Clacton (cliffs, foreshore and golf course)

D.R. Bridgland

Highlights

A key locality for studies of Pleistocene stratigraphy and palaeontology, the complex site at Clacton reveals a channel-fill traditionally assigned to the Hoxnian Stage. This series of deposits, attributed to the Thames-Medway, contains faunal and floral remains indicative of temperate-climate conditions. In addition to the considerable stratigraphical, palaeontological and palaeoenvironmental significance of the site, it is famous as the type locality for the Clactonian Palaeolithic Industry. The location of the Clacton deposits is such that a stratigraphical link between the Thames system and the East Anglian Pleistocene succession is provided, making this one of the most important Pleistocene sites in southern Britain. The palaeogeographical position of the site in relation to the regional Thames terrace sequence, together with the stratigraphical evidence it provides, indicates a Hoxnian (*sensu* Swanscombe) age for the interglacial sediments here, immediately postdating the Anglian diversion of the Thames.

Introduction

The cliffs, foreshore and immediate inland area at Clacton-on-Sea together constitute a complex Pleistocene site of international significance. Clacton lies in the south-eastern corner of the Tendring Plateau. Recent work has shown that the gravels in this area belong mainly to the pre-diversion Thames system (Rose *et al.,* 1976; Bridgland, 1980, 1988a; Green *et al.,* 1982; Bridgland *et al.,* 1988, 1990; Part 1 of this chapter). At Clacton, fossiliferous Pleistocene channel deposits are preserved in an arcuate area to the south of the town centre (Figure 5.17), intersecting with the present coastline at Lion Point, Jaywick (western end) and to the south of the pier (eastern end). These sediments have yielded many Palaeolithic artefacts, which form a characteristic assemblage of flakes and cores, with no formal tools such as hand-axes (Warren, 1912, 1922, 1933, 1958). Clacton is the type locality of this particular Palaeolithic industry, to which the name Clactonian was first applied by Warren (1926; see below).

Although they were discovered and extensively described in the last century (Brown, 1838, 1840, 1841; Fisher, 1868a; Dalton, 1880), much of our present knowledge of the Clacton Channel Deposits can be credited to S.H. Warren, who devoted a considerable proportion of his life's work to the deposits at Clacton and the Clactonian Industry (Warren, 1922, 1923a, 1924b, 1933, 1940, 1951, 1955, 1958). Pollen from these sediments was used to construct one of the first British interglacial pollen diagrams (Pike and Godwin, 1953), subsequently the basis for their ascription to the Hoxnian Stage (West, 1956, 1963; Turner, 1973). The deposits have been widely regarded as downstream correlatives of those at Swanscombe in the Lower Thames (Chapter 4), the two sites having been correlated by a comparison of their molluscan faunas (Kerney, 1971; Turner and Kerney, 1971). Two full-scale archaeological excavations have taken place on the golf course (Oakley and Leakey, 1937; Singer *et al.,* 1973) and a further investigation, as yet unpublished, was recently undertaken of exposures created during the redevelopment of the holiday camp (Wymer, 1988; (Figure 5.17)). The most recent summaries of palaeoenvironmental evidence from Clacton were by Wymer (1974, 1985b) and Roe (1981).

The Clacton site has figured prominently in recent work that has attempted to correlate between the Pleistocene sequences in the Thames Basin and East Anglia (Bridgland, 1980, 1988a; Bridgland *et al.,* 1988). The results of this work suggest that the Clacton Channel was the product of the post-diversion Thames and that it represents an early phase of deposition by that river following the adoption of its modern valley through London (see (Figure 5.5)A).

Description

The Clacton Channel Deposits have been poorly accessible during the past half century, so that most work on them during this period has relied on temporary exposures, boreholes or museum collections. Earlier workers were able to describe continuous cliff exposures between the site of the holiday camp and Holland-on-Sea, but these disappeared long ago beneath ornamental gardens. Although it has recently been possible to re-excavate fragments of this section (Bridgland *et al.,* 1988), it is necessary to consult the early published descriptions to assess the characteristics and extent of the Clacton sediments.

The deposits were discovered in the late 1830s by John Brown of Stanway, who wrote a number of short papers describing them and their fossil content (Brown, 1838, 1839, .1840, 1841, 1845, 1857). Brown (1840, 1841) noted the occurrence of both marine and freshwater molluscs at Clacton and that only the latter type occurred in the lowest stratum, which also yielded mammalian remains. He divided the sequence into seven separate beds, broadly reflecting a change from a freshwater/lacustrine environment to 'fluvio-marine' (estuarine) conditions. He also recorded a bed with freshwater shells near the top, possibly an early reference to Warren's (1923a, 1955) 'bed 1' (see below).

References to the fossiliferous beds at Clacton also appeared in a number of other early publications, notably those of Owen (1846), Wood (1848), who suggested that the lacustr-Me' deposit might be the freshwater equivalent of the Red Crag, and his son (Wood, 1866b), in his original description of the East Essex Gravel (see above, Introduction to Part 2). In addition, Fisher (1868a, 1868b) published descriptions of the sections, partly from his own observations and partly based on an old manuscript by Brown, and Dalton (1880) included an illustrated description of the site in the Colchester memoir. Both Dalton and Fisher reproduced Brown's stratigraphy without significant modification, but Picton (1912) later proposed a more detailed subdivision. Other early writers concentrated on aspects of the palaeontology: Jones (1850) described the ostracods, Dawkins (1868, 1869) and Ransome (1890) described the mammalian remains, Webb (1894, 1900), Kennard and Woodward (1897, 1923) and Kennard (1924) all described the Mollusca, whereas Hinton (1923) provided a report on the rodent remains.

Prior to the work of Warren, the Clacton Channel Deposits were known only from the site of their original discovery, the West Cliff section. Warren (1923a, 1933) recognized that part of the Clacton sequence occurs at Lion Point, Jaywick, exhumed from beneath saltings. He later interpreted the Clacton and Lion Point sites as 'sections across the same fluviatile channel a few miles apart' (Warren, 1933, p. 15). As Warren showed, the channel follows an arcuate course between Jaywick Sands and the West Cliff (Figure 5.17), but the full sequence of deposits is only preserved at the latter (eastern) end. The channel is excavated in London Clay, but in the cliffs it can also be observed to dissect the Lower Holland Gravel (Figure 5.18). Its base is reputed to decline to at least 6 m below O.D. (Warren, 1955).

The most complete succession of Clacton Channel Deposits is preserved at the West Cliff locality, where a sequence of fluvial beds overlain by estuarine sediments occurs. Warren (1923a, figs 1 and 2; p. 611) originally proposed a complex subdivision of the sediments here, with an upper series of estuarine clays and sands and a lower series of freshwater gravel, loam and clay. He subsequently found that many of his earlier subdivisions could not be followed laterally for any great distance and adopted the following more generalized sequence for what is widely regarded as the definitive description of the channel deposits (Warren, 1955; (Figure 5.19)):

		Thickness
6. Surface soil and colluvium		1–3 m
5. Upper bedded gravel	(Mersey Island/ Wigborough Gravel?)	*c.* 2 m
4. Estuarine sand with shells, passing laterally into estuarine calcareous clay	(Clacton Estuarine Beds)	up to 4 m
3. Estuarine laminated clay ('peaty shale'); contains a localized lens with freshwater fauna, Warren's (1923a) 'bed 1'		up to 5 m
2. Loamy sands and clays, with much channelling	(Upper Freshwater Beds)	up to 4 m
1. Clayey gravel and sand	(Lower Freshwater Beds)	up to 7 m
London Clay (or Lower	Holland Gravel)	

Thicknesses vary considerably as the northern feather-edge of the channel sequence is approached (Figure 5.18). The basal sand and gravel is typically *c.* 1 m thick, the minimum thickness of the Clacton Freshwater Beds (beds 1 and 2 combined) being just over 2 m. The overlying Estuarine Beds (beds 3 and 4) continue the sequence up to *c.* 10 m O.D. (Figure 5.18) and (Figure 5.19). Within the Estuarine Beds, Warren (1923a) recorded a thin (0.3 m) and discontinuous bed ('bed 1') containing only non-marine fauna. Molluscs, ostracods, plant macrofossils and pollen have been obtained from both the Freshwater and Estuarine Beds, except where the latter are oxidized, near the modern land surface. The Freshwater Beds have also yielded a rich mammalian fauna and large collections of Clactonian artefacts; the richest concentrations were in the upper part of the Lower Freshwater Beds (Warren, 1923a, 1955). Unfortunately most of the early collections from the different beds have been combined and it is also possible that material from the Lion Point foreshore locality may have been grouped with that from the West Cliff section (Wymer, 1985b).

