Ardleigh (Martells Quarry)

[TM 053 280]

D.R. Bridgland

Highlights

At this site cold-climate river gravels, assigned to the pre-diversion Thames, are interbedded with various organic sediments, some of which are indicative of temperate (interglacial) conditions. The latter have yielded the remains of deciduous trees. The site therefore reveals an early Middle Pleistocene cold-warm-cold climatic cycle expressed in Thames sediments. The complex sequence at Ardleigh also includes cold-climate organic deposits, a later (?tributary) gravel and soils formed under both warm and cold climatic conditions.

Introduction

Martells Quarry, Ardleigh, is the type locality for the Ardleigh Gravel, second highest of the four Low-level Kesgrave Group formations recognized on the Tendring Plateau (Bridgland, 1988a; see above, Introduction to Part 1; (Figure 5.2) and (Figure 5.3) and (Table 5.3)). There has been a pit at Ardleigh for many years, attention first being drawn to the site by Spencer (1966), following the discovery of bones, including a skull fragment of a ziphiid whale. Later work has revealed the presence at Ardleigh of lenses and beds of organic sediments within the Ardleigh Formation, two distinct types being recognized, one indicative of a temperate climate and the other, higher in the sequence, of intensely cold conditions (Bridgland, 1988a; Bridgland *et al.,* 1988; Bridgland and Gibbard, 1990).

A complex succession of Pleistocene deposits is now recognized at Ardleigh, with evidence for periglacial conditions at more than one level and a complex palaeosol at the top of the sequence (Bridgland *et al.,* 1988). The interglacial represented by the lower set of organic sediments at Ardleigh is thought to correlate broadly with the 'Cromerian Complex' of The Netherlands (see Chapter 1; Zagwijn *et al.,* 1971; Zagwijn, 1986; de Jong, 1988).

Description

Spencer (1966) produced a diagrammatic illustration of a section at Ardleigh (without a scale), showing a partly submerged sequence of sands and gravels with a cryoturbated zone just above the water level. He considered the deposits above this zone of cryoturbation to be glacial outwash and those below to be of fluvial origin.

Recent work at this site has revealed a much greater stratigraphical complexity than was envisaged by Spencer (Bridgland et al, 1988). The sequence now recognized is as follows:

		Thickness
4a. Complex rubified and cryoturbated relict soil	(Valley Farm and Barham Soils)	up to 1.5 m
4. Brown/orange gravel and sand. This has a low frequency of rounded flint pebbles; *Rhaxella* chert is present (Table 5.2). Palaeocurrents are towards the south-west	(Martells Gravel)	up to 3 m
3a. Silty clay, dark grey and organic, with plant macrofossils. This occurs as variable beds and lenses *c.* 1.5 m below the top of member 3	(cold-climate deposits)	0.1–1 m

3. Pale buff gravel and sand. This has a relatively high frequency of rounded flint pebbles; *Rhaxella* chert is absent (Table 5.2); palaeocurrents are towards the north-east	(Ardleigh Upper Gravel)	up to 5 m
2. Sand, dark grey/black and organic. This has high silt, clay and organic contents. It contains plant macrofossils and pollen. It occurs as variable beds and lenses.	(Ardleigh interglacial deposits)	up to 0.5 m
1. Pale, buff gravel and sand. This has a relatively high frequency of rounded flint pebbles; *Rhaxella* chert is absent; palaoecurrents are towards the north-east	(Ardleigh Lower Gravel)	up to 2 m
London Clay		

Two separate gravel deposits occur here in superposition. They are distinguished on the bases of differences in clast lithology and sedimentological criteria, particularly palaeocurrent evidence. These are the Ardleigh Gravel (members 1 and 3) and the Martells Gravel (member 4). With member 2, the Ardleigh interglacial deposits, members 1 and 3 combine to form the Ardleigh Gravel Formation, which belongs to the Low-level Kesgrave Subgroup. The GCR site is the type locality for all these units.

The Ardleigh Gravel has a composition typical of the Low-level Kesgrave Subgroup in this area (Table 5.2), with evidence for north-eastward palaeocurrents adding support to its interpretation as a Thames deposit (Bridgland, 1988a; Bridgland *et al.,* 1988). It is divided into two members, (1) the Ardleigh Upper Gravel and (3) the Ardleigh Lower Gravel, by the interglacial deposits (member 2), which represent a temperate interval (Bridgland *et al.,* 1988; (Figure 5.9)). The Ardleigh Lower and Upper Gravels clearly represent different cold-climate episodes, but they cannot be distinguished in the absence of the organic interglacial deposits.

The temperate-climate organic sediments comprise variable lenses and beds of predominantly sandy deposits, frequently showing deformation structures suggestive of internal collapse while waterlogged (Figure 5.10). These beds contain pollen, plant macrofossils and beetle remains. Poorly preserved wood remains and occasional indeterminate, abraded mammal bones that have been found in the lower parts of the Ardleigh Upper Gravel may have been reworked from the interglacial level. The Ardleigh interglacial deposits have been revealed intermittently by continued quarrying over a wide area, occurrences probably representing fills of isolated shallow channels (Bridgland and Gibbard, 1990). Pollen analyses have indicated that these various remnants are not all contemporaneous (Bridgland and Gibbard, 1990). These analyses have allowed the compilation of a preliminary and fragmentary pollen diagram, combining evidence from three of these isolated channel-fills (Bridgland and Gibbard, 1990). All three parts of this diagram record the occurrence of deciduous trees, namely birch (*Betula*), oak (*Quercus*), elm (*Ulmus*), alder (*Alnus*), willow (*Salix*) and hazel (*Corylus*). Pine and spruce were also present throughout (with the exception of the basal part of the oldest channel-fill). In two of the channel-fills, regarded as earlier than the third, the pollen was dominated by herb taxa, indicating cooler conditions and suggesting an earlier part of the interglacial. The basal layers of one of the channel-fills was practically devoid of tree pollen, suggesting that the very onset of interglacial conditions was represented. It was presumed that this was the oldest of the sampled sediment bodies (Bridgland and Gibbard, 1990). In the third part of the diagram, tree pollen constitutes over 60% of the total and a greater diversity of forest trees is indicated, suggesting the middle part of an interglacial.

