Westmill Quarry

[TL 344 158]

D.R. Bridgland and D.A. Cheshire

Highlights

Exposures at this site have provided evidence for determining the Anglian history of the River Thames and its tributaries. They reveal a complex sequence of gravels and tills that records the replacement of the Thames in this area by a newly formed River Lea. This was a direct response to glacial inundation of the former Thames valley, which eventually deflected that river into its modern course through London.

Introduction

One of the thickest Pleistocene sequences in the Thames basin can be seen at Westmill Quarry, Hertfordshire, where over 20 m of sediments, all attributed to the Anglian Stage, are exposed. These deposits represent the drift sequence, made up of fluvial, glacial, glaciofluvial and glaciolacustrine sediments, that plugs the old valley of the Thames. This old valley separates the Chilterns and the hills of North London, occupying an area known as the Vale of St Albans. The fact that the Vale of St Albans was once glaciated was recognized by Walker (1871) and Whitaker (1889). Salter (1905) and Sherlock and Noble (1912) suggested that this glaciation brought about the cessation of northeastward drainage, a view that was subsequently confirmed by the recognition of proglacial lake deposits in various parts of the Vale of St Albans (Sherlock, 1924; Sherlock and Pocock, 1924; Clayton and Brown, 1958; Gibbard, 1974, 1977; see below, Moor Mill).

The sequence of events during the Anglian glaciation of the Vale of St Albans was reconstructed by Gibbard (1974, 1977, 1978a), the Westmill Quarry section providing critical evidence for his interpretation. Gibbard recognized two glacial advances into the Vale of St Albans during the Anglian. He considered the Thames drainage to have survived the first of these advances, despite local ponding in the Ware area, but that the river was blocked and diverted by the second. Subsequently Cheshire (1981, 1983a, 1983b, 1986a), in a detailed study of till lithologies and stratigraphy, found evidence for four separate Anglian ice advances into the area. According to Cheshire, it was the first of these that effected the diversion of the Thames.

Description

Westmill Quarry is a modern excavation, first described by Gibbard (1974, 1977, 1978a, 1978b), who recorded a sequence of two gravels and two tills. A further till was subsequently recognized by Cheshire (1983a, 1983b, 1986a), who also suggested that the upper till at Westmill, the Eastend Green Till of Gibbard, should be renamed the 'Westmill Till', on the grounds that it is not stratigraphically equivalent to the tills exposed at Gibbard's type site at Eastend Green (see below). The sequence currently recognized at Westmill is therefore as follows (see (Figure 3.9)):

			Thickness
5.	Chalky till, blue-grey to brown	(Westmill Till)	up to 4 m
	3b. Chalk-rich gravel	(Ugley Gravel)	0–3.5 m
4.	Very chalky till, pale brown (N.B. occurs as lenses within or below 3a)	(Stortford Till)	
	3a. Chalk-poor gravel	(Hoddesdon Gravel)	
3.	Sand and gravel, cross-bedded	(Westmill Upper Gravel)	7–11 m
2.	Chalky till, dark grey	(Ware Till)	0–3 m

1.	Sand and gravel, cross-bedded Chalk surface, 48–54 m O.D., rising towards the north-west.	(Westmill Lower Gravel)	up to 9 m

Two separate fluviatile formations are represented in this sequence, which also includes glacigenic members. Gibbard (1974, 1977) regarded the fluvial deposits here as equivalent to the Winter Hill Formation of the Middle Thames, of which they appear to be a downstream continuation. However, further stratigraphical studies have shown that only the Westmill Lower Gravel is actually a continuation of the Winter Hill Formation; the Westmill Upper Gravel can be mapped in parts of the Lea catchment not formerly occupied by the Thames as a distinct body of sediment, probably equivalent to the Black Park Formation of the main river (Cheshire, 1986a; see below).

The Westmill Lower Gravel (unit 1) is generally more massive in its lower part, usually with a very coarse flinty lag' at the base, resting on an irregular Chalk surface that has suffered scouring and/or solution. Towards the top of the unit the proportion of cross-bedded sand and calcareous silt (the latter interpreted as channel-fill material) increases. Both tabular and trough cross-bedding occur and fining-upwards sequences are common. Imbrication in the gravel and foreset orientation in the sand reveal that palaeocurrent flow was towards the north-east. The gravel contains a mixture of flint (over 80%) and quartz and quartzite (accounting for most of the remainder), plus subordinate southern and far-travelled (exotic) material. This is a composition suggestive of a Thames origin (Table 3.2), an interpretation that is supported by the palaeocurrent evidence (Gibbard, 1974, 1977; Cheshire, 1983b, 1986a).

