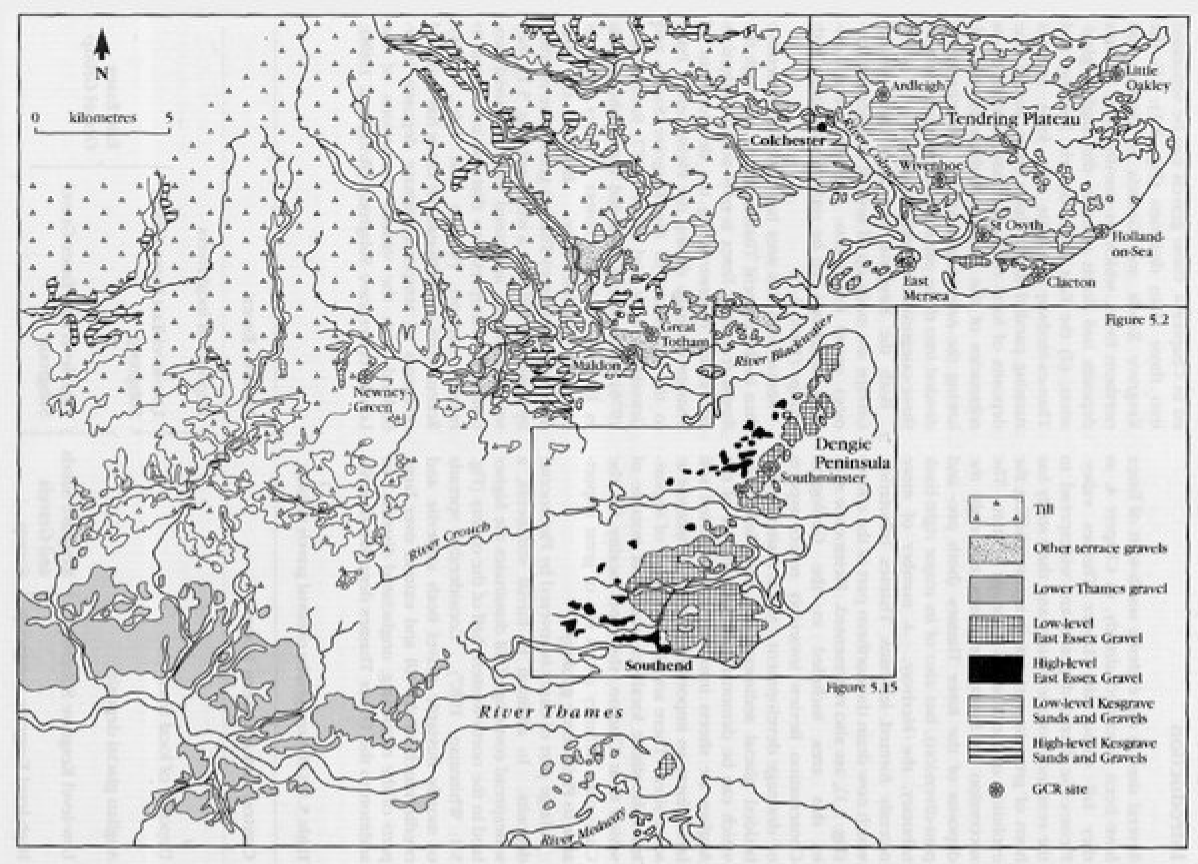
(1) -Chalk, a non-durable, is only present locally and was therefore excluded from calculations, but shown instead as a % of the total durable material.

(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 5.1) Pleistocene geology of Essex, showing the various types of gravel described in this chapter, the extent of the Anglian till sheet and the relation of these to the existing drainage systems (modified from Bridgland, 1988a).