At a higher stratigraphical level within the Ardleigh (Upper) Gravel there occur further organic sediments. These contain macrofossils of cold-climate plants, predominantly mosses, grasses and sedges, and clearly represent the vegetation of a periglacial episode. It is apparent, from the occurrence of ice-wedge casts originating from the upper surface of the Ardleigh (Upper) Gravel (Figure 5.9), that permafrost conditions prevailed prior to the deposition of the overlying Martells Gravel.

In contrast to the Ardleigh Gravel, the Martells Gravel (member 4) contains a lower proportion of rounded flint pebbles (of the type reworked from the Palaeogene) than is usual in the Kesgrave Group. It contains significant amounts of *Rhaxella* chert, a rock that is extremely scarce in the Kesgrave Sands and Gravels upstream (to the south and west) of the Crag basin (Table 5.2). Foreset orientations indicate palaeocurrents towards the west-south-west, essentially a reversal of the flow direction indicated by palaeocurrent measurements from the Ardleigh Gravel (Figure 5.9). The combination of these various lines of evidence implies that the Martells Gravel was deposited by a river flowing from the north-east, which leads to the conclusion that it is not a Thames deposit and not part of the Kesgrave Group.

At the top of the sequence at Ardleigh, a rubified and cryoturbated palaeosol is developed in the upper part of the Martells Gravel, immediately beneath the modern topsoil (Figure 5.9). Ice-wedge casts originating from the top of the fluvial sequence have also been recognized, superimposed on the earlier system of wedges developed from the surface of the Ardleigh (Upper) Gravel (Figure 5.9).

Interpretation

The principal significance of the Ardleigh GCR site lies in the occurrence there, within a gravel formation ascribed to the Low-level Kesgrave Subgroup, of lower Middle Pleistocene temperate-climate sediments. As yet the palaeontological evidence from these sediments is insufficiently distinctive to allow the temperate episode they represent to be identified. The vegetational sequence revealed in the fragmentary pollen diagram (Bridgland and Gibbard, 1990) is similar to that found in the early parts of other lower Middle Pleistocene interglacial deposits. The presence and persistence of spruce, the early expansion of elm and the low frequency of hazel were all identified as significant by Bridgland and Gibbard (1990), but there are no features in the pollen record at Ardleigh that are of biostratigraphical or chronostratigraphical significance.

Palaeomagnetic measurements from the Ardleigh interglacial deposits (T. Austin, in Bridgland and Gibbard, 1990) have indicated a normal polarity, implying that they post-date the Matuyama–Brunhes magnetic reversal, which is taken as the base of the Middle Pleistocene (Chapter 1). The oldest known interglacial epi sode with which they could be correlated is therefore 'Cromerian Complex Interglacial II' of the Dutch sequence (see Chapter 1).

The relation of these sediments, which lie near the base of the Ardleigh Gravel sequence, to the interglacial channel-fill at Little Oakley (Bridgland *et al.,* 1988, 1990; see below) is of great importance. The latter deposits, which contain molluscan and vertebrate remains as well as pollen, are interpreted as of broadly Cromerian age and thought to belong within the 'Cromerian Complex' as identified in The Netherlands. They occur in the same terrace formation as the Ardleigh sediments, but are 17 km to the east-north-east (downstream). This places them within the area of the confluence between the Kesgrave Thames and the early Medway, within the Oakley Gravel Formation, the lateral Thames-Medway equivalent of the Ardleigh Gravel (Figure 5.2) and (Figure 5.4)C. The channel at Little Oakley cuts through the local Oakley Gravel, implying that the interglacial represented there may be later than that at Ardleigh. This would suggest that the Ardleigh Upper Gravel was laid down in the interval between the Ardleigh and Little Oakley interglacials (see, however, Little Oakley). Gibbard (1988b) has attributed the Ardleigh interglacial deposits to a temperate interval between the Pastonian and Cromerian and has suggested correlation with either Interglacial II or Interglacial III of the 'Cromerian Complex' (see Chapter 1).

With cold-climate gravels both above and below the interglacial sediments, it is apparent that the sequence within the Ardleigh Formation at the GCR site represents all three aggradational phases of the climatic model for terrace formation promoted in Chapter 1, as follows:

Phase 4 (post-interglacial aggradation)	Ardleigh Upper Gravel	(member 3)
Phase 3 (interglacial aggradation)	Ardleigh interglacial sediments	(member 2)
Phase 2 (pre-interglacial aggradation)	Ardleigh Lower Gravel	(member 1)

The relation of the Little Oaldey channel deposits to this model will be discussed below (see Little Oakley).

Assuming the Ardleigh temperate episode to be earlier than that represented at Little Oakley, only one other site is currently known in Britain where a possible correlative of the Ardleigh interglacial sediments occurs, this being at Broomfield, near Chelmsford. As at Ardleigh, both temperate- and cold-climate organic deposits occur at Broomfield (Gibbard, 1988b; Whiteman, 1990). Whiteman (pers. comm.) considers that the gravel at Broomfield, which is buried beneath Lowestoft Till, may be an upstream continuation of the Ardleigh Formation.