The Ware Till (unit 2) rests upon the eroded surface of the Westmill Lower Gravel, which varies from 55 m to 60.2 m above O.D. Occasionally present at the base of the till is a yellowish-brown laminated silty clay about 0.15 m thick, the laminations suggesting deposition in water; elsewhere the same till overlies the deposits of a local proglacial lake (Gibbard, 1974, 1977). The upper surface of the till is erosional, the deposit having been cut out completely by later channelling in some areas. Because its matrix consists largely of unoxidized clays (with occasional pyrite) derived from the Jurassic, the Ware Till is dark greyish-brown in colour and has a lower calcareous content than the other two tills in the Westmill area. Its particle-size distribution is remarkably uniform throughout, possessing a large and characteristic peak in the fine-sand fraction and a low proportion of pebble clasts in comparison with the later tills. Although the small-clast composition is more variable than the particle-size distribution, the till is characteristically richer in quartz and poorer in flint and *Rhaxella* chert than later tills in the Vale of St Albans sequence. The Ware Till in this area is brecciated; fabric studies show no preferred clast-orientation, indicating emplacement under low-stress glacial conditions or subsequent multi- or non-directional disturbance. *Rhaxella* chert is a rock made up largely of sponge spicules of very characteristic shape and size, occurring only in the Oxfordian and Portlandian (Middle Jurassic).

It is believed to have been carried in quantity into the London Basin by Anglian ice, from sources in north Yorkshire (Bridgland, 1986a).

The Westmill Upper Gravel (unit 3) is variable in lithology and lateral extent. It contains lenses and larger bodies of cross-stratified sand and finer gravel, but is predominantly massive. The upper part of the deposit is also sandy and shows trough cross-stratification. There is a change in composition within these gravels that coincides with a major change in palaeocurrent direction. Immediately above the Ware Till the gravel contains relatively abundant Chalk (13%) and soft 'erratics'. Higher in the sequence these become less frequent, the Chalk component falling to 2–4%. Palaeocurrent measurements from these levels indicate flow towards the north-east. In the upper 3–4 m of the gravel, the Chalk content dramatically increases to 22%, again associated with an increase in soft far-travelled material, particularly from the Mesozoic of central and eastern England. Palaeocurrent measurements from this horizon show local flow to the south-west. Gibbard attributed this change in composition and palaeocurrent directions, which occurs at around 68 m O.D. in the Westmill sequence, to the initiation of a new stream flowing from the north-east. He considered this stream to represent outwash from an approaching ice sheet, that which deposited the overlying (Westmill) Till. Cheshire (1986a) has correlated this higher division of the Westmill Upper Gravel with his Ugley Gravel, as defined at Ugley Park Quarry (see below). The lower division of the Westmill Upper Gravel has been referred by Cheshire to his Hoddesdon Gravel, which contains less Chalk than the Ugley Gravel (Table 3.2); it contains no Chalk at all in the Lower Lea valley south of the Hoddesdon type locality [TL 354 077].

The Stortford Till (unit 4) occurs as detached lenses or channel-fills above, within or cutting through the Ware Till (Figure 3.9). In places a coarse gravel up to 0.8 m thick intervenes between the two tills (basal Hoddesdon Gravel). Although the occurrence of the Stortford Till is localized, at its maximum thickness of 3.5 m this deposit exceeds the laterally more persistent Ware Till. It may be easily distinguished from the latter in the field by its very much greater Chalk content and lighter colour. Unlike the Ware Till, the Stortford Till does not have a vertically uniform particle-size distribution. At its type locality (Stortford Green borehole, TL 479 195; Cheshire, 1986a), the Stortford Till shows a progressive decline in the frequency of medium-fine sand from its base to its top. Only parts of this transition are seen in the Westmill area, some lenses appearing to have incorporated material from the subjacent Ware Till. The flint and *Rhaxella* chert (small-clast) content is greater than in the Ware Till, but the proportion of quartz is reduced (Cheshire, 1986a). Fabric studies indicate a regional ice-flow direction from the north-east.

The Westmill Till (unit 5) superficially resembles the Stortford Till, being light yellowish-brown and having a noticeably high Chalk content. It is the thickest of the three tills, increasing to more than 4 m where it overlies hollows in the surface of the Westmill Upper Gravel. The till crops out extensively in the Westmill area but has been eroded locally from the interfluve to the north and east. The particle-size distribution is vertically uniform and shows a low medium-sand content compared with the Ware and Stortford Tills (with well-defined modes in the 125 and 63 micron fractions). The proportion in the pebble fraction is also greater. The small-clast composition is remarkably uniform, being characterized by relatively high proportions of flint and *Rhaxella* chert, whereas there is less quartz than in other tills. Shear planes are present, generally dipping towards the north-east, indicating ice movement from that direction. Fabric studies show a very strong NE–SW preferred orientation (Gibbard, 1974; Cheshire, 1986a), confirming ice movement from the north-east.