According to the summary by Wymer (1985b), the mammalian assemblage from the natural exposures includes beaver (*Castor fiber*)*,* the voles *Arvicola cantiana* and *Microtus agrestis,* lion (*Panthera leo*)*,* straight-tusked elephant (*Palaeoloxodon antiquus*)*,* horse (*Equus ferus*)*, the* extinct rhinoceroses *Dicerorhinus kirchbergensis* and *D. hemitoechus,* red deer (*Cervus elaphus*)*, the* large fallow deer *Dama dama clactoniana* and boar (*Sus scrofa*)*.*

Assimilating data from the work and collections of A.S. Kennard, A.G. Davis, the Museum of the Geological Survey and the British Museum (Natural History), Warren recorded *c.* 100 species of land and freshwater Mollusca from the Upper and Lower Freshwater Beds at Clacton. The most common freshwater taxa, all of which persist into at least the basal part of the Estuarine Beds, are: *Bithynia tentaculata, Lymnaea peregra, L. truncatula, Gyraulus albus, Armiger crista* (L.), *Valvata piscinalis, Pisidium amnicum, P. clessini* (Neumayr), *P. benslowanum, P. nitidum, Sphaerium corneum, Potamida littoralis* (Cuvier) and *V. cristata* (Müller). *Vallonia costata is the most common terrestrial species. Only eight freshwater taxa were listed by Warren as present exclusively in* the Freshwater Beds and all are uncommon. All the common freshwater species listed above are also abundant at Swanscombe. Additionally, the Freshwater Beds yielded four species of ostracod, all currently living in rivers or lakes in Europe (Withers, in Warren, 1923a).

The Clacton Estuarine Beds contain a number of freshwater mollusc species that are absent in the Freshwater Beds; for example, Kennard and Woodward (1923) listed *Paladilhia radigueli* (Bourguignat), *Viviparus diluvianus* and *Corbicula fluminalis.* Of these, *P. radigueli,* which is probably part of the *Hydrobia ventrosa* complex (R.C. Preece, pers. comm.), was abundant. Warren (1955) subsequently recorded small numbers of this snail in the Freshwater Beds from the cliff-top borehole and from Jaywick. It is nowadays, however, regarded as a probable brackish-water species (R.C. Preece, pers. comm.). *Paladilhia radigueli* and V. *diluvianus* are also present in small quantities in Warren's (freshwater) 'bed 1', which occurs within the Estuarine Beds (see above and (Figure 5.19)). Marine species from the Estuarine Beds included *Cerastoderma edule* L., *Hydrobia ulvae* (Pennant), *Littorina littoralis* (L.), *Mytilus edulis* (L.), *Scrobicularia plana* (da Costa), *Macoma balthica* (L.) and *Turritella communis* Risso (Brown, 1841; Dalton, 1880; Baden-Powell, 1955). This assemblage comprises estuarine taxa characteristic of a sandy mud substrate (R.C. Preece, pers. comm.). Other taxa were recorded by Baden-Powell (1955) from estuarine deposits filling Warren's channels iii–iv; these channels should probably be treated separately, as their relation to the main Clacton Channel requires further investigation (see below). A number of species of foraminifera have also been recorded from the Estuarine Beds, the dominant taxon being *Nonion depressula* Walker and Jacob (Ovey, in Warren, 1955; van Voorthuysen, in Baden-Powell, 1955).

Although a wealth of plant remains had been recognized in the deposits several years previously (Reid and Chandler, 1923), it was with the development of pollen analysis that the biostratigraphical significance of the Clacton palaeobotany was first realized. The pioneering palynological study of the channel deposits by Pike and Godwin (1953) was based on a cliff-top borehole (see (Figure 5.17) and (Figure 5.19)). In this borehole, pollen-bearing clays and silts ascribed to the Estuarine Beds overlay organic silty sands with freshwater shells, also polleniferous, which were attributed by Warren (1955) to the Lower Freshwater Beds. The pollen sequence from this borehole showed that the freshwater sediments were laid down during a warm-temperate period, with deciduous woodland established in the region, whereas the overlying Estuarine Beds represent a period of declining warmth, in which coniferous forests became dominant (Pike and Godwin, 1953). The spectra from the Estuarine Beds, which record a marked increase in silver fir (*Abies*) pollen, have subsequently been assigned to biozone IIIb of the Hoxnian interglacial, whereas the underlying freshwater sediments have been attributed to biozone HoIIIa (Turner and Kerney, 1971). Turner and Kerney (1971) also succeeded in extracting pollen from the Upper Freshwater Beds from a borehole through the modern beach (drilled in the 1950s but not analysed at that time). These sediments proved to contain high levels of oak and alder and were ascribed by Turner and Kerney to biozone Ho IIb, indicating that they pre-date the entire sequence in the cliff-top borehole. Warren's view that the Lower Freshwater Beds were represented in the Pike and Godwin pollen sequence was therefore refuted (Figure 5.19).

Plant macrofossils, mostly seeds and fruits, were described from both boreholes by Turner and Kerney (1971). These authors broadly confirmed the earlier records of Reid and Chandler (1923), but were also able to relate the new material to the pollen biozones. Plant macrofossils appear to have been distributed throughout the deposits; Reid (in Reid and Chandler, 1923) considered there to be little difference between the assemblages from different beds. Reid and Chandler recorded 137 species, generally indicative of temperate, rather dry conditions. An important new record by Turner and Kerney was that of *Azolla filiculoides* (Lam.), a water fern that is no longer native to Britain and is thought to characterize the Hoxnian Stage.

Sections excavated on the golf course in the early 1930s, in the inland part of the outcrop of the Clacton Channel Deposits (Figure 5.17), revealed the following sequence (Oakley and Leakey, 1937) :

		Thickness
	Pale brown hillwash	0.3–0.6 m
	Variegated silty clay (loam')	0.3–0.6 m
	White or variegated calcareous clay	0.0–0.6 m
Clacton Channel Deposits	Pebbly silver-sand, cross-bedded, with lenses of silty clay and local seams of calcareous clay ('marl')	0.6–1.2 m
	Red sandy gravel	> 0.9 m

In a second excavation at the golf course, 300 m to the east of the first (Figure 5.17) and (Figure 5.20), a similar sequence was revealed, although the variegated calcareous clay ('marl') was overlain by a brown fissile, sometimes stony clay, devoid of fossils or artefacts (Singer *et al.,* 1973). Over much of the area the calcareous clay directly overlay the gravel. The deposits were considerably deformed and disturbed by post-depositional periglacial processes (Gladfelter, 1972; Singer *et al.,* 1973; Wymer, 1985b), confirming that the site has experienced at least one period of intense cold since the sediments were laid down. An important new fossil record from the second golf course excavation was that of *Trogontherium cuvieri* Fischer, an extinct large beaver unknown in Britain after the Hoxnian Stage (Stuart, 1982a). An additional ostracod species was identified in the calcareous clay (Robinson, in Wymer, 1985b), *Cyclocypris hucki* Triebel (synonymous with *Scottia tumida* Kempf — J.E. Robinson, pers. comm.), which is typical of flowing water.