The interpretation of the Martells Gravel, which overlies the Ardleigh Gravel at the GCR site, is somewhat problematic. As described above, the Martells Gravel contains significantly less rounded flint (reworked from the Palaeogene) than the underlying Ardleigh Gravel and it also differs in that it contains *Rhaxella* chert. Both differences suggest an apparent affinity to outwash gravels from the Anglian glaciation, which also have these particular ('northern) characteristics (Bridgland, 1980, 1986b; Bridgland et al, 1988). However, Anglian outwash deposits also differ from Kesgrave Group gravels in that about half of their exotic component (derived from the north and west) is made up of non-quartzose lithologies (an example is the ice-proximal Ugley Gravel at Ugley Park Quarry (see Chapter 3, Part 2). The exotic suite found in Kesgrave Group gravels typically includes over 80% quartz and quartzites. The Martells Gravel shares this high proportion of quartzose exotics with the Kesgrave Group, thus differing markedly from outwash gravel. The palaeocurrent evidence from the Martells Gravel, which indicates flow from the north-east, would appear to preclude the interpretation of the unit as either outwash or a Kesgrave Thames deposit. In the latter case flow towards the north-east would be expected, the exact opposite of what is indicated, whereas the location of the Lowestoft Till margin well to the west of Ardleigh (Figure 5.4)F suggests that any outwash streams crossing the Tendring Plateau would have flowed in a broadly eastward or southeastward direction.

The most plausible interpretation of the Martells Gravel, based on these facts, is as the product of a river flowing from the north-east into the pre-diversion Thames valley or, if of post-Anglian age, into the Colne valley (Bridgland *et al.,* 1988). Such a river would have drained an area covered by earlier Kesgrave Group Thames gravels and by Red Crag. The former would have supplied much of the material in the Martells Gravel, ensuring a high quartz and quartzite content, but the inclusion of pebbles reworked from the Crag would have diluted the rounded flint, which is not found in quantity in the Crag, and added the *Rhaxella* chert, which is an important component of Crag pebble beds. The river presumably had an insufficiently large catchment to tap the Westleton Beds of northern Suffolk, as these would have yielded abundant rounded flint, largely indistinguishable from that reworked from the Palaeogene of the London Basin. No other remnants of gravels that may have been aggraded by this hypothetical river have been identified.

There is little evidence for the age of the Mattells Gravel. It is clearly later than the Ardleigh/Oaldey Gravel and presumably post-dates Thames occupation of the Ardleigh/Oakley Formation floodplain. No soil development has been observed at the top of the Ardleigh Gravel, beneath the Martells Gravel, in recent studies. However, Spencer (1966) recorded a zone of cryoturbation at Ardleigh beneath an upper gravel, although no details of thickness were given. He quoted the grid reference of his section, which leaves no doubt that he referred to earlier sections in the present Martells Pit. If the upper gravel identified by Spencer was the Martells Gravel, his description may record a zone of cryoturbation at the top of the Ardleigh Gravel, where only ice-wedge casts have been seen in recent exposures. Spencer's record was cited by Rose *et al.* (1985a), who claimed that his cryoturbated zone represented the early Anglian Barham Soil. The only cryoturbated horizon recorded recently is that developed in the top of the Martells Gravel (Figure 5.9); this would appear to lie too close to the modern land surface to be the horizon identified by Spencer, unless his section revealed a higher, later gravel that is missing from more recent exposures. Confirmation of a cryoturbated and/ or weathered horizon at the top of the Ardleigh Gravel might provide additional information about the difference in age between it and the overlying Martells Gravel. C. Turner (pers. comm.) has suggested, however, that Spencer's cryoturbation layer was in fact the deformed lower (temperate) organic member, the penecontemporaneous deformation structures that disrupt this deposit (see Description and (Figure 5.10)) having been mistaken for involutions.

The rubified and cryoturbated zone at the top of the Martells Gravel is reminiscent of the superimposed (temperate) Valley Farm and (cold) Barham Soils, which have been identified in the upper levels of the various Kesgrave Group formations (Rose *et al.,* 1976, 1985a, 1985b; Rose and Allen, 1977; Kemp, 1985a; see above, Introduction to Part 1). The Valley Farm Soil was recorded at the top of a sequence at Ardleigh by Rose *et al.* (1976), although the later Barham Soil was not recognized. The combination of this record and the reinterpretation by Rose *et al.* (1985a) of Spencer's section suggests that palaeosols may be represented at two different stratigraphical levels at Ardleigh. The Valley Farm