Interpretation

Westmill Quarry, perhaps because of its considerable size and depth, has proved to be a most valuable site for examining the thick sequence of Anglian Stage deposits that fills the old Thames valley through the Vale of St Albans. Although this sequence has been dissected in post-Anglian times by streams of the Colne and Lea systems, a large proportion of the Anglian sediments remains intact. Detailed studies of the area in recent years (Gibbard, 1974, 1977, 1978a; Cheshire, 1981, 1983a, 1983b, 1986a) have increased knowledge of the characteristics and three-dimensional form of these deposits. The importance of the Westmill site in such studies is underlined by the fact that it is the type locality of the Westmill Lower and Upper Gravels, the Ware Till and the Westmill Till.

Gibbard (1974, 1977, 1978a, 1983, 1985) considered the Westmill Lower and Westmill Upper Gravels to be part of a single aggradation by the Thames, which he correlated with the Winter Hill Gravel of the main river. An ostra-cod fauna (Robinson, 1978, 1983), obtained from a bed of silt, 0.3–0.4 m thick, within the Westmill Lower Gravel, indicates that cold-climate conditions prevailed during the aggradation of this member, immediately prior to the arrival of Anglian ice in the area. Robinson pointed to the species *Paralimnocythere compressa* (Brady and Norman) as probably the most significant of seven taxa recognized. This species is believed to indicate a fluviatile setting within a cold steppe or tundra environment, as well as a broadly Middle Pleistocene age.

Gibbard did not recognize the Ware Till in the western part of the Vale of St Albans; he correlated the glacial deposits in that area with the upper till (Westmill Till) at Westmill, assigning both to his 'Eastend Green Till' (see below, Moor Mill). Gravel underlying the Ware Till in the latter area was termed Westmill Gravel by Gibbard, who considered it to be the lateral equivalent of both gravel members at Westmill Quarry. Gibbard's correlation of the Westmill Gravel with the Winter Hill Gravel of the Middle Thames, on the basis of elevation and composition, provided an important link between the Thames terrace sequence and the glacial stratigraphy of eastern England. Cheshire's (1981, 1983a, 1983b, 1986a) subsequent revision of this stratigraphical scheme, in which the Westmill Upper Gravel was recognized as a post-diversion River Lea deposit, demonstrated that only the Westmill Lower Gravel (Figure 3.10)A is a correlative of the Winter Hill Gravel. The stratigraphical link established by Gibbard was upheld by Cheshire, however; on account of its close association with the glaciation of the Vale of St Albans, the Winter Hill/Westmill Lower Gravel can be confidently dated to the Anglian glacial maximum, providing a clear chronostratigraphical marker within the Thames succession.

Gibbard recognized that the Ware Till ice advance had caused ponding of the Thames at the north-eastern end of the Vale of St Albans. Evidence for this ponding event is provided by laminated silts underlying the Ware Till in the Hertford area (Gibbard, 1974, 1977, 1978a). These Watton Road Laminated Silts' (type locality: Watton Road Quarry, TL 431 149) were formed in a proglacial lake at the edge of the Ware Till ice, which later overrode the lake beds ((Figure 3.10)B). Gibbard recorded a minimum of 485 varve-like couplets within this unit; if this rhythmic sequence was seasonally controlled, this would imply that the lake existed for at least 485 years. Gibbard considered that Thames drainage via the Vale of St Albans and the 'Mid-Essex Depression' (see Chapter 5) survived the Ware Till glacial advance and that the river was ponded again, at the western end of the vale, by the later advance that led to the deposition of his 'Eastend Green Till'.