Oakley and Leakey (1937) had considered the calcareous clay to belong to the Estuarine Beds, but shells discovered in less weathered parts of this deposit in the recent holiday camp exposures suggest that it is of fluvial origin (R.C. Preece, pers. comm.). The deposit observed by Warren in his Channel vi on the Jaywick foreshore appears to have been a continuation of this calcareous clay, termed 'marl' by Warren and most subsequent authors. Exposures at the holiday camp revealed remnants of bedding in this material, which is an oxidized silty clay with redeposited calcium carbonate nodules and occasional shells (mostly in its lower part). It is probably equivalent to the Upper Freshwater Beds of the West Cliff section.

Channels iii and iv of Warren (1940, 1955), which actually represent the two ends of a single continuous feature ridge of London Clay (Figure 5.17) and (Figure 5.18). A recent borehole survey of the holiday camp area (Jj. Wymer, pers. comm.) has confirmed Warren's observation that a separate channel occurs on the seaward side of the main Clacton Channel. Warren (1955) interpreted this as part of the same channel system and considered it to be filled with the Clacton Estuarine Beds. He reported (1955, p. 284) that all the channel fragments seen by him yielded the same fauna, with the elephant *Palaeoloxodon antiquus* and the bivalve *Potamida littoralis,* and the same Clactonian industry. This seems, however, to conflict with his observation that Channels iii, iv and vi contain only the Estuarine Beds, since the elephant bones and artefacts were only supposed to occur in the Freshwater Beds. A sentence in Warren's 1955 paper (p. 288) clarifies this in the case of Channel iii–iv; this contains marine Mollusca of species recorded from the Estuarine Beds in the West Cliff section, together with occasional bones of *Palaeoloxodon antiquus,* but non-marine molluscs are absent. According to Warren's (1940) observations of the Jaywick foreshore and hinterland, the deposits of the main

Clacton Channel are themselves divided into two parallel strips by a low ridge of London Clay, his (1955) Channels v and vi (see (Figure 5.17) and (Figure 5.18)). The recognition of estuarine sediments at foreshore level in Channel iii–iv (that on the seaward side of the main channel) raises a number of interesting possibilities, as they are significantly lower than the Estuarine Beds at the West Cliff locality (Figure 5.19). This may indicate a period of erosion following the deposition of the Upper Freshwater Beds, an explanation that was apparently favoured by Warren (1955) — his 'minor non-sequence'? The recognition at Cudmore Grove, East Mersea (only 9 km upstream from Clacton), of a sequence, also ascribed to the Hoxnian Stage, in which estuarine sediments underlie fluviatile ones (Bridgland *et al.,* 1988), raises the possibility that these low-level estuarine sediments on the Jaywick–Clacton foreshore might pre-date the Freshwater Beds (see below). The possibility that the separate iii–iv channel-fill at Clacton is a later Colne deposit and totally unrelated to the Hoxnian sequence is another alternative that cannot be ruled out. The fauna recorded from this channel is not stratigraphically diagnostic; the marine molluscs are all species that are extant and straight-tusked elephant (even if not reworked into these dep osits, as Warren (1955) suspected) is recorded from later interglacials. Detailed investigations of the sediments in this channel and at Cudmore Grove will hopefully resolve these uncertainties in the near future.

The earliest description of Palaeolithic artefacts recovered from the Clacton Channel Deposits was by Warren (1912), although a number of brief notices of earlier discoveries from (or possibly from) these beds had appeared (Evans, 1872, p. 521; Anon., 1906, 1911a, 1911b; Warren, 1911) and J.W. Kenworthy had assembled a small collection of material from the exposures at Clacton that is now in the Passmore Edwards Museum at Stratford (Wymer, 1985b). As well as flint artefacts, the collections from Clacton include a number of bone implements (regarded as questionable by Wymer, 1985b) and the tip of a wooden spear, found by Warren in 1911, which remains unique in the British Palaeolithic (Oakley *et al.,* 1977; McNabb, 1989). The artefacts come from the Lower and Upper Freshwater Beds, the richest concentrations occurring in the gravel of the former, whereas the fine-grained sediments of the Upper Freshwater Beds (including the calcareous clay at the golf course) have yielded the best preserved material, including the celebrated wooden spear.

Interpretation

The Clacton Channel Deposits provide a wealth of palaeontological evidence of considerable value for environmental reconstruction; in addition, some of the taxa recognized are of considerable biostratigraphical significance. The sediments also represent an important element within the sequence of Thames and Thames-Medway deposits that is now recognized in north-east Essex, the interpretation of which has significant implications for the Pleistocene evolution of Thames drainage. All of the above help to evaluate the palaeoenvironmental context of the type Clactonian Industry and to relate this to the British Pleistocene sequence.

The relation of the Clacton sediments to the Thames system has been established only in recent decades. Warren (1923a) originally attributed the Clacton Channel to a small local stream. Later, when he observed that the channel originally exposed in the West Cliff was one of several running side by side, he concluded that 'scoured-out deeps in the bed of a wide river' were represented (Warren, 1955, p. 284) and that the deposits were the product of the main Thames-Medway. Estimates of the age of the Clacton sediments, which were attributed to the 'Great Interglacial' (= Hoxnian) by Pike and Godwin (1953), implied that they belong to the post-diversion Thames system; the subsequent correlation of the Swanscombe and Clacton sediments on the basis of their molluscan faunas by Kerney (1971) reinforced this view. Although alternative interpretations have been proposed (Gladfelter, 1975), the post-diversion Thames origin of the Clacton Channel Deposits has been confirmed by recent work in eastern Essex (Bridgland, 1980, 1983a, 1988a; (Figure 5.5)A).

Palaeontology

The wealth of palaeontological data from Clacton is important for both environmental reconstruction and relative dating. Most recent authors have agreed that the deposits accumulated under fully interglacial conditions during the Hoxnian. Many early descriptions included faunal lists, but the most detailed summaries of the palaeontology were by Warren (1923a, 1924b, 1955). Warren's final (1955) summary was revised in the light of Pike and Godwin's (1953) description of an interglacial pollen sequence, later assigned to the Hoxnian Stage (West, 1963; Turner, 1973).

The molluscan faunas from the various deposits at Clacton are particularly informative. In addition to the most abundant taxa, listed above, there are certain species of biostratigraphical significance. Most notable amongst these are *Belgrandia marginata, Valvata piscinalis forma antiqua, Vivzparus diluvianus* and *Corbicula fluminalis,* all of which first appear in the Estuarine Beds or very near the top of the Freshwater Beds (Warren, 1955; Kerney, 1971). These species are part of the so-called 'Rhenish fauna' recognized at Swanscombe, where they appear near the junction between the Lower Loam and the Lower Middle Gravel (Kennard, 1942; Kerney, 1971; see Chapter 4, Swanscombe). According to Kennard (1942), this assemblage was indicative of a connection between the Thames and Rhine at this time. The condition of specimens of *C. fluminalis, V. piscinalis* f. *antiqua* and V. *diluvianus* from Clacton suggests reworking from an older deposit (Kennard and Woodward, 1923), possibly a lower bed within the Clacton sequence that was destroyed by intraformational erosion. The appearance of these 'Rhenish' taxa, coupled with other similarities in the molluscan faunas, enabled Kerney (1971) to relate the interglacial pollen sequence recognized at Clacton to the succession at Swanscombe, which lacks a satisfactory palynological record (see Chapter 4, Swanscombe). The Mollusca also provide important palaeoenvironmental information; in particular, they allow the distinction of the freshwater and estuarine sediments at Clacton. Freshwater species dominate the assemblage from the Estuarine Beds, but they are accompanied by marine taxa (Warren, 1955). The most complete summary of the marine Mollusca from Clacton was by Baden-Powell (1955), who noted that the assemblage could not be distinguished from those found in Holocene deposits. His faunal list indicates in which of Warren's six channels the various taxa have been found.