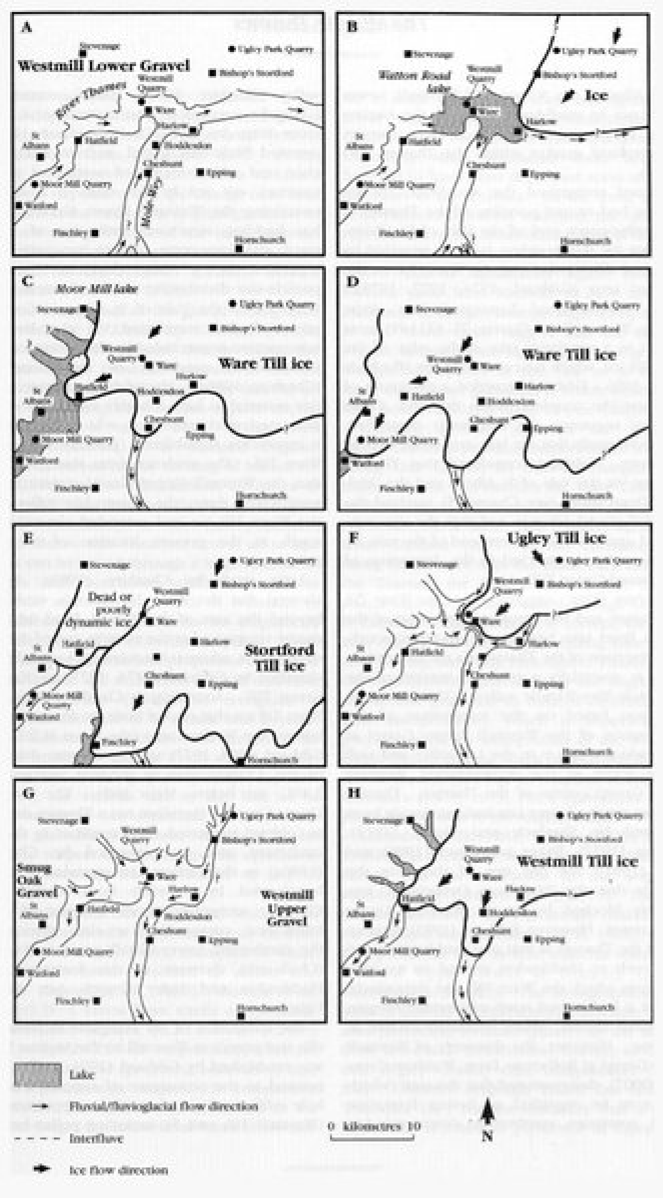
Gravel	Site	Sample	Flint: Tertiary	Flint: Nodular	Flint: Total	Southern: Greensand chert	Southern: Total	Exotics: Quartz	Exotics: Quartzite	Exotics: Carb. chert	Exotics: Rhax chert	Exotics: Igneous	Exotics: Total	Ratio (others q/qtzt)	Ratio (q/qtzt)	Total count	National Grid Reference
Anglian glacial gravels **	Ugley	1	61.9	25.7	87.9			3.5	0.8	1.5	0.4	1.9	11.9		0.55	520	TL 516278
		2	3.6	37.6	87.1			2.6	1.7	2.1	1.7	1.9	12.6		1.56	420	
Upper St Osyth Gravel	Fingringhoe	1A	15.4	13.8	80.8	2.4	2.4	4.1	4.5	4.1	1.4	0.8	16.8	0.29	0.95	509	TM 0419 2017
		1B	15.9	13.7	80.7	3.7	3.7	5.7	6.8	0.9	0.9	0.9	17.7	0.05	0.84	455	
	St Osyth	2	8.7	19.1	90.8	2.1	2.1	4.2	0.9	2.1		0.2	8.5	0.41	4.35	530	TM 1196 1704
	11.2-16	*2(8)0*	*24.9*	*9.4*	*78.4*	*2.4*	*2.4*	*11.9*	*1.0*	*2.7*	*0.4*	*0.3*	*18.8*	*0.18*	*12.50*	*714*	
Upper Holland Gravel	Bypass Rd.	1A	9.9	21.5	82.1	8.8	9.5	5.8	0.4	2.5		0.4	8.4	2.27	2.50	203	TM 1161 1705
		1B	12.6	16.1	74.8	16.6	13.6	2.5	0.6	1.5		0.6	5.7	6.20	4.00	517	
	Ea's Hall 1	1	13.7	11.5	75.8	21.7	21.7	0.5	0.8	0.5			2.2	19.75	0.53	506	TM 1432 1625
	11.2-16	*2(8)0*	*26.0*	*8.8*	*80.1*	*10.2*	*10.5*	*4.2*	*1.5*	*2.7*	*0.5*	*0.1*	*9.1*	*1.60*	*2.79*	*252*	
		2	13.6	*	77.6	15.0	15.0	3.0	0.5	7.8		0.8	7.2	4.50	11.11	501	TM 1439 1625
	Burrs Road	1	10.8	*	64.8	30.0	30.4	0.7		1.4	1.4		3.8	45.00		207	TM 1935 1759
		2	11.6	*	66.0	29.4	29.0	3.5		1.5	0.6		5.5	9.20		500	TM 1927 1754
	Holland-on-Sea	1	15.5	8.7	70.7	26.5	26.7	2.2	0.2	1.0	0.5		4.6	10.35	11.11	435	TM 2106 1662
		2A	15.7	9.8	68.9	25.1	25.1	3.0	0.7	0.7		0.5	6.0	6.70	4.35	207	TM 2109 1665
	Greensforces(?)	2B	20.7	13.5	71.3	15.6	15.1	4.7	5.2	1.4	0.2		12.6	1.62	0.90	422	