Cheshire (1981) suggested that the Ware Till ice advance and the resultant formation of the Watton Road lake had caused an initial southward diversion of the Thames via the Lower Lea, which is essentially a reversed section of the early Mole–Wey–Wandle valley. This interpretation was based on the recognition of the continuation of the Westmill Upper Gravel at Hoddesdon, which is in the Lea valley and well to the south of the reconstructed Westmill Lower Gravel course of the Thames. Thames drainage via the Lower Lea had previously been suggested by Sherlock and Noble (1912), Hawkins (1922), Baker and Jones (1980) and Jones (1981), the last two of these on the grounds that the 'Mid-Essex Depression' was probably blocked by ice in Westmill Upper Gravel times. However, Gibbard (1983) suggested that the Thames at that time had been forced southwards to Hoddesdon around an ice lobe (that from which the Ware Till was deposited), but that it had curved north-eastwards to regain its original course, which remained ice-free at this time. However, the discovery of Westmill Upper Gravel at Bullscross Farm, Waltham Cross [TL 340 007], demonstrated that this unit (which must now be regarded as having formation status) continues southwards down the Lea valley (Cheshire, 1983c, 1986a), contrary to Gibbard's suggestion. An excavation at Bullscross Farm by the GCR Unit (Anon., 1982a) revealed Mole–Wey gravel, rich in Greensand chert and with evidence of northward palaeocurrents, cut out by the edge of a channel containing the Westmill Upper Gravel, which has bedding structures indicative of southward palaeocurrents. These two gravels are separated by a thin 'diamicton' with a particle-size distribution almost identical to the Ware Till of the Vale of St Albans. Confirmation of this correlation on the basis of composition is precluded by the non-calcareous (?decalcified) condition of the 'diamicton' (Cheshire, 1986a). Macrofabric evidence shows this material to have a highly significant mono-polar preferred orientation, which suggests that it represents remobilized (possibly solifluted) Ware Till. The evidence from this site shows that the Westmill Upper Gravel stream flowed southwards down the Lower Lea valley after the Ware Till ice had extended almost as far south as the present location of the M25 motorway.

Later work by Cheshire (1983a, 1986a) showed that the Ware Till extends westwards beyond the area of the Watton Road lake and can be recognized at the western end of the Vale of St Albans, where it is equivalent to the deposit classified by Gibbard (1974, 1977) as 'Eastend Green Till'. According to Cheshire, it was the Ware Till ice that caused both the formation of a lake in the Watford area (the Moor Mill lake of Gibbard, 1974, 1977) and the ultimate diversion of the Thames into its modern course ((Figure 3.10)C; see below, Moor Mill). The Westmill Upper Gravel is therefore not a Thames deposit, as Gibbard suggested. It is confined to the Lea catchment and was regarded by Cheshire (1986a) as the earliest Lea aggradation, albeit largely fed by outwash from Anglian ice. Cheshire recognized, from analyses of clast-lithological composition at sites throughout the catchment, lower (Chalk-poor) and upper (Chalk-rich) divisions of this formation, his Hoddesdon and Ugley Gravels (see below, Ugley).

The attribution of the complete sequence of tills and gravels at Westmill to the Anglian Stage was established by Gibbard (1974, 1977), who pointed to the occurrence of supposed kettlehole infills in the surface of the uppermost till (Westmill Till; unit 5), including pollen-bearing sediments ascribed to the Hoxnian Stage. Organic deposits of this type have been found at Hatfield (first described by Sparks *et al.* (1969)) and Colney Heath (Gibbard, 1977, 1978a, 1978c). Successive pollen spectra obtained from these deposits reveal the change from cold conditions at the end of the Anglian glaciation to the ameliorating climate of the early Hoxnian Stage. The Hatfield sequence continues into the latter half of the Hoxnian (biozone Haab) (Gibbard and Cheshire, 1983).

Recent reappraisal of the glacial stratigraphy in the Vale of St Albans by Cheshire (1983a, 1983b, 1986a) has raised doubts about the relations of the Hoxnian deposits to the till sequence. There is also a possibility that the till directly underlying the Hoxnian organic deposits at Hatfield is not *in situ.* It has been variously described as a slumped deposit, possibly deformed by the melting of buried ice (Rose, 1974), as flow till (Gibbard, 1978c) or as soliflucted till that has been derived from higher ground immediately to the east (Cheshire, 1986a). Below this disturbed unit is an *in situ* till that can be traced through a large number of quarries and boreholes south-westwards to Moor Mill and north-eastwards to Westmill; in both directions it appears to be continuous with the Ware Till (Cheshire, 1986a). The Ware Till has characteristic properties of particle size, carbonate and small-clast content that have allowed Cheshire (1986a) to recognize it throughout the Vale of St Albans and beyond. His work shows that only this, the earliest of the Vale of St Albans tills, is firmly dated as pre-Hoxnian by overlying polleniferous deposits. However, the various tills in the Vale of St Albans sequence are separated only by cold-climate glaciofluvial gravels, so there is no reason to suspect that any temperate episode(s) occurred between the deposition of any of them.