The mammalian remains at Clacton were described in detail by Warren (1923a). He noted that the elephants were of the straight-tusked species (*Palaeoloxodon antiquus*) and that mammoth did not occur, a feature consistent with a Hoxnian age (Stuart, 1982a). The important observation that fallow deer remains from Clacton differ from living examples was made by Dawkins (1868) and Falconer (1868), who both (independently) identified them as a distinct (larger) species, although they are currently interpreted as a subspecies *Dama dama clactoniana* (Stuart, 1974, 1982a; Leonardi and Petronio, 1976; Lister, 1986). The Clacton fallow deer is thought to characterize Hoxnian deposits in Britain; it is an important component of the Swanscombe fauna (see Chapter 4, Swanscombe), supporting the proposed correlation of the two sites (Sutcliffe, 1964).

Two types of extinct rhinoceros occur in the Clacton Channel, *Dicerorhinus hemitoechus* and *D. kircbbergensis* (Sutcliffe, 1964). Rhinoceros teeth from the basal gravel (basal bed 1) were found to have fibrous vegetable matter lodged in crevices, which was interpreted as the remains of the animals' food (Pike and Godwin, 1953; Warren, 1955). This material yielded pollen taxa dominated by non-arboreal types, which led Pike and Godwin to suggest that it represented an earlier (pre-temperate) phase of the interglacial, earlier than any of the sediments encountered in their cliff-top borehole (see above). Warren, on the other hand, suggested that non-arboreal pollen from food remains might have mixed with tree pollen from the containing sediments to give the assemblages obtained. He thought that the remains might provide important evidence for the diet of these animals.

Occasional remains of small mammals have been known to occur in the Clacton Channel Deposits from the time of their earliest description, Brown (1840) having recorded water rat from his original section (see, however, Hinton, 1923). Unfortunately, the assemblage of small vertebrates remains sparse, particularly in comparison with possible correlative sites such as Cudmore Grove and Little Thurrock (Stuart, 1974; Sutcliffe and Kowalski, 1976; Wymer, 1985b; Bridgland *et al.,* 1988; see below, Cudmore Grove). This is despite the careful sieving of the sediments exposed in the second golf course excavation (Singer *et al.,* 1973; Wymer, 1985b), which added only the vole *Clethrionomys* sp. and giant beaver to the assemblage.

Analyses of samples from the cliff-top borehole (see above), as well as older samples collected by Warren, formed the basis for the Clacton pollen diagram published by Pike and Godwin (1953). This has the following characteristics: abundant (but generally declining) alder; oak and elm relatively abundant in the lower part of the sequence; hazel declining throughout the sequence; pine consistently important throughout; and silver fir becoming dominant towards the top. A comparison with other British and continental sites suggested a correlation with the 'Penultimate Interglacial' (Pike and Godwin, 1953), which was later redefined as the Hoxnian (West, 1963; Turner, 1973). Turner and Kerney (1971) subsequently confirmed this interpretation. These authors worked additionally on samples, obtained from the borehole at beach level (see above), of earlier sediments within the Upper Freshwater Beds than those analysed by Pike and Godwin. These sediments, which they attributed to biozone HoIIb, yielded the biostratigraphically significant unnamed palynomorph known as 'Type X', which is thought to be characteristic of the Hoxnian Stage in Britain (Turner and Kerney, 1971).

Wymer (1974) reported that pollen analysis of the calcareous clay ('marl') at the golf course site had revealed spectra dominated by pine, birch and grasses. These spectra, obtained using heavy liquid flotation techniques, were attributed by Mullenders and Desair-Coremans (in Wymer, 1974; preliminary interpretation in Singer *et al.,* 1973) to the early Hoxnian Stage (biozone HoI). This interpretation led to the conclusion that the golf course sequence was older than that at the West Cliff, in which biozones Hollb, Illa and nib have been identified (Wymer, 1974, 1981, 1985b; Gladfelter, 1975; (Figure 5.19)). Supporting evidence for differentiating the sediments at the golf course from those in the West Cliff has been claimed from the recognition of periglacial structures in the basal gravel that pre-date the accumulation of the overlying calcareous clay (Gladfelter, 1972; Singer *et al.,* 1973; Wymer, 1985b). On the basis of this evidence, Wymer (1985b) suggested that the earliest human occupation of the site, represented by abraded artefacts in the gravel (see below), occurred in a pre-Hoxnian (*sensu* Clacton) temperate interval. This interpretation was disputed by West (in Wymer, 1985b), who considered all the cryoturbation structures observed in the golf course sections to have formed after deposition of the calcareous clay. It is possible that some deformation of the gravel prior to burial by the calcareous clay might have been caused by some other process, perhaps related to waterlogging.

The palynological basis for regarding the golf course sediments as earlier than those at the West Cliff has also been challenged. Turner (1975, 1985) has seriously questioned the reliability of the pollen assemblages from the golf course site, because of the very low pollen concentrations in these sediments. He argued that the observed concentration of pine and birch had occurred as a result of the destruction of less durable grains during the weathering to which these oxidized sediments have clearly been subjected. Indeed, it was pointed out by Turner (1985) that the occasional grains of hazel, oak and alder pollen identified by Mullenders and Desair-Coremans imply that these taxa, which are highly susceptible to weathering, were once considerably more common. These deciduous species are not characteristic of the early parts of interglacials; their presence in the calcareous clay suggests instead that it accumulated during biozone II or III (Turner, 1985). It is therefore likely that the golf course sequence is entirely comparable to that in the West Cliff sections, with the Lower and Upper Freshwater Beds represented, the former by the gravel and the latter by the weathered calcareous clay. The Estuarine Beds are apparently missing at the golf course; in fact the westernmost feather-edge of the outcrop of these beds has been observed recently at the holiday camp (Figure 5.18). Warren's (1955) observations suggest that these or other estuarine deposits may be present on the foreshore at Jaywick, however (see (Figure 5.18)).

Geochronological evidence

Szabo and Collins (1975) obtained a radiometric (uranium-thorium) date of 245,000 (+35,000/ −25,000) years BP from a bone sample from the 1969 excavations at the golf course. As noted by Wymer (1985b), this is considerably younger than many predictions for the Hoxnian, based on an age for the preceding Anglian glaciation of between 400,000 and 470,000 years, as suggested by Kukla (1977).