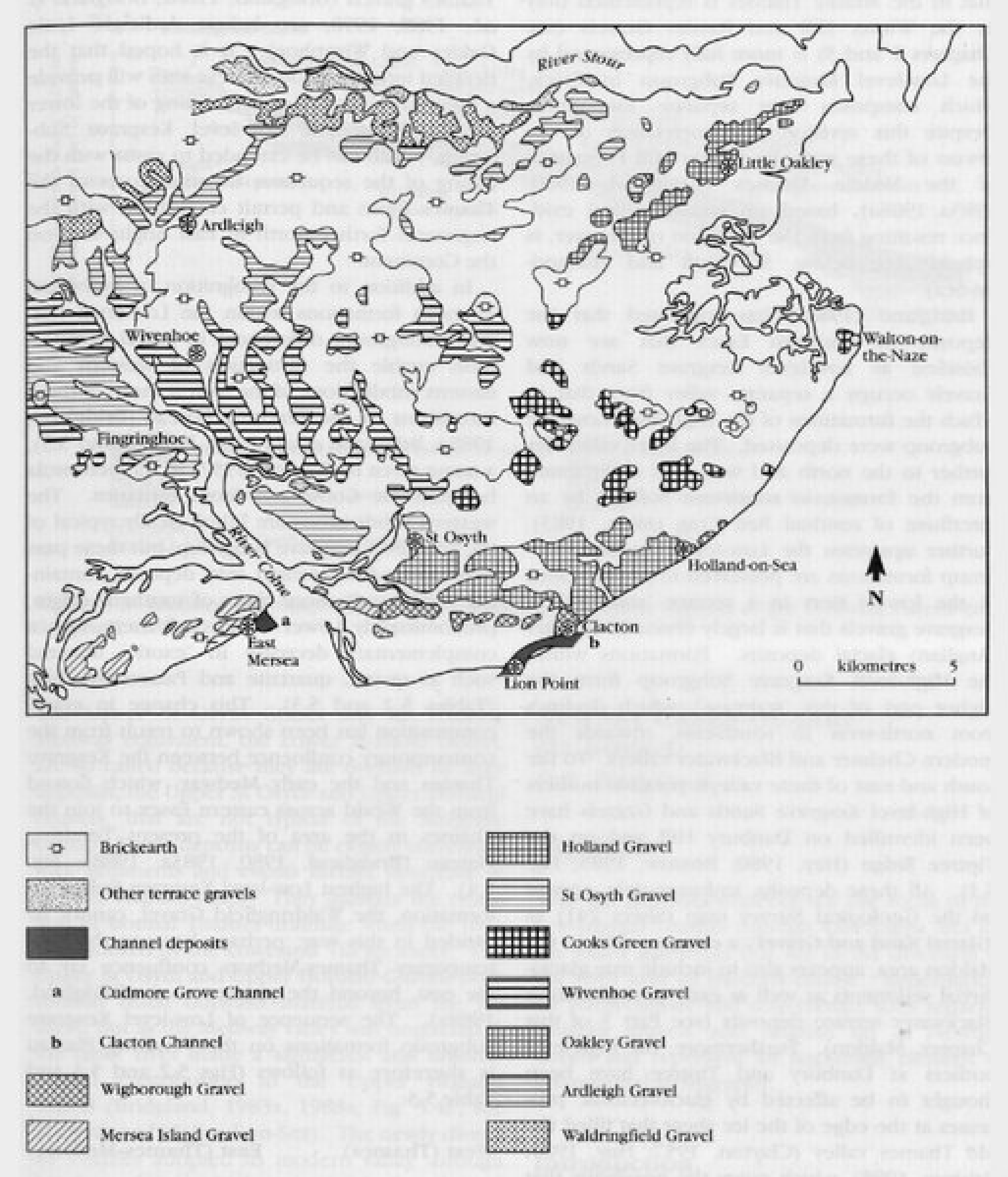
Soil has recently been tentatively identified over much of the Tendring Plateau 'in relict form' (Kemp, 1985a). However, in this area, where it is at or near the modern surface and not overlain by Anglian glacial deposits, it is impossible to demonstrate the pre-Anglian origin of the reddened material. The correlation of this soil layer with the pre-Anglian Valley Farm Soil would be of considerable significance, since the age and origin of the Martens Gravel cannot be established by other means. However, a post-Anglian rubified soil has been recorded from the Chelmsford area (Rose *et al.,* 1978), so the presence of a reddened zone in the Martells Gravel may be of little stratigraphical value.

Spencer (1966) suggested that the lower part of the sequence at Ardleigh was of Hoxnian age. He appears to have based this suggestion on the occurrence of the whale bone. However, as Spencer noted, ziphiid whale bones of this type are common in the basement bed of the Red Crag at Walton-on-the-Naze, some 20 km to the east of Ardleigh. It seems likely that this bone had been reworked from such a source and that its provenance at Ardleigh was the Martens Gravel, which has already been claimed to contain certain gravel material reworked from the Crag, and has been shown to be the product of a river flowing from the direction of the Crag outcrop (see above). Further investigation of sections in the area may throw more light on the relation of Spencer's section to the sequence described at the GCR site and on the relations of the relict soils at Ardleigh to the Valley Farm and Barham Soils of East Anglia.