The Hatfield site has also yielded Mollusca, of species indicative of a temperate fluvial environment (Sparks *et al.,* 1969), examples of which have recently been subjected to amino acid analyses (Bowen *et al.,* 1989). Bowen *et al.* obtained D : L ratios from shells of *Lymnaea, Gyraulus* and *Valvata* (0.22 ± 0.02, 0.246 ± 0.002 and 0.247 ± 0.02 respectively) that are within the range of specimens believed to date from Oxygen Isotope Stage 9. In comparison with results from other sites attributed to the Hoxnian Stage, the ratios from Hatfield are sim ilar to those from Hoxne itself, but significantly lower than those from Swanscombe and Clacton. The comparison with Swanscombe is important, since sediments there are also believed to have been deposited soon after the diversion of the Thames. Of the three genera from Hatfield that were analysed, the only one represented in the Swanscombe data is *Valvata,* from which Bowen *et al.* obtained a ratio of 0.30. This is significantly higher than the *Valvata* ratio from Hatfield (0.247) and was attributed to Oxygen Isotope Stage 11 by Bowen *et al.* These ratios suggest that the Hatfield organic sediments are significantly younger than the glacial deposits of the Vale of St Albans, since the Anglian glaciation is widely believed to have occurred during Stage 12 (see Chapter 1).

Cheshire (1986a) regarded the Westmill Upper Gravel as penecontemporaneous with the Smug Oak Gravel, an outwash-charged early Comm deposit that overlies the Ware Till in the western part of the Vale of St Albans ((Figure 3.10)G; see below, Moor Mill). This is highly significant, since Gibbard (1977, 1978a) correlated the Smug Oak Gravel with the Black Park Gravel of the Thames, the first formation that can be traced into the modern valley through London. If Cheshire's interpretation is correct, the River Lea, during Westmill Upper Gravel times, was also feeding the Black Park Gravel Thames with outwash-derived material from the Anglian ice sheets that persisted in eastern Hertfordshire. This interpretation, which is supported by projections of the long-profiles of the Westmill Upper Gravel and the Black Park Gravel into the Lower Thames (see (Figure 4.7)), further strengthens Gibbard's (1977, 1979, 1985) attribution of the Black Park Gravel to the Anglian Stage.

Cheshire (1978, 1981, 1983a, 1983b, 1986a, 1986b) has identified two tills in the Vale of St Albans that are additional to the, sequence established by Gibbard (1974, 1977). The first of these additional tills was initially described in the Hertford area (Cheshire, 1978, 1981), where it is preserved only as thin lenticles within the Westmill Upper Gravel at Foxholes Quarry, Hertford [TL 340 123]. The stratigraphical position of this till is represented elsewhere in the area (including Westmill Quarry) by the change from low-Chalk (Hoddesdon Gravel) to Chalk■rich (Ugley Gravel) clast composition (Table 3.2). Cheshire originally called this unit the 'Foxholes Till', but the discovery that a more substantial remnant is preserved at Ugley (see below, Ugley Park Quarry) led him to adopt the name Ugley Till. The other additional till, the Stortford Till, is the middle of the three tills recognized at Westmill (unit 4). It represents a glacial advance into the Vale of St Albans intermediate between deposition of the Ware Till and the Ugley Till ((Figure 3.10)E). The Stortford Till is therefore stratigraphically the second till in the regional sequence.

According to the revised stratigraphy established by Cheshire (1986a; in Allen *et al.,* 1991), the Ware Till, deposited by the earliest of the four ice advances, can be traced throughout the Vale of St Albans. It rests upon proglacial lake deposits in the Watford area (Gibbard, 1977; see (Figure 3.10)C and D), indicating its importance in effecting the diversion of the Thames. In the area south-west of the northern suburbs of Hatfield, the Ware Till is not overlain, directly or indirectly, by any subsequent glacial deposit. Decay of the Ware Till ice initiated independent drainage in the Lea and Colne basins. The Stort-ford Till advance possibly occurred before the wasting of the Ware Till ice was complete. Dead ice from the Ware Till ice lobe would have formed a barrier to this second advance, which may explain why the Stortford Till does not extend across the low ground to the south-west of the Hertford area (Cheshire, 1986a). The main thrust of the Stortford Till advance reached further south than that of the Ware Till, with lobes extending to Finchley, in the former

Mole–Wey valley ((Figure 3.10)E) and Hornchurch (see Chapter 4). The Stortford Till ice then retreated to a position north of Bishop's Stortford before a third advance of ice, extending as far as Hertford, led to the deposition of the Ugley Till ((Figure 3.10)F). The ice once more retreated to the north of Bishop's Stortford and the carbonate-rich Ugley Gravel, the upper division of the Westmill Upper Gravel, was added to the sequence (the drainage pattern before and after the Ugley Till advance was probably similar — see (Figure 3.10)G). The final ice advance, leading to the deposition of the Westmill Till, extended further than the Ugley Till, sending lobes into the Vale of St Albans and the Lower Lea valley that reached terminal positions in north Hatfield and near Waltham Cross respectively (Cheshire, 1986a). All four tills record the advance of ice into the region from the north and/or north-east.