The most recent evidence, independent of stratigraphy, for the age of the Clacton deposits has come from amino acid analyses (see Chapter 1 for explanation). Early work in this field by Miller *et al.* (1979), using shells of *Corbicula fluminalis,* grouped Clacton with sites in the Lower Thames such as Crayford and Aveley, which are attributed in this volume to Oxygen Isotope Stage 7 (see Chapter 4). However, in more recent analyses using a modified technique, Bowen *et al.* (1989) have obtained higher ratios, indicative of a greater age, using specimens of *Pisidium* (0.305 ± 0.001 (n = 2)) and *Valvata* (0.299 ± 0.002 (n = 3)) from Clacton. These ratios are comparable with results (mainly using different species) from Swanscombe, which Bowen *et al.* correlated with Oxygen Isotope Stage 11. Since the Anglian Stage is considered to correlate with Oxygen Isotope Stage 12 (see Chapter 1), a Stage 11 age for Clacton would conform with the widely held view that the site represents an immediately post-Anglian (post-diversion) Thames-Medway channel, an interpretation that has been reaffirmed by palaeogeographical reconstructions, based on terrace stratigraphy, of the sequence in eastern Essex (Bridgland, 1988a; (Figure 5.5)). The biostratigraphical correlation of the sequences at Clacton and Swanscombe is also upheld by the conclusions of Bowen *et al.,* but the ascription to the Hoxnian interglacial is questioned, since amino acid ratios obtained from shells from the Hoxne type locality are lower and were considered to be indicative of Stage 9 (see Chapter 1). The term Hoxnian, as applied here to the Clacton sequence, should therefore be taken to mean Hoxnian *sensu* Swanscombe, pending confirmation (or otherwise) that the Hoxne sediments represent the same time interval as those at Swanscombe and Clacton.

Evidence for sea levels and possible subsidence

The Clacton site provides important evidence for Hoxnian sea levels, since part of the sequence is of estuarine origin. Palynological studies have revealed that the change from freshwater to estuarine conditions at Clacton occurred in the late-temperate phase of the interglacial, biozone HoIII (see above). There is evidence for a minor non-sequence at this point in the succession, with erosion to the lower levels occupied by the estuarine deposits at Lion Point (see (Figure 5.18); see above). However, the pollen record (Pike and Godwin, 1953) shows little evidence for a lengthy break in deposition. Warren (1955) noted that the estuarine deposits overlap the Freshwater Beds, but considered this to be exactly what would be expected as a result of a marine transgression. There are several reasons for concluding that this transgression did not extend upstream far beyond Clacton and that sea level may have generally declined during the interval represented by the Estuarine Beds. Firstly, Warren (1955, p. 287) noted that land and freshwater taxa greatly predominate over marine species throughout the lower part of the Estuarine Beds, except at their extreme base. Secondly, the occurrence of the freshwater lens, Warren's 'bed 1' (see above; (Figure 5.19)), suggests that there was a brief break in estuarine conditions, although this may simply represent the transport of fluvial sediment into the estuarine environment during a flood event. Finally, the palaeobotanical record shows that deciduous forest was replaced by coniferous woodland during the deposition of the Estuarine Beds, suggesting a deterioration of climate that might be expected to have been accompanied by a fall in sea level.

A problem encountered in attempts to determine contemporary sea levels from the Clacton Estuarine Beds is that many workers have considered the area of the southern North Sea coast to have been significantly lowered by subsidence during the late Pleistocene (West, 1963, 1972; Evans, 1971; Kerney, 1971). This interpretation appears to be based largely on the views of Wooldridge (1927b, 1928; Wooldridge and Henderson, 1955), who defined a precise western limit to such downwarping, his 'Braintree line', and the widespread acceptance of a Hoxnian sea-level maximum at *c.* 32 m O.D. (Zeuner, 1945, 1959; West, 1963, 1972), much higher than the Clacton Estuarine Beds. Both these bases have been challenged in recent years. The bulk of the evidence for subsidence of the edge of the North Sea Basin is for differential movement during the Holocene, which has been demonstrated by various authors (Rossiter, 1972; D'Olier, 1975; Devoy, 1977, 1979; Greensmith and Tucker, 1980). The measured rates of differential warping during the Holocene are sufficiently high to have lowered the coastal area of Essex by many metres if this relative movement had occurred continuously throughout the Middle and Late Pleistocene. Differential warping on this scale would have lowered all the Middle Pleistocene terrace deposits in eastern Essex to below modern sea level, so it is apparent that the process could only have operated during a small proportion of this time, perhaps during high sea-level phases when sedimentation was occurring in the present offshore areas (Bridgland, 1983a, 1988a). The association of a 32 m sea level with the Hoxnian interglacial is traditionally based on extrapolation from Mediterranean areas by Zeuner (1945, 1959) and the occurrence of Hoxnian deposits at this elevation in the 'Goodwood raised beach' of West Sussex and at Swanscombe. The Goodwood raised beach deposit has recently been thoroughly reinvestigated at Boxgrove and appears to be pre-Hoxnian (Roberts, 1986), whereas Swanscombe is clearly a fluvial site, with no direct relevance to contemporary sea level. Moreover, the height difference between the deposits at Swanscombe and Clacton, a fall of around 27 m over a distance of approximately 110 km (along the course reconstructed in (Figure 5.5)A), implies a downstream gradient of *c.* 1:4000, which is within the range of gradients observed amongst the fluvial terraces of the Middle and Lower Thames. This important fact, which was noticed by a number of previous workers, including Zeuner (1945), Singer *et al.* (1973) and Clayton (1977), allows the reconstruction of a Thames and Thames-Medway course for the Hoxnian Stage (*sensu* Swanscombe) in which the Clacton and Swanscombe sediments are shown to be broadly contemporaneous deposits of the same river system (Bridgland, 1980, 1983a, 1988a; (Figure 5.5)A). The problems of reconciling the various evidence for sea levels during the Hoxnian Stage will be further discussed below (see Cudmore Grove).

Palaeolithic evidence

Warren (1912, 1922) was the first to recognize that the flint artefacts from Clacton, a mixture of thick stone-struck flakes and relatively crude cores, did not belong either to the Acheulian Industry, since there were no hand-axes, or the Mousterian Industry, which is characterized by more advanced preparation of cores (Levallois technique; see Chapter 1) than is seen in the Clacton material. The assemblage was initially defined as Mesvinian by Breuil and a detailed description was published under this title by Warren (1922). However, Breuil (in Warren, 1926) subsequently recognized earlier and later divisions of the Mesvinian Industry and recommended confining the term Mesvinian to the later division. Warren (1926) noted that the Clacton assemblage belonged to the earlier of these divisions and was therefore pre-Mesvinian; he proposed the term Clactonian for this industry.

At about the same time, a comparable Clactonian industry was identified in the Lower Gravel at Swanscombe (Chandler, 1930, 1931; see Chapter 4). A detailed description of the Clactonian artefacts from both these sites was published by Breuil (1932b), who considered (in agreement with Chandler) that the artefacts from the Swanscombe Lower Gravel were generally older than those from Clacton. This view, supported by Warren (1933), was probably influential in the formulation of King and Oakley's (1936) model for Lower Thames evolution, in which the Clacton sequence was correlated with a hiatus between the Lower Loam and Lower Middle Gravel at Swanscombe (see Chapter 4, Swanscombe and Globe Pit).

In 1934 the first of two archaeological excavations was carried out at the Jaywick golf course, from which 190 artefacts were recovered (Oakley and Leakey, 1937). This material was not restricted to definite levels, nor was there any correlation between differences in typology and stratigraphical position. The unabraded condition of many of the artefacts led Oakley and Leakey to suggest the proximity of a working floor. The second series of excavations at the golf course (in 1969 and 1970) yielded over 1200 artefacts (Wymer and Singer, 1970; Singer et al., 1973; Wymer, 1985b; (Figure 5.20)). These were most common in the basal gravel, occurring throughout the deposit, but with a slight concentration near its southern edge. The condition of the material varied from mint to very rolled, the former becoming increasingly common towards the top of the gravel. The industry continues sporadically in the overlying calcareous clay, which produced low numbers of well-preserved artefacts. Certain flakes have been refitted on to cores or other flakes, including two examples from the calcareous clay fitting on to pieces from the gravel/clay interface (Wymer, 1985b). The majority of conjoinable material occurred at the latter interface, in an 'accumulation of discarded flint work and broken bones' resting on the gravel (Wymer, 1985b, p. 283). Wymer claimed the mint and conjoinable material from the top of the gravel to represent the debris of human occupation in primary context, a view apparently supported by the successful identification of microwear characteristics on the edges of some artefacts, indicating the type of usage to which they had been put (Keeley, in Roe, 1981; in Wymer, 1985b). Mint artefacts occurred frequently in the upper part of the gravel, whereas abraded ones were evenly distributed throughout the deposit. Wymer regarded the former as part of the primary context debitage that had been incorporated into the gravel from above, perhaps by trampling while the deposit was waterlogged; he considered the abraded material to have been derived from an earlier occupation, pre-dating the deposition of the gravel. A minimum age in the late Anglian or very early Hoxnian Stage is implied for this early occupation. Wymer (1974, 1985b) was inclined to attribute this assemblage to a pre-Hoxnian (*sensu* Clacton) 'mild phase', but this interpretation relied heavily on the pollen evidence from the golf course site, now regarded as unreliable (see above).