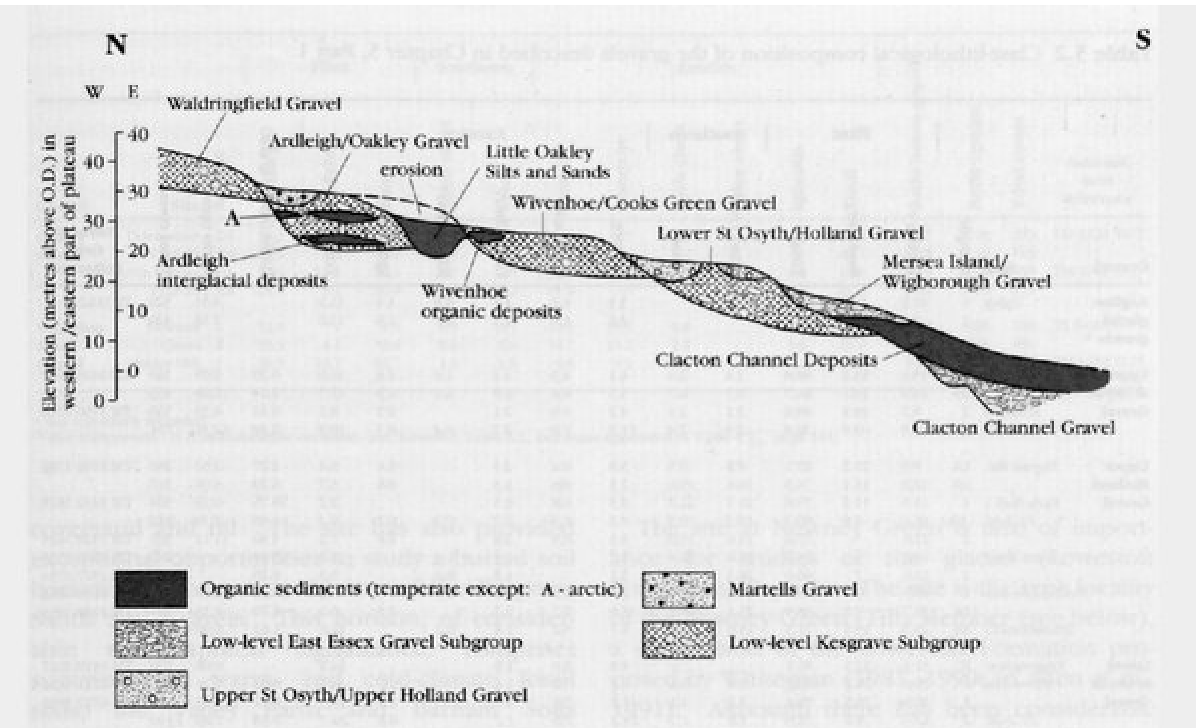
Conclusions

Martells Quarry, Ardleigh, is an important site for Pleistocene stratigraphy and palaeoenvironmental reconstruction. The sequence here includes sediments deposited by an ancestral River Thames at a time when it flowed across East Anglia, long before its diversion, by ice, into its modern valley. Deposits from two cold-climate episodes separated by a temperate (interglacial) interval are represented here. The interglacial deposits are of considerable significance in that they may be unique in Britain. The interglacial represented probably belongs within a complex of cold and warm episodes recognized in The Netherlands (referred to as the 'Cromerian Complex', after the most famous site of this general age, near Cromer in Norfolk), implying a date somewhere between 750,000 and 450,000 years BP. The site has been identified as the type locality for an important formation within the Kesgrave Group of early Thames deposits, the Ardleigh Gravel, which is itself subdivided by the interglacial beds where these are present. The Ardleigh Lower and Ardleigh Upper gravels therefore represent two different cold periods. Further fossiliferous beds occur within the Ardleigh Upper Gravel. These are most unusual in that they contain plant remains representative of a tundra environment. A later, enigmatic upper deposit, the Martens Gravel, appears to be the product of a later river draining from the north-east, but its age is indeterminate at present.

References



(Figure 5.2) Pleistocene gravels of the Tendring Plateau (after Bridgland, 1988a).



(Figure 5.3) Idealized N—S transverse section through the Pleistocene deposits of the Tendring Plateau (after Bridgland, 1988a).

See Chapter 3, Part 2		Tendring Plateau		South of Blackwater		
Middle Thames	**Vale of St Albans**	**Low-level Kesgrave Thames**	**Low-level Kesgrave Thames - Medway**	**High-level East Essex Gravel Medway**	**Climate**	**Stage**
Winter Hill U.Gr.	Moor Mill Clay	Upper St Osyth Gr.[1]	Upper Holland Gr.[1]	Chalkwell/Caidge Gr.	Glacial	Anglian[2]
Winter Hill L.Gr.	Westmill L.Gravel	Lower St Osyth Gr.	Lower Holland Gr.	Chalkwell/Caidge Gr.	Periglacial	early Anglian
No equivalent formations recognized in the area upstream from Essex, with the possible exception of the Rassler Gravel of the Reading area (see Chapter 1 and Fig. 1.3)		*Rejuvenation event*				
		Wivenhoe Formation: Wiv.U.Gr. intgl.seds Wiv.L.Gr.	Cooks Green Gravel	Canewdon/St Lawr.Gr.	Periglacial Temperate Periglacial	
		Rejuvenation event				
		Ardleigh Formation: Ard.U.Gr. intgl.seds Ard.L.Gr.	? L.Oakley Slts & Sds[3] Oakley Gravel	Belfairs/Mayland Gr.	Periglacial Temperate Periglacial Temperate Periglacial	'Cromerian Complex'
		Rejuvenation event				
		Waldringfield Gr.	None recognized	Ashingdon Gravel?	Periglacial	

1 Not part of the Kesgrave Group (deposited while the Thames was blocked).
2 Anglian glacial maximum.
3 The Little Oakley Silts and Sands may date from the same temperate episode as the Ardleigh interglacial deposits.

(Table 5.3) Correlation of gravel formations in Essex within the Kesgrave Group with deposits in other areas.