From the foregoing account it would seem that the southward-draining River Lea arose as a reversal of part of the pre-Anglian Mole–Wey–Wandle course, as a result of the advance of Ware Till ice into the Hertford area. Cheshire (1983c, 1986a) in fact suggested that the Mole–Wey may have already been captured by a tributary of the Darent–Medway prior to the glaciation, with a southward-flowing river occupying the Lower Lea valley by this time. He considered that southward through-drainage via the Lower Lea was initiated by overflow from the Watton Road lake, which was dammed by Ware Till ice during the early part of its advance into the Vale of St Albans ((Figure 3.10)B). This event preceded the formation of the Moor Mill lake, which did not occur until the Ware Till ice had advanced beyond the Hertford area, blocking the Vale of St Albans drainage entirely and diverting the Thames southwards to the Windsor area ((Figure 3.10)C and D). Thus for a brief interval, during the existence of the Watton Road lake and during the latter part of the interval represented by the Winter Hill/Westmill Lower Gravel, Thames waters presumably found their way from the Vale of St Albans into the Medway system via the Lower Lea valley, perhaps initiating deposition of the gravel identified in the Lea valley as Westmill Upper Gravel. The initial diversion of the Thames therefore seems to have resulted from the overflow of the Watton Road lake, not that at Moor Mill. This earlier lake-overflow produced a very short-lived Thames route via the Vale of St Albans and the Lower Lea, similar to that envisaged by earlier authors (Sherlock and Noble, 1912; Hawkins, 1922; Baker and Jones, 1980; Cheshire, 1981; Jones, 1981). If this earliest diverted route is represented at all within the sedimentary record of the Thames downstream from London, it would be expected to have contributed to the earliest post-diversion deposits within the channel-system recognized in eastern Essex, which are correlated with the Black Park Formation of the Middle Thames (Bridgland, 1988a; Chapter 5). Thus the latest parts of the Winter Hill/Westmill Lower Gravel aggradation would be contemporaneous with deposits at the Black Park level, east of London, although the latter have been buried by the subsequent (early Saalian) deposition of the Boyn Hill/Orsett Heath Gravel and have yet to be separately identified (see Chapter 4, Hornchurch and Wansunt Pit). The close association of the Winter Hill and Black Park Gravels is well-established; it has been suggested above that the downcutting from the Winter Hill to the Black Park level was simply a response to the diversion of the Thames (see above, Chapter 1).

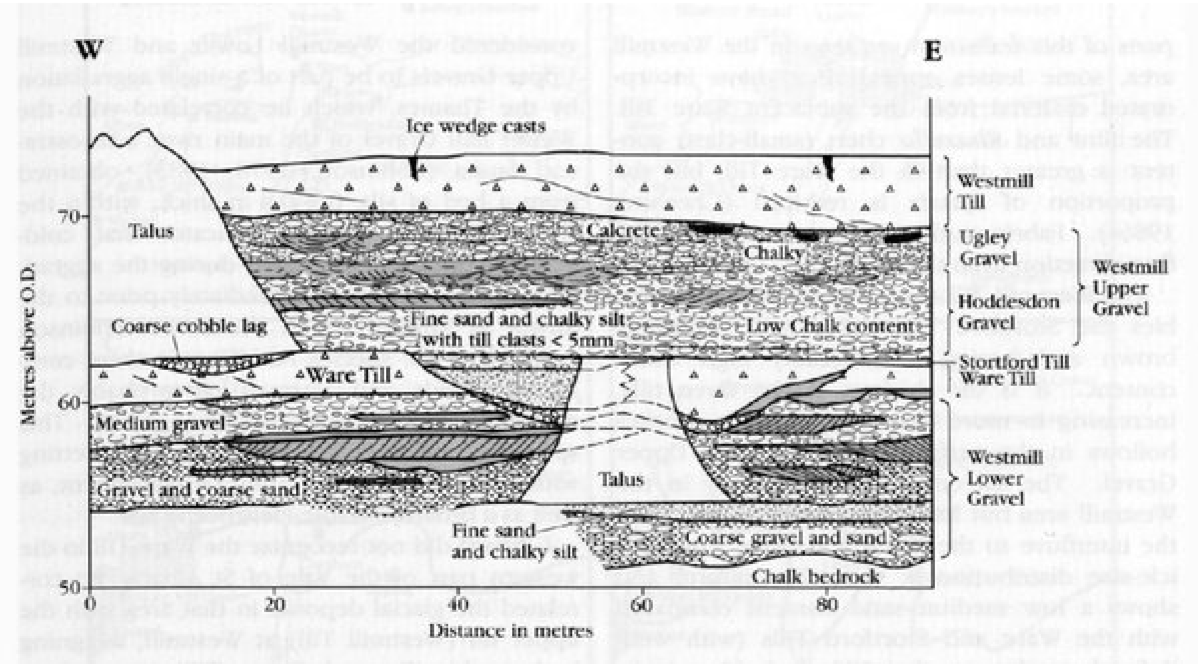
The Westmill succession therefore represents a remarkably complete record of Anglian Stage deposition in the Vale of St Albans, including both fluvial and glacial deposits. The sequence in this district, established over several years from exposures in Westmill Quarry, is unique in the Vale of St Albans, in that tills related to three of the four Anglian glacial advances now recognized in Hertfordshire and western Essex are represented. The fluvial sediments in this sequence represent the last phase of pre-diversion Thames aggradation and the newly formed (post-Thames diversion) River Lea.