A later artefact assemblage, again in derived condition, occurred in a small gravel fan overlying the calcareous clay at the golf course, attributed by Wymer (1985b) to solifluction in a periglacial climate. Wymer considered this deposit, which also contains bone fragments, to pre-date the Freshwater Beds of the West Cliff section. It seems more likely, however, that the calcareous clay is itself part of the Freshwater Beds (see above) and that the gravel fan, if it is really of periglacial origin, is of post-Hoxnian age and incorporates material reworked from the Clacton Channel Deposits.

Until recently the Clactonian Industry was regarded as stratigraphically older in Britain than the earliest appearance of the Acheulian, a view based largely on the sequence at Swanscombe and the absence of hand-axes in the Clactonian gravels at Swanscombe, Clacton and Little Thurrock (Wymer, 1974; Gladfelter and Singer, 1975; see Chapter 1). Flaws in this argument have long been apparent; later Clactonian industries were noted, for example, in the Lynch Hill Gravel of the Reading area (Wymer, 1968), with which the Little Thurrock site would be correlated according to the interpretation presented in Chapter 4 (see Globe Pit). There are also a few records of hand-axes or of evidence for their manufacture from Clacton and the Swanscombe Lower Gravel. Breuil (1932a) intimated that derived 'Chellean' (= Abbevillian or Early Acheulian) implements occurred at the base of the Swanscombe succession, mixed with the indigenous Clactonian material. A hand-axe was apparently recovered from the Lower Gravel during the Waechter excavations (Ohel, 1979; Newcomer, in Ohel, 1979). Wymer (1985b) pointed out that a number of hand-axes had been found on the foreshore at Lion Point and Clacton, but none was located *in situ* in the channel deposits. Furthermore, Singer *et al.* (1973) discovered three possible hand-axe finishing flakes in the 1970 Clacton excavations, all in derived condition. There is now abundant stratigraphical evidence that hand-axes were made in Britain prior to the deposition of the Clacton Channel sediments (see Chapter 1). Industries comprising only primitive hand-axes, classified as Early Acheulian, have also been described in likely pre-Hoxnian gravels at Farnham, Surrey and Fordwich, Kent (Roe, 1964, 1968a, 1975); they are presumably contemporary with or earlier than the Clactonian industries of both Clacton and Swanscombe. Hand-axes have been found in gravels of the Thames system that are now attributed to the late Anglian (see Chapter 3, Highlands Farm Pit and Hamstead Marshall) and in conjunction with a Cromerian mammalian fauna at Boxgrove, West Sussex (Roberts, 1986; Chapter 1). Thus there is no reason why derived hand-axes or characteristic flakes from their manufacture should not occur in the Clacton Channel Deposits, although it is clear that the important industry in the immediate area, which apparently persisted from late Anglian to mid-Hoxnian times, involved no hand-axe manufacture.

Various authors have proposed chronological divisions of the Clactonian Industry over the years, generally based on typology and/or condition, together with stratigraphical considerations (Breuil, 1932b; Warren, 1958; Collins, 1969; for summary, see Roe, 1981). Wymer (1968) argued that such divisions were unjustified and subsequent stratigraphical revisions have revealed that there is little basis for them. Following a recent re-evaluation of the industry, J. McNabb (pers. comm.) found no typological or technological grounds for separating the assemblages from Clactonian sites at Barnham, Suffolk (see Wymer, 1985b), Little Thurrock and Swanscombe in the Lower Thames (see Chapter 4) and Clacton itself. He also considered the essential characteristics of the Clactonian to be present within an assemblage of apparently pre-Anglian artefacts from High Lodge, near Mildenhall, Suffolk (see Wymer, 1985b, 1988; Chapter 1), implying that the industry was practised in Britain before the Anglian Stage.

The occurrence of Palaeolithic assemblages lacking both hand-axes and evidence for the refined flaking techniques employed in the Mousterian industries has puzzled archaeologists since they were first recognized. Warren (1951) compared cores from Clactonian sites to the early pebble and flake tool industries of Africa and Asia, considering the Clactonian to be an offshoot of the tradition of these primitive industries, an idea first mooted by Oakley (1949). In this industry flint working was carried out using bold strokes with a hard (stone) hammer, producing characteristically pronounced bulbs of percussion (Baden-Powell, 1949). Wymer (1985b) has emphasized, however, that there is no such thing as a 'typical Clactonian flake'; hard-hammer flakes of the type making up the bulk of Clactonian assemblages are also found in other industries, including post-Palaeolithic ones, although in these they tend to represent a smaller proportion of the total material. This fact has led to the suggestion that the Clactonian is merely a 'facies' of the Acheulian, assemblages without hand-axes (Clactonian) representing debitage from locations where preliminary working of raw material took place, with tool manufacture occurring elsewhere (Ohel, 1977, 1979). This suggestion scarcely seems feasible, as hand-axe manufacture is not a lengthy process; it is inconceivable, if the Clactonian knappers were hand-axe makers, that no evidence of this would be found amongst many thousands of artefacts at a site such as Clacton (excepting the three questionable and abraded finishing flakes from the Singer/Wymer excavation — see above). The above suggestion also fails to explain the geographical distribution of flake and hand-axe industries. Clacton lies at the western extremity of a 'province' of flake-core industries, which dominate the eastern European and Asian Palaeolithic, whereas hand-axe industries are dominant in the southwestern and southern part of Europe (see Roe, 1981). Britain lies, according to some authorities, on the frontier between these two 'provinces', in an area where both Clactonian and hand-axe industries are found, possibly resulting from separate cultural groupings.

Stratigraphical relations of the Clacton deposits

Doubt has existed for many years about the precise stratigraphical relations between the Clacton Channel Deposits and the Pleistocene gravels of the Clacton area. The early descriptions and illustrations of the cliff sections at Clacton (Brown, 1840; Wood, 1866b; Fisher, 1868a; Dalton, 1880; Prestwich, 1890b) indicate that the channel deposits cut through earlier stratified gravel, which was later termed the Holland Gravel (Warren, 1923a; 1955). Fisher (1868a) claimed (in the caption to an illustration of the cliff section) that the channel deposits and the Holland Gravel were both overlain by an 'obliquely bedded gravel of unascertained relation', newer than the channel deposits but older than the overlying colluvial 'trail' (Fisher, 1868a, p. 214). Fisher's figure shows what appears to be cross-bedding, inclined towards the northern end of the section. Most later descriptions either ignored any gravel overlying the channel deposits or described it as a poorly bedded unit that might have resulted from solifluction. Fisher's claim, coupled with Warren's consistent caution regarding the matter (Warren never saw the critical area exposed), led to controversy over the relation between the channel deposits and the Holland Gravel (summarized by Wymer (1985b)). Clarification of this relationship has only been achieved by recent trial excavations in the West Cliff (Bridgland et al.,1988; see below).