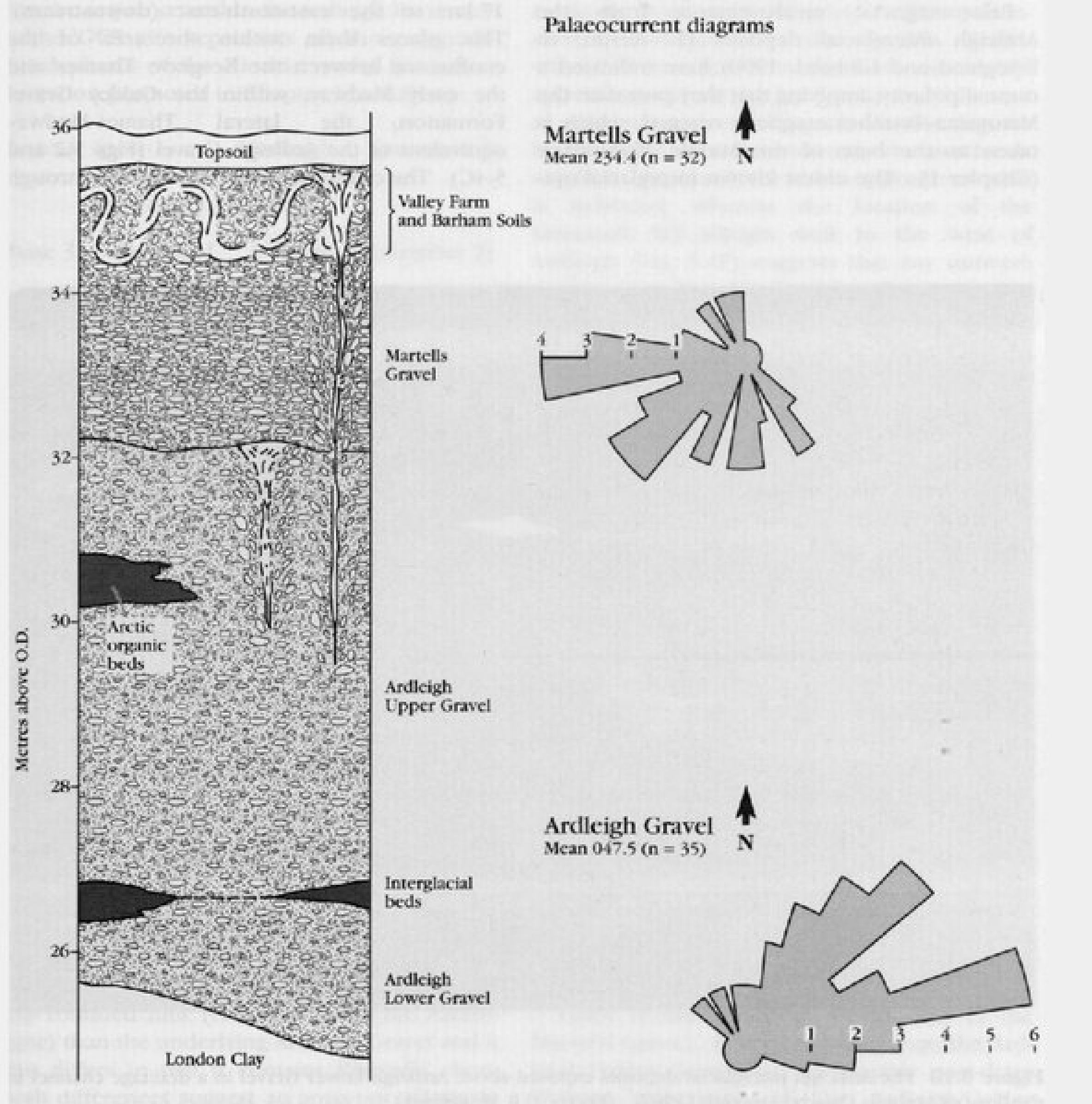
Gravel	Site	Sample	Flint: Tertiary	Flint: Nodular	Flint: Total	Southern: Good chert	Southern: Total	Exotics: Quartz	Exotics: Quartzite	Exotics: Carb chert	Exotics: Rhax chert	Exotics: Igneous	Exotics: Total	Ratio (others q/qtzt)	Ratio (qtz/qtzt)	Total count	National Grid Reference
Anglian glacial gravels**	Ugley	1	61.9	25.7	87.9			5.5	0.8	1.5	0.6	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	15.1	13.8	80.8	2.4	2.4	4.1	4.5	4.1	1.4	0.8	16.8	0.29	0.95	909	TM 0219 2017
		1B	15.9	13.7	80.7	3.7	3.7	5.7	6.8	0.8	0.9	0.9	17.7	0.05	0.84	455	
	St Osyth	2	8.7	19.1	89.8	2.1	2.1	4.2	0.9	2.1		0.2	8.5	0.41	4.35	530	TM 1195 1704
	11.2-16	*2(S)*	*14.9*	*9.4*	*78.8*	*2.8*	*2.8*	*11.9*	*1.0*	*2.7*	*0.4*	*0.3*	*16.8*	*0.18*	*12.50*	*714*	
Upper Holland Gravel	Bypass Rd.	1A	9.9	21.5	82.1	8.8	8.5	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	
	Earls Hall 1	1	13.5	11.5	75.8	21.7	21.7	3.5	0.8	0.5			2.2	19.75	0.53	364	TM 1432 1625
	11.2-16	*2(S)*	*26.0*	*8.8*	*80.3*	*10.2*	*10.5*	*4.2*	*1.5*	*2.7*	*0.3*	*0.1*	*9.1*	*1.80*	*2.79*	*352*	
		2	13.6	*	77.6	15.0	15.5	3.6	0.3	7.8		0.6	7.2	4.50	11.11	361	TM 1439 1625
	Burrs Road	1	10.8	*	64.8	30.3	30.4	0.7		1.4	1.4		3.8	45.00		287	TM 1935 1759
		2	11.6	*	66.6	29.4	29.8	3.3		1.5	0.6		5.5	9.20		320	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	18.35	11.11	415	TM 2108 1662
		2A	15.7	9.8	68.9	25.1	25.1	3.6	0.7	0.7		0.5	6.0	6.70	4.35	207	TM 2109 1663
	[illegible]	2B	21.7	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	8.0	1.8			11.9		0.80	376	TM 0219 2017
	Moverons	1	29.0	16.8	90.8	3.6	3.6	8.1	7.0	1.4		1.0	18.3	0.06	1.20	829	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*	*32.3*	*5.9*	*73.5*	*1.6*	*1.7*	*14.2*	*7.6*	*1.7*		*0.8*	*24.7*	*0.08*	*1.80*	*1140*	
		3	31.8	13.1	77.3	3.6	3.7	11.4	7.8	1.3		0.7	21.7	0.04	1.47	956	TM 0699 1825
	St Osyth	1A	35.1	*	77.1	3.5	3.5	11.1	7.7	1.8		0.2	22.6	0.05	1.45	550	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*	*78.0*	*1.7*	*1.7*	*12.5*	*4.8*	*2.0*		*0.3*	*20.2*	*0.10*	*2.61*	*1129*	
Lower Holland Gravel	St Osyth	3	21.6	16.8	83.1	1.4	1.4	10.3	2.7	1.6		0.5	15.3	0.11	3.20	561	TM 1201 1703
		5	21.8	10.8	83.0	4.6	4.2	5.8	6.8	1.8		0.5	13.3	0.50	0.85	525	TM 1215 1605
		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 1600
	Bush Paddock	1	43.3	10.5	83.9	4.8	5.1	5.9	3.7	0.8		0.5	11.8	0.55	1.59	567	TM 1257 1611
	11.2-16	*1*	*45.8*	*5.7*	*75.8*	*10.5*	*10.8*	*9.2*	*2.4*	*0.8*	*0.1*	*0.2*	*15.8*	*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	0.14	1.06	412	TM 2109 1663
		2D	26.7	13.8	80.5	1.8	1.8	9.2	5.6	1.1		0.5	16.5	0.12	1.64	555	
	Holland Haven	1A	21.9	*	81.0	2.1	2.9	7.3	3.7	1.6	0.1	0.3	13.1	0.26	1.96	382	TM 2208 1744
		1B	31.6	14.6	85.1	2.5	5.1	9.6	4.6	0.4			15.9	0.26	2.08	200	
		2	25.3	*	82.1	2.0	3.0	8.4	3.9	1.7	0.2	0.2	14.8	0.24	2.17	326	TM 2205 1743
	11.2-16	*2*	*31.4*	*7.2*	*78.8*	*1.2*	*0.2*	*12.4*	*2.2*	*1.4*	*0.2*	*0.9*	*18.0*	*0.06*	*5.64*	*939*	
	Clacton cliffs	4C	30.9	15.2	80.3	8.5	8.3	5.2	4.4	1.2	0.7		9.7	1.18	0.72	433	TM 1720 1433
		4D	38.7	12.6	81.3	5.3	5.5	6.4	2.8	2.0		0.5	12.8	0.60	2.27	357	
	11.2-16	*4D*	*35.9*	*6.6*	*78.7*	*10.2*	*10.8*	*5.5*	*3.0*	*1.2*	*0.4*		*10.8*	*1.15*	*1.52*	*864*	
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	0.56	371	TM 0456 2530
	(Wiv. 11 G.)	2A	38.1	14.7	74.5	0.4	0.7	12.4	5.5	1.4		0.6	26.7	0.05	1.31	203	TM 0495 2598
	Alresford	1	38.8	8.1	73.5	0.4	0.6	16.2	8.1	2.6		0.7	26.8	0.02	1.75	158	TM 0711 2102
	11.2-16	*1*	*32.1*	*4.7*	*66.1*	*1.4*	*1.4*	*17.7*	*10.0*	*2.3*		*1.1*	*32.4*	*0.05*	*2.67*	*720*	
		2	21.5	16.9	82.5	0.9	0.9	7.3	7.0	1.5		0.6	16.6	0.01	1.04	314	TM 0711 2102
Cooks Green Gravel	Cooks Grn	1A	21.3	*	83.8	3.2	3.2	7.2	3.5	1.0		0.5	13.6	0.32	2.04	325	TM 1869 1856
		1B	27.7	14.4	86.2	2.3	2.3	8.3	2.2	2.8			13.8	0.23	3.75	492	
	11.2-16	*1B*	*26.9*	*7.8*	*72.5*	*3.7*	*3.7*	*15.4*	*4.7*	*3.2*		*0.3*	*23.7*	*0.17*	*3.47*	*1205*	
		2	29.4	12.7	80.3	3.5	3.5	8.1	4.1	1.3		0.3	13.5	0.27	1.90	304	TM 1898 1840
	Gt Holland	1	25.5	19.5	84.3	1.7	1.7	8.4	6.0	0.7			16.0	0.12	1.41	419	TM 2112 1802
	11.2-16	*1*	*25.9*	*8.6*	*80.3*	*3.1*	*3.2*	*9.9*	*5.9*	*1.8*	*0.1*	*0.2*	*16.5*	*0.22*	*1.61*	*1093*	
Little Oakley Silts and Sands	L Oakley	AB	33.6	12.6	87.4	0.8	0.8	4.2	5.9	1.7			11.8	0.08	0.71	119	TM 2250 2952
	11.2-16	*AB*	*26.4*	*7.3*	*73.0*	*2.0*	*2.0*	*17.3*	*5.0*	*2.0*			*24.8*	*0.05*	*1.52*	*208*	
		AC	33.7	16.7	83.7	0.4	0.5	4.8	4.6			0.4	15.9	0.05	1.98	252	TM 2225 2951
	11.2-16	*AC*	*20.7*	*8.5*	*72.1*	*1.6*	*1.6*	*15.2*	*6.1*	*1.2*	*0.1*	*0.6*	*25.2*	*0.07*	*2.45*	*678*	
		AF	26.0	16.3	80.3	1.9	1.9	9.6	6.2	1.2			17.9	0.11	1.46	223	TM 2250 2946
	11.2-16	*AF*	*29.8*	*6.9*	*79.9*	*2.2*	*2.3*	*15.3*	*6.5*	*1.8*		*0.6*	*26.9*	*0.11*	*2.22*	*640*	
Martello Gravel	Ardleigh	3	20.5	14.1	76.5	1.6	1.6	10.4	6.2	3.4	0.2	0.8	21.9	0.08	1.20	312	TM 0515 2800
		4C	19.5	13.2	76.7	0.7	0.7	11.7	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*	*14.5*	*7.6*	*2.7*	*0.1*	*1.0*	*27.8*	*0.05*	*3.09*	*906*	
Ardleigh Gravel	Ardleigh	1	26.8	15.4	75.6	0.7	0.7	10.9	7.5	0.8		1.5	23.6	0.04	1.58	590	TM 0530 2852
	11.2-16	*1*	*27.1*	*7.7*	*72.1*	*1.2*	*1.7*	*15.4*	*7.5*	*2.2*		*0.2*	*25.0*	*0.07*	*2.11*	*1008*	
		2	23.7	10.2	80.0	1.5	1.5	9.5	5.6	2.0			17.7	0.10	1.72	815	TM 0535 2805
	11.2-16	*2*	*29.0*	*6.4*	*69.9*	*0.7*	*1.0*	*16.0*	*9.5*	*3.0*		*0.7*	*29.1*	*0.04*	*1.57*	*1215*	
		4B	29.5	13.0	75.4	1.5	1.5	9.8	9.1	1.1		1.1	23.0	0.07	1.04	447	TM 0520 2867
	[illegible] L.G.1	4A	33.5	12.7	72.0	0.4	0.4	11.6	13.9	1.1		0.9	27.5	0.01	0.82	553	