Conclusions

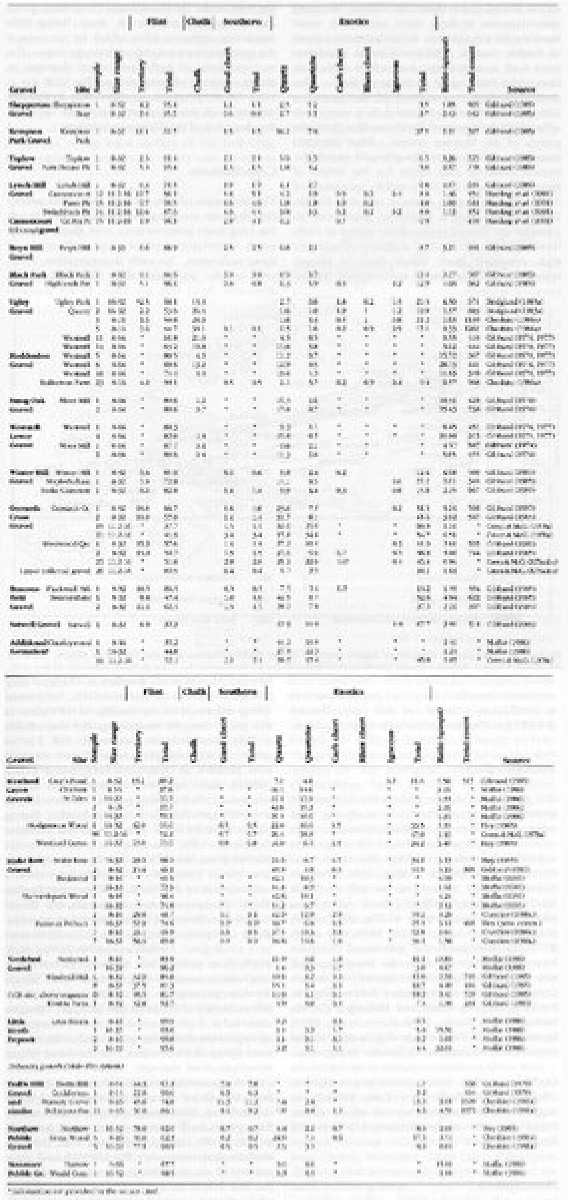
Westmill Quarry provides exposures through a complex series of gravels and tills (boulder clays), laid down during probably the most significant cold phase of the Quaternary ice age, around 450,000 years ago (the Anglian Stage). The lowest gravel (the Westmill Lower Gravel) was laid down by the Thames when it flowed through the Vale of St Albans and into Essex, along a more northerly route than the present river. This gravel was the last to be deposited by the Thames in this old northern course. The overlying deposits at Westmill consist of a complex series of tills (deposits laid down directly by ice sheets) and fluvial gravels deposited by the newly formed River Lea, the latter fed by meltwater streams flowing from ice sheets as they advanced and retreated across the area. It was these Anglian ice sheets that were responsible for the blocking and diversion of the Thames, eventually leading to the formation of the modern Thames valley through London.

In all, four separate advances of ice into this part of Hertfordshire have been recognized, three of which have left a direct record, in the form of till, at Westmill. Thus, collectively, the deposits exposed here are important for charting the course of the Thames before it was diverted southwards by the ice, as well as for establishing the number, extent and direction of movement of the various Anglian ice advances that are known to have affected this region.