Most early workers considered the Holland Gravel to belong to the 'Glacial Series' of Wood and Harmer (1868), but Warren (1923a, 1924b, 1933) recognized that the gravels covering the Tendring Plateau, including that in the Clacton district, were terrace deposits of the Thames. In these early papers he suggested a correlation of these gravels with the Boyn Hill Terrace, regarding the Clacton Channel Deposits as a possible equivalent, laid down by a smaller stream, of the Taplow aggradation of the Thames. Subsequently, Warren (1951) cited the opinion of Solomon (in Oakley and Leakey, 1937), that the Holland Gravel was not of Thames but of Colne origin. He later changed his opinion again, realizing that the channel deposits were the product of a river of sufficient size to be the main Thames, and suggested that the Holland Gravel was a pre-diversion Thames deposit (Warren, 1955), a view that has been confirmed by recent work (Rose *et al.,* 1976; Bridgland, 1983a, 1988a).

A number of separate deposits have recently been identified within what was formerly classified as Holland Gravel. Within the main sheet of Holland Gravel, which stretches from the cliffs at Clacton and Holland to the St Osyth gravel pits, lower and upper divisions have been recognized (see above, St Osyth and Holland-on-Sea). On the basis of clast composition, it has been demonstrated that the Lower Holland Gravel is a pre-diversion Thames-Medway deposit, whereas the Upper Holland Gravel, overlying and apparently channelled into the top of the Lower Holland Gravel, appears to date from the brief period during the Anglian glaciation when the Thames was blocked by ice and no longer reached the Clacton area (Bridgland, 1983a, 1988a; Bridgland *et al.,* 1988, 1990). This interpretation is again based on the clast content of the Upper Holland Gravel, which is predominantly indicative of a Medway provenance, supplemented by small amounts of the type of material introduced by the Anglian glaciation. On the basis of these observations, the Holland Gravel Formation has been ascribed to the Anglian Stage and correlated with the Winter Hill Formation of the Middle Thames ((Table 1.1) and (Figure 1.2); (Table 5.3) and see above, St Osyth and Holland-on-Sea). Thus the Clacton Channel Deposits cut through and overlie the downstream equivalent of the Winter Hill Gravel, the last Thames formation to be aggraded prior to the diversion of the river.

A later gravel formation, the Mersea Island/Wigborough Gravel, has also been recognized in the Clacton area within the broad definition of the Holland Gravel applied by earlier workers (Bridgland, 1983a, 1988a; Bridgland *et al.,* 1990). This deposit is represented by a string of remnants along the southern fringe of the Tendring Plateau, running from Point Clear to Jaywick. These appear, from their distribution and altitude, to be a continuation of the gravels of Mersea Island (Figure 5.2) and (Figure 5.5)B. This has been confirmed by clast-lithological analysis (Table 5.5), which indicates that the deposits are part of the Low-level East Essex Gravel Subgroup, interpreted as the product of the post-diversion Thames-Medway (Bridgland, 1980, 1983a, 1988a; Bridgland *et al.,* 1988; see above, Introduction to Part 2). The Mersea Island Gravel (Figure 5.2) contains only a few percent of quartzose exotic clasts, in contrast to the 12–20% present in pre-diversion Thames-Medway gravels, and also contains significantly more Greensand chert from the Medway catchment (Table 5.5). However, between Point Clear and Jaywick the clast content of this formation changes markedly over a short lateral (downstream) distance. In this transition, from gravel of Mersea Island to Wigborough type, quartzose exotics become more important at the expense of Greensand chert, so that the deposit closely resembles the Lower Holland Gravel. A possible explanation for this change is an influx of material reworked from the pre-diversion gravels covering the Tendring Plateau, possibly as a result of a confluence between the Thames-Medway and an early River Colne, which would have formed in the eastern end of the abandoned pre-diversion Thames valley ((Figure 5.5)B). It is possible that the upper gravel in the West Cliff at Clacton, illustrated by Fisher (1868a), represents a downstream continuation of this post-diversion formation (see below).

Analysis of the clast content of the Clacton Channel Gravel (basal Lower Freshwater Beds) indicates that it too is the product of the post-diversion Thames-Medway (Bridgland, 1980, 1983a, 1988a; Bridgland *et al.,* 1988; (Table 5.5)). However, the relation between the Clacton Channel Gravel and the Wigborough Gravel is unclear from the mapped distribution of these deposits. The former is benched into the London Clay at the extreme south-eastern edge of the

Tendring Plateau, at a height of *c.* –6 m O.D., and was aggraded to at least +10 m O.D. (Figure 5.18), whereas the latter has a surface level falling from 15 m O.D. at Point Clear to 11 m O.D. at Jaywick. In the latter area the London Clay rises to the land surface between the outcrops of the Wigborough Gravel and the Clacton Channel Deposits (Figure 5.2). The geomorphology would therefore seem to suggest that the excavation of the Clacton Channel resulted from post-Wigborough Gravel rejuvenation. It has been suggested, however, that the Wigborough Gravel formerly extended further south, covering the channel deposits (Bridgland, 1988a; Bridgland *et al.,* 1988). Only a single post-diversion Thames-Medway terrace formation has been recognized north of the Crouch, the Asheldham Gravel/Mersea Island/Wigborough Gravel (Bridgland, 1983a, 1988a; (Figure 5.5)B). On the Dengie Peninsula (between the Crouch and Blackwater estuaries), this formation fills and overlies a buried channel, the Asheldham Channel (see below, Southminster and (Figure 5.28)). An upstream equivalent of this channel has been identified south of the Crouch, the Southend Channel (Figure 5.5)A, and it has been suggested that the Swanscombe Lower Gravel channel is its correlative (Bridgland, 1980, 1983a, 1988a). Downstream the same channel is believed to continue across Mersea Island, where it contains estuarine and fluvial deposits that are exposed, beneath the Mersea Island Gravel, at Cudmore Grove (Bridgland *et al.,* 1988; (Figure 5.5)A). This has been interpreted as an upstream equivalent of the Clacton Channel (Bridgland, 1980, 1983a, 1988a). According to this regional interpretation, the Wigborough Gravel must once have covered the Clacton Channel Deposits, but has since been removed by erosion, except for the series of remnants between Point Clear and Jaywick.

In order to clarify the relations between the gravels of the Clacton cliffs and the Clacton Channel Deposits, temporary sections were excavated at four points along the West Cliff during April 1987 by P. Harding and the author. The first three sections were entirely within the Clacton Estuarine Beds, although augering at the base of section 3 may have reached London Clay. The fourth section was of considerable interest, however, in that it revealed the feather-edge of the interglacial beds, in the form of a blue-grey clay, interstratified between bedded gravels (Bridgland *et al.,* 1988). A large flake was discovered *in situ* at the intersection between the top of the lower gravel and the base of this clay (Figure 5.21); a small flake was also found in the upper gravel. The lower deposit is considered to be the Lower Holland Gravel, the last terrace formation of the pre-diversion Thames-Medway. The gravel above the channel deposits, presumably that observed by Brown and illustrated by Fisher, is clearly a bedded fluvial deposit, albeit with a rather high silt/clay content and perhaps somewhat disturbed (both of which could be the result of proximity to the land surface, within the zone of cryoturbation and pedogenesis). This upper gravel has a clast-content similar to the Mersea Island and Clacton Channel Gravels, suggesting that it too represents the post-diversion Thames-Medway (Low-level East Essex Gravel Subgroup). There is a surprising similarity in clast composition between the Clacton Channel Gravel and the upper gravel in the West Cliff section, on the one hand, and the Mersea Island Gravel, on the other (Table 5.5). The Clacton site is well downstream of the supposed confluence with the Colne, so reworked quartzose material from the pre-diversion gravels, as seen in the Wigborough Gravel at Jaywick, should be present there. An eastward projection of the series of Wigborough Gravel remnants indicates that the formation should intersect with the present coast in the area of the West Cliff section. This poses a problem of interpretation, in that the characteristics of the gravel above the channel deposits do not support its identification as part of the Wigborough Gravel, although it occupies the geographical and stratigraphical position in which that formation would be expected. A possible explanation is that the upper gravel in the cliffs is more closely allied to the channel deposits than to the Wig-borough Gravel, which is assumed to represent a later cold episode. The Colne tributary may not have operated as a major source of gravel (reworked from the Kesgrave Group deposits to the north and west) until after the Hoxnian Stage (*sensu* Clacton). Alternatively, mixing of Thames-Medway- and Colne-derived gravel may have been incomplete, allowing deposits of Mersea Island Gravel affinities to be deposited downstream from the confluence with the Colne.