Gravel	Site	Sample	Flint: Tertiary	Flint: Nodular	Flint: Total	Southern: Good chert	Southern: Total	Exotics: Quartz	Exotics: Quartzite	Exotics: Carb chert	Exotics: Rhax chert	Exotics: Igneous	Exotics: Total	Ratio (others q/qtzt)	Ratio (qtz/qtzt)	Total count	National Grid Reference
Oakley Gravel	Dovercourt	D4	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
	11.2-16	*D4*	*23.3*	*6.3*	*75.0*	*4.7*	*4.9*	*11.1*	*5.5*	*1.7*			*20.1*	*0.20*	*2.13*	*741*	
	Little Oakley	K4	30.5	15.5	80.2	2.0	2.0	8.6	7.2	4.6	0.1	0.3	17.4	0.15	1.19	653	TM 2191 2947
	11.2-16	*K4*	*25.7*	*9.1*	*76.4*	*2.1*	*2.2*	*13.9*	*7.6*	*1.9*	*0.2*	*0.3*	*21.5*	*0.12*	*1.70*	*673*	
Waldringfield Gravel	[illegible]	1	52.9	*	72.5	0.5	0.5	10.5	11.7	0.8		1.3	25.5	0.02	0.90	595	TL 045004
	Green	2	55.3	4.1	70.6	0.6	0.6	14.7	10.2	0.8		3.6	26.9	0.02	1.45	490	
	Motley Hill	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 3125