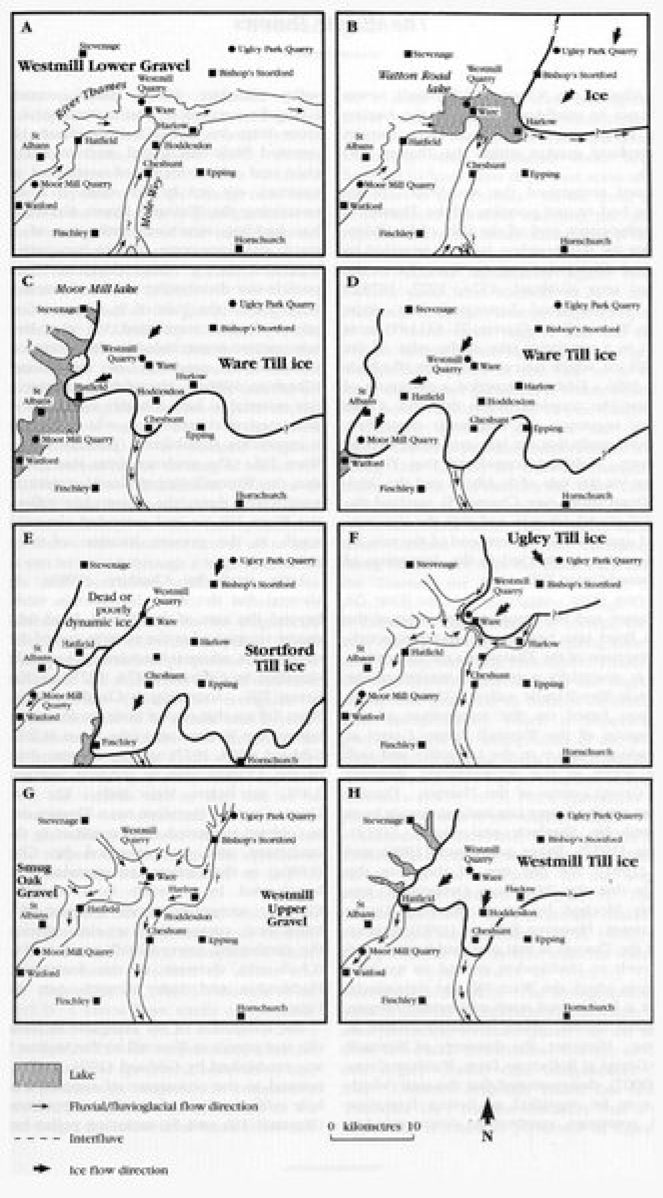
[References](#)



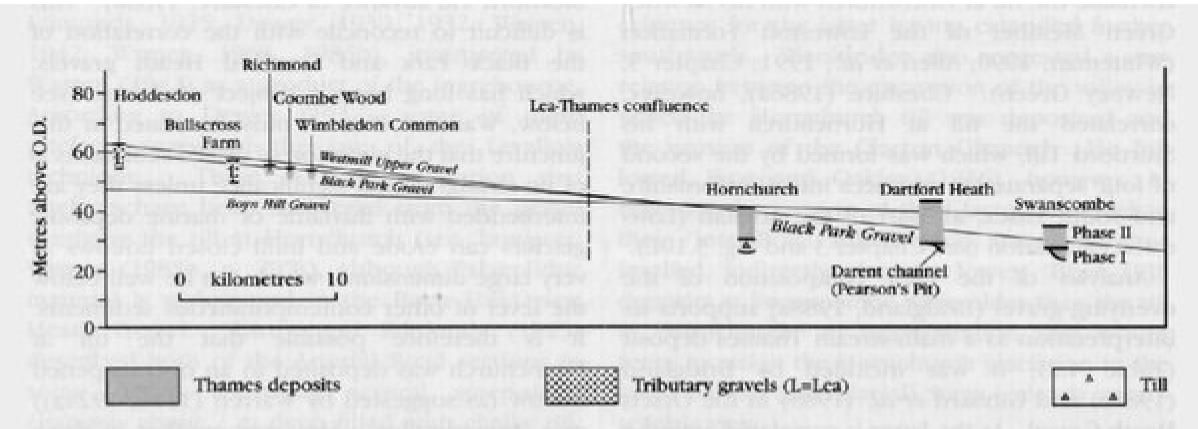
(Figure 3.9) Section in the north face of Westmill Quarry, recorded in June 1981 (after Cheshire, 1983b).



(Table 3.2) Clast-lithological data (in percentage of total count) from the Middle Thames and Vale of St Albans (compiled from various sources). The data concentrates on key sites, GCR sites and localities mentioned in the text. Note that many different size ranges are included and that these yield strikingly different data (this can be observed where results from different fractions from the same deposits have been analysed). As in (Table 4.2), (Table 5.1) and (Table 5.3), the igneous category includes metamorphic rocks (very rarely encountered) and the quartzite category includes durable sandstones. The Tertiary flint category comprises rounded pebbles (sometimes subsequently broken) reworked from the Palaeogene (see glossary with (Table 4.2)).



(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.