The possibility that the regional sequence is more complex than has yet been established, and that the Clacton Channel post-dates the Wigborough Gravel, cannot be ruled out however, since no gravel of Wigborough type has yet been found overlying the channel deposits. Indeed, since the Wigborough Gravel and the Lower Holland Gravel are very difficult to separate on the basis of clast-lithological content (see (Table 5.2) and (Table 5.5)), it is possible that the gravel underlying the channel deposits in the cliff section could be the Wigborough Gravel, rather than the Lower Holland Gravel. At present the interpretation of this cliff section still relies heavily on the regional stratigraphical framework derived from studies of the terrace sequence in eastern Essex as a whole. Further consideration will be given to this question below, in the report on the closely related site at Cudmore Grove, East Mersea.

The correlation of the Clacton Channel Deposits with the lower part of the Swanscombe sequence ((Table 1.1) and (Figure 1.2)), implied by the above interpretation, confirms many previously published opinions, notably those of Singer *et al.* (1973), on the basis of the Palaeolithic industries at the two sites. In fact a small collection of Clactonian artefacts has also been obtained from equivalent deposits (Asheldham Channel Gravel) at Burnham-on-Crouch [TQ 945 972], further establishing a link between this particular phase of Thames evolution and the Clactonian Industry (Bridgland, 1988a). Bridgland (1980, 1983a, 1988a) suggested a correlation between these early post-diversion deposits and both the Black Park and Boyn Hill Gravels of the Middle Thames. He believed that the steeper Black Park aggradation had fallen below the level of the Boyn Hill in eastern Essex, so that the Black Park Gravel is represented within the lower part of the Boyn Hill/Mersea Island/Wigborough Formation (no rejuvenation can be recognized between the Black Park and Boyn Hill Formations downstream from London). This implies that the erosion of the Clacton Channel, prior to its infilling during the Hoxnian Stage, may have resulted from downcutting associated with the pre-Black Park rejuvenation; this incision has been directly attributed elsewhere in this volume to the diversion of the Thames (see Chapters 1, 3 and 4). It is also possible that any basal, pre-Hoxnian sediments in the Clacton Channel may equate with the Black Park Formation of the Middle Thames.

Summary

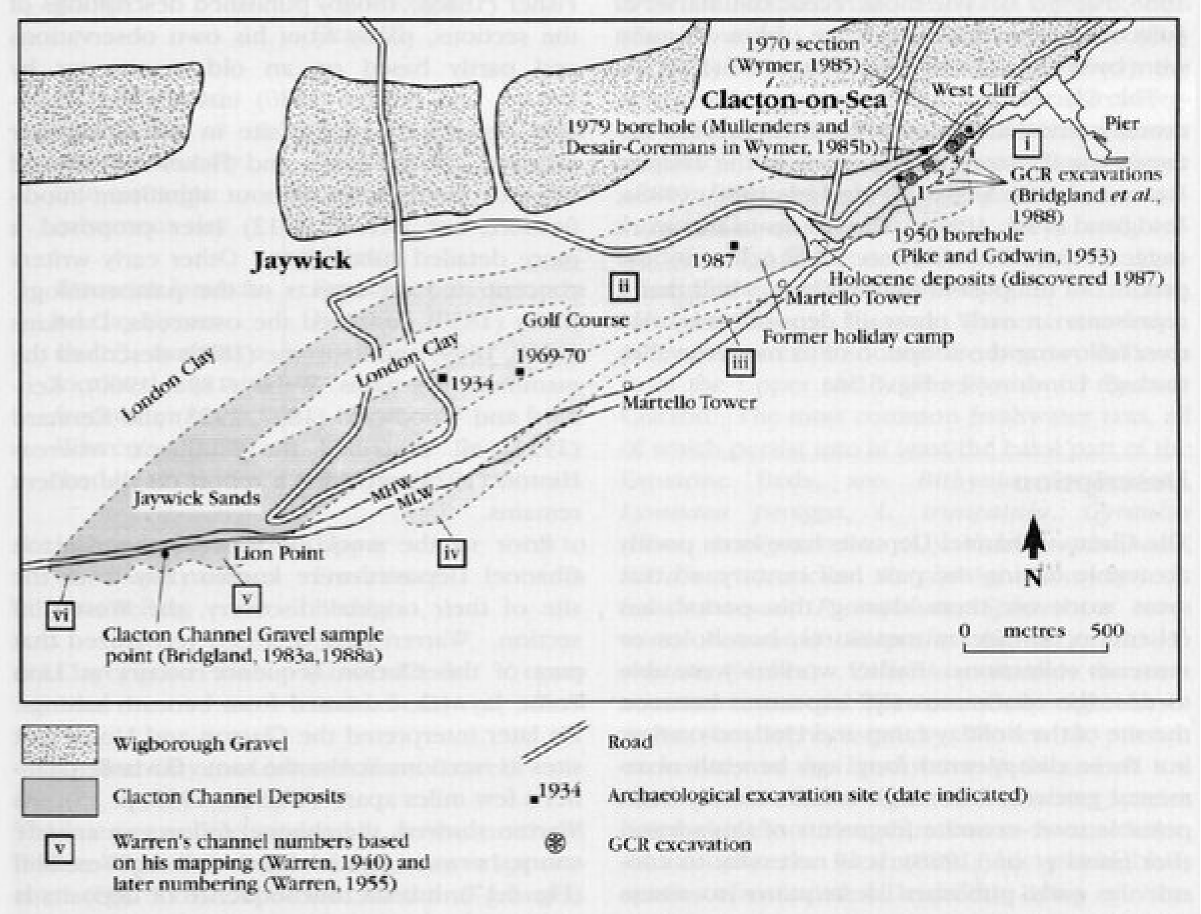
The complex GCR site at Clacton has been shown to be a Pleistocene locality of international significance. It provides evidence from many of the various disciplines involved in Quaternary studies, in particular from Palaeolithic archaeology and palaeontology. The site has yielded a range of faunal material seldom bettered in others of this age, including highly significant large-mammal and mollusc faunas. It is extremely likely that modern sampling of the freshwater beds at the West Cliff site, which have not been exposed for many years, would produce an assemblage of smaller vertebrates to match those from other sites more recently investigated. The site also has a particularly rich palaeobotanical record.

The wealth of palaeontological information from Clacton is of increased value since the site can be directly related to the Thames terrace sequence. This is not the case with the Hoxnian type site, which represents a lacustrine infill and is therefore more difficult to relate to an integrated regional stratigraphy. Swanscombe, the only other well-known Hoxnian site within the Thames system, lacks a convincing palaeobotanical record; indeed, the Clacton sequence has been used to calibrate that at Swanscombe, by a comparison of their molluscan faunas.