Lower St Osyth Gravel	Fingringhoe	1C	31.1	12.5	85.1			6.8	0.0	1.0			13.9		0.60	376	TM 0419 2017
	Moverons	1	29.0	16.8	80.8	3.0	3.0	8.1	7.0	1.6		1.0	18.1	0.06	1.20	429	TM 0711 1818
		2	30.8	16.5	79.6	1.1	1.1	11.2	5.5	0.7		0.5	19.3	0.07	2.13	1021	TM 0712 1819
	11.2-16	*2*	*32.5*	*5.9*	*73.5*	*1.6*	*1.7*	*14.2*	*7.6*	*2.7*		*0.8*	*24.7*	*0.08*	*1.85*	*1340*	
		3	31.8	13.8	77.3	3.6	3.7	11.4	7.8	1.3		0.7	21.7	0.06	1.47	904	TM 0699 1825
	St Osyth	1A	35.4	*	77.1	3.5	3.5	11.1	7.7	3.8		0.2	22.6	0.05	1.45	570	TM 1161 1706
		1B	36.6	*	79.6	1.5	1.5	10.4	4.9	1.5		0.7	18.6	0.10	2.13	748	
	11.2-16	*1B*	*30.7*	*7.7*	*76.0*	*1.7*	*1.7*	*12.5*	*4.8*	*2.0*		*0.5*	*20.2*	*0.10*	*2.61*	*1129*	
Lower Holland Gravel	St Osyth	3	31.6	16.8	83.1	1.4	1.4	10.3	2.7	1.6		0.5	15.3	0.11	1.25	561	TM 1201 1703
		5	21.8	30.8	85.0	6.6	4.2	5.8	6.8	1.8		0.5	15.3	0.39	0.85	525	TM 1215 1665
		6	29.5	16.8	81.3	2.2	2.5	8.8	5.5	1.5			16.0	0.18	1.67	519	TM 1225 1688
	Bush Paddock	1	43.5	10.5	83.9	6.8	5.1	5.8	3.7	0.8		0.5	11.8	0.55	1.58	567	TM 1257 1611
	11.2-16	*1*	*40.8*	*5.7*	*75.8*	*10.5*	*10.6*	*9.2*	*2.4*	*0.8*	*0.1*	*0.2*	*12.8*	*0.79*	*3.87*	*1275*	
	Holland-on-Sea	2C	32.8	11.9	80.6	2.2	2.2	8.0	7.5	1.0		0.2	17.2	0.15	1.00	412	TM 2109 1663
		2D	26.7	13.8	80.5	1.8	1.8	9.2	5.6	1.3		0.5	16.5	0.12	1.61	575	
	Holland Haven	1A	21.9	*	81.0	2.1	2.9	7.3	5.7	1.6	0.8	0.5	15.3	0.26	1.96	582	TM 2208 1761
		1B	31.6	14.6	81.1	2.5	3.1	9.6	4.6	0.4			15.9	0.26	2.08	269	
		2	25.3	*	82.2	2.3	3.0	8.4	3.9	1.7	0.2	0.2	14.8	0.24	2.17	534	TM 2205 1743
	11.2-16	*2*	*31.4*	*7.2*	*76.8*	*1.2*	*1.2*	*12.4*	*2.2*	*1.4*	*0.2*	*0.9*	*18.0*	*0.06*	*5.64*	*939*	
	Clacton cliffs	4C	33.9	15.2	81.3	8.5	3.0	8.2	4.4	1.2	0.7		9.7	1.38	0.72	455	TM 1730 1455