* Not separately recorded

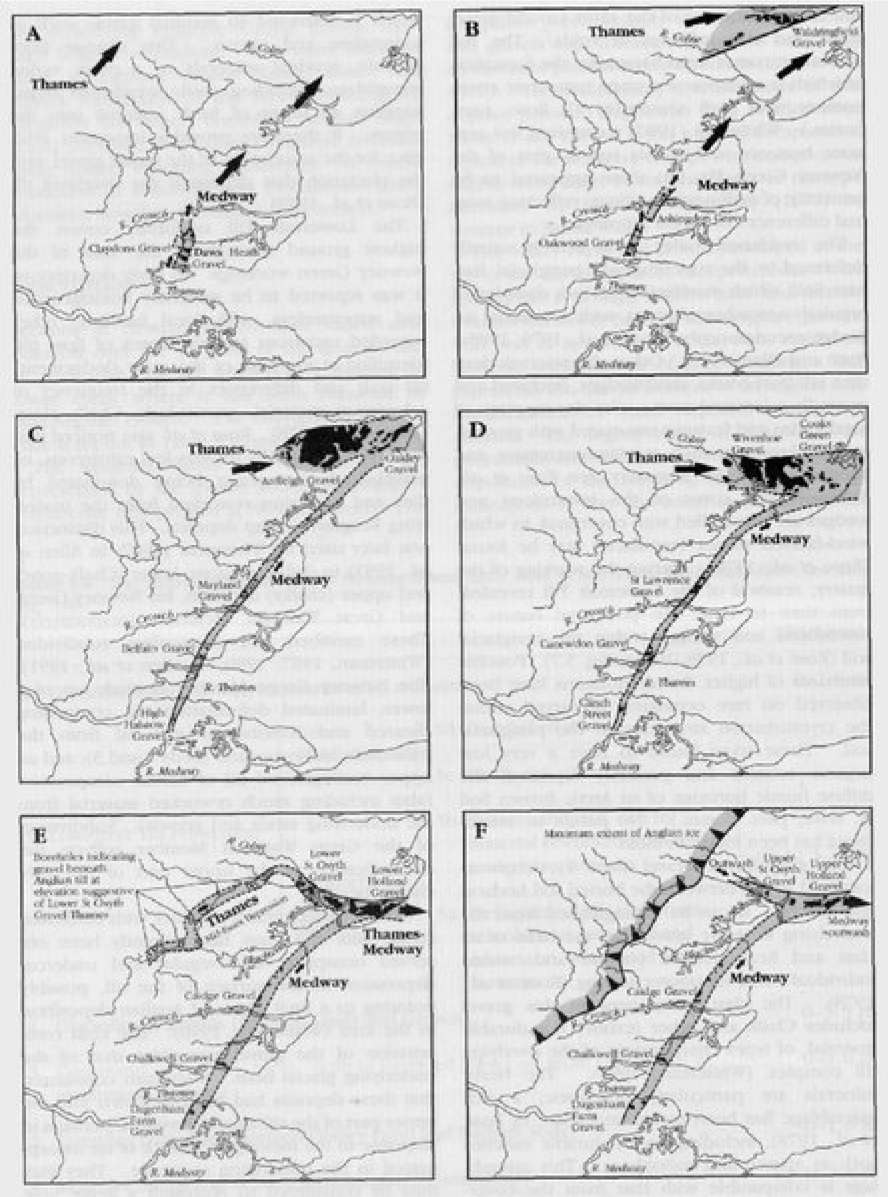
** (for comparison. N.B. non-durables excluded - see, however: Table 3.1, and notes appended to Table 4.2., page 101)

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



(Figure 5.9) Idealized Pleistocene sequence at Ardleigh (after Bridgland et al., 1988).

(Figure 5.10) The Ardleigh interglacial deposits exposed above Ardleigh Lower Gravel in a drainage channel in the floor of Martells Quarry, Ardleigh (1987). (Photo: D.R. Bridgland.)



(Figure 5.4) Palaeodrainage of eastern Essex up to the Anglian glaciation (after Bridgland, 1988a): (A) Palaeodrainage at the time of deposition by the Medway of the Claydons and Daws Heath Gravels, part of the Rayleigh Hills gravels. The Thames and Medway are thought to have had separate routes to the North Sea at this time. (B) Palaeodrainage at the time of deposition by the Medway of the Oakwood and Ashingdon Gravels. The Waldringfield Gravel, which might be a correlative of the Ashingdon Gravel, is also shown. It is believed that the Thames and Medway joined during Waldringfield Gravel times, but this confluence is believed to have been situated to the east of the present coastline. (C) Palaeodrainage at the time of deposition by the Thames of the Ardleigh Gravel. (D) Palaeodrainage at the time of deposition by the Thames of the Wivenhoe Gravel. (E) Palaeodrainage during the early Anglian Stage, prior to the inundation of the Thames valley by the Lowestoft Till ice sheet. (F) Palaeodrainage during the Anglian glaciation, prior to the diversion of the Thames but after its valley became blocked by ice. The highly distinctive Upper St Osyth and Upper Holland Gravels were laid down at this time.