		4D	38.7	12.6	80.5	5.5	5.5	6.4	2.8	2.0		0.5	12.9	0.61	2.27	357	
	11.2-16	*4D*	*25.9*	*6.8*	*78.7*	*10.2*	*10.8*	*5.5*	*3.0*	*1.2*	*0.4*		*10.8*	*1.13*	*1.52*	*804*	
Wivenhoe Gravel	Wivenhoe	1B	25.1	17.8	83.1	3.8	3.8	5.4	5.7	2.7		0.5	18.3	0.05	0.96	371	TM 0461 2530
	(Wiv.2/Co.)	2A	36.4	14.7	74.5	0.4	0.7	12.4	5.5	1.4		0.4	26.2	0.09	1.31	205	TM 0495 2598
	Alresford	1	36.0	8.1	75.5	0.4	0.6	16.2	8.1	2.6		0.7	26.6	0.02	1.75	158	TM 0711 2102
	11.2-16	*1*	*33.2*	*4.7*	*66.1*	*1.4*	*1.4*	*17.7*	*10.0*	*2.1*		*1.1*	*32.4*	*0.05*	*2.67*	*726*	
		2	21.5	16.9	82.5	0.9	0.9	7.3	7.0	1.5		0.6	16.6	0.08	1.04	568	TM 0711 2102
Cooks Green Gravel	Cooks Grn	1A	21.5	*	85.8	3.2	3.2	7.2	3.5	1.0		0.5	13.6	0.30	2.64	325	TM 1880 1856
		1B	27.7	16.4	86.2	2.9	2.9	8.5	2.2	2.8			13.8	0.29	3.75	492	
	11.2-16	*1B*	*26.9*	*7.8*	*72.8*	*3.7*	*3.7*	*15.4*	*4.7*	*2.2*		*0.3*	*23.7*	*0.17*	*3.47*	*1205*	
		2	29.6	12.7	80.3	3.5	3.5	8.1	4.1	1.5		0.3	15.5	0.27	1.90	504	TM 1808 1840
	Gt Holland	1	25.5	19.5	86.3	1.7	1.7	8.4	6.0	0.7			16.0	0.12	1.41	459	TM 2112 1832
	11.2-16	*1*	*25.9*	*8.6*	*80.5*	*3.1*	*3.2*	*9.9*	*5.5*	*1.6*	*0.1*	*0.2*	*16.5*	*0.22*	*1.61*	*1293*	
Little Oakley Silts and Sands	L Oakley	AB	33.6	12.6	87.4	0.8	0.8	4.2	3.5	1.7			11.8	0.08	0.71	119	TM 2250 2952
	11.2-16	*AB*	*26.4*	*7.5*	*73.0*	*2.0*	*2.0*	*17.3*	*5.8*	*2.0*			*24.8*	*0.05*	*3.12*	*205*	
	AC	33.7	10.7	80.7	0.6	0.6	9.5	4.8	5.6			0.6	15.9	0.05	1.98	252	TM 2225 2951
	11.2-16	*AC*	*20.7*	*8.5*	*73.8*	*1.6*	*1.6*	*13.2*	*5.0*	*1.2*	*0.1*	*0.6*	*25.2*	*0.07*	*2.45*	*678*	
		AF	26.0	16.3	80.5	1.9	1.8	9.6	6.5	1.5			17.9	0.11	1.46	223	TM 2250 2946
	11.2-16	*AF*	*20.8*	*6.9*	*79.8*	*2.2*	*2.3*	*15.3*	*6.9*	*1.8*		*0.6*	*26.9*	*0.11*	*2.22*	*640*	
Martello Gravel	Ardleigh	3	20.5	14.3	75.5	1.6	1.6	10.4	6.2	3.4	0.2	0.8	21.9	0.08	1.26	512	TM 0515 2800
		4C	19.5	15.2	76.7	0.7	0.7	13.7	7.8	2.5	0.1	0.5	21.6	0.03	1.61	605	TM 0520 2807
	11.2-16	*4C*	*26.2*	*6.5*	*72.5*	*1.0*	*1.2*	*16.5*	*7.0*	*2.7*	*0.1*	*1.0*	*21.8*	*0.05*	*1.89*	*996*	
Ardleigh Gravel	Ardleigh	1	26.8	15.4	75.8	0.7	0.7	10.9	7.5	0.8		1.5	23.6	0.04	1.56	590	TM 0530 2812
	11.2-16	*1*	*27.1*	*7.7*	*72.1*	*1.2*	*1.7*	*15.4*	*7.3*	*2.2*		*0.2*	*25.9*	*0.07*	*2.13*	*2008*	
		2	23.7	10.2	80.0	1.5	1.5	9.5	5.6	2.0			17.7	0.10	1.72	615	TM 0535 2805
	11.2-16	*2*	*29.0*	*6.4*	*69.9*	*0.7*	*1.0*	*16.9*	*9.5*	*1.0*		*0.7*	*29.1*	*0.04*	*1.57*	*1215*	
		4B	29.5	13.0	75.4	1.5	1.5	9.8	9.5	1.1		1.1	23.0	0.07	1.06	467	TM 0520 2807
	Oakleigh L.O.1	4A	35.3	12.7	72.0	0.4	0.4	13.6	13.5	1.1		0.9	27.5	0.01	0.82	553	
Oakley Gravel	Dovercourt	DA	30.5	12.1	79.1	2.1	2.4	9.8	4.7	1.6		1.1	18.5	0.17	2.08	379	TM 2328 3127
	11.2-15	*DA*	*25.5*	*8.3*	*75.0*	*4.7*	*4.9*	*12.2*	*5.5*	*1.7*			*20.1*	*0.29*	*2.13*	*783*	
	Little Oakley	KA	30.5	15.5	80.2	2.0	2.0	8.8	7.2	4.6	0.2	0.3	17.4	0.15	1.19	653	TM 2191 2947
	11.2-15	*KA*	*25.7*	*9.1*	*76.4*	*2.1*	*2.2*	*13.9*	*7.0*	*1.9*	*0.2*	*0.3*	*21.3*	*0.12*	*1.70*	*673*	
Waldringfield Gravel	Newbourn	1	52.9	*	72.5	0.5	0.5	10.5	11.7	0.8		1.2	25.5	0.02	0.90	595	TL 645064
	Green	2	55.3	4.1	70.6	0.6	0.6	14.7	10.2	0.8		3.6	26.3	0.02	1.45	499	
	Morley Hall	1	26.3	13.7	82.7	1.6	1.6	9.6	9.6	1.6			15.6	0.09	1.06	305	TM 1282 5125

* Not separately recorded

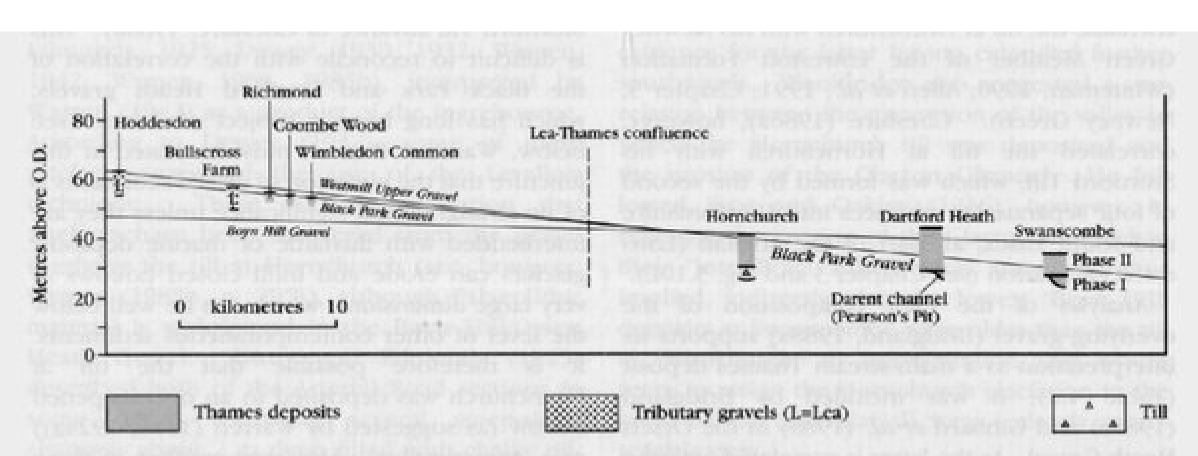
** (for comparison. N.B. non-durables excluded - see, however, Table 3.1, and notes appended to Table 4.2., page 101)

(Table 5.2) Clast-lithological composition of the gravels described in Chapter 5, Part 1.

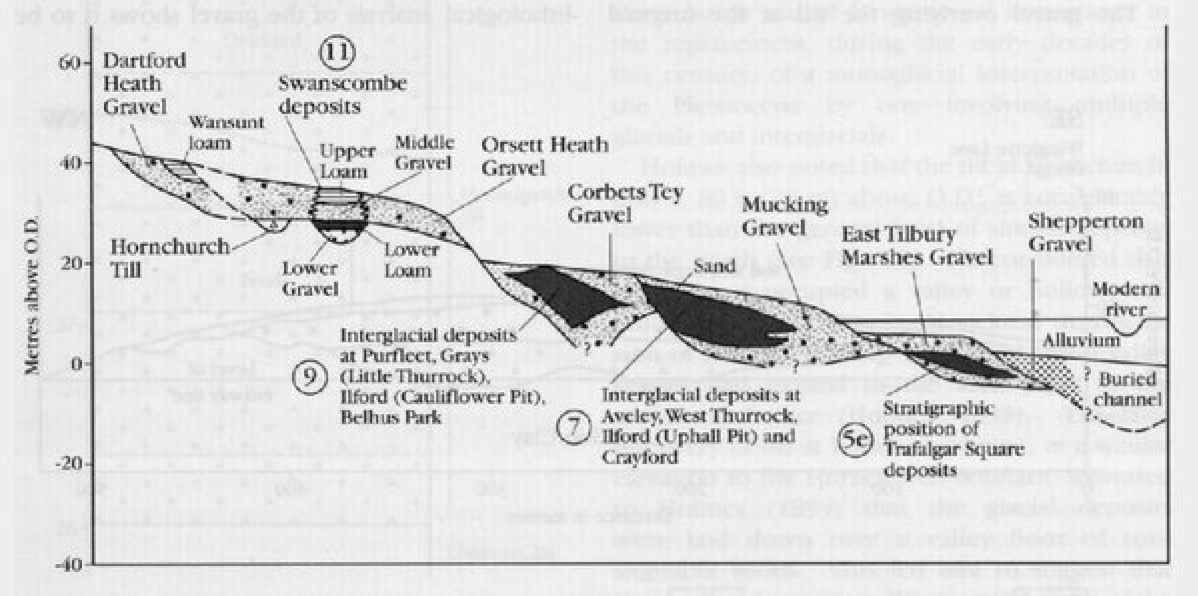
(Table 5.5) Clast-lithological composition of gravels described in Chapter 5, Parts 2 and 3.



(Figure 3.10) Palaeodrainage during key phases of the Anglian evolution of the Vale of St Albans (from Cheshire, 1986a): (A) During deposition of the Westmill Lower Gravel; (B) During the existence of the Watton Road lake; (C) During the existence of the Moor Mill lake; (D) At the maximum extent of the Ware Till ice; (E) At the maximum extent of the Stortford Till ice; (F) At the maximum extent of the Ugley Till ice; (G) During the deposition of the Westmill Upper Gravel and the Smug Oak Gravel; (H) During the Westmill Till ice advance.



(Figure 4.7) Long profile projections of the Black Park and Boyn Hill Formations between the Middle and Lower Thames. The correlation with the Westmill Upper Gravel of the Lea basin is also shown.



(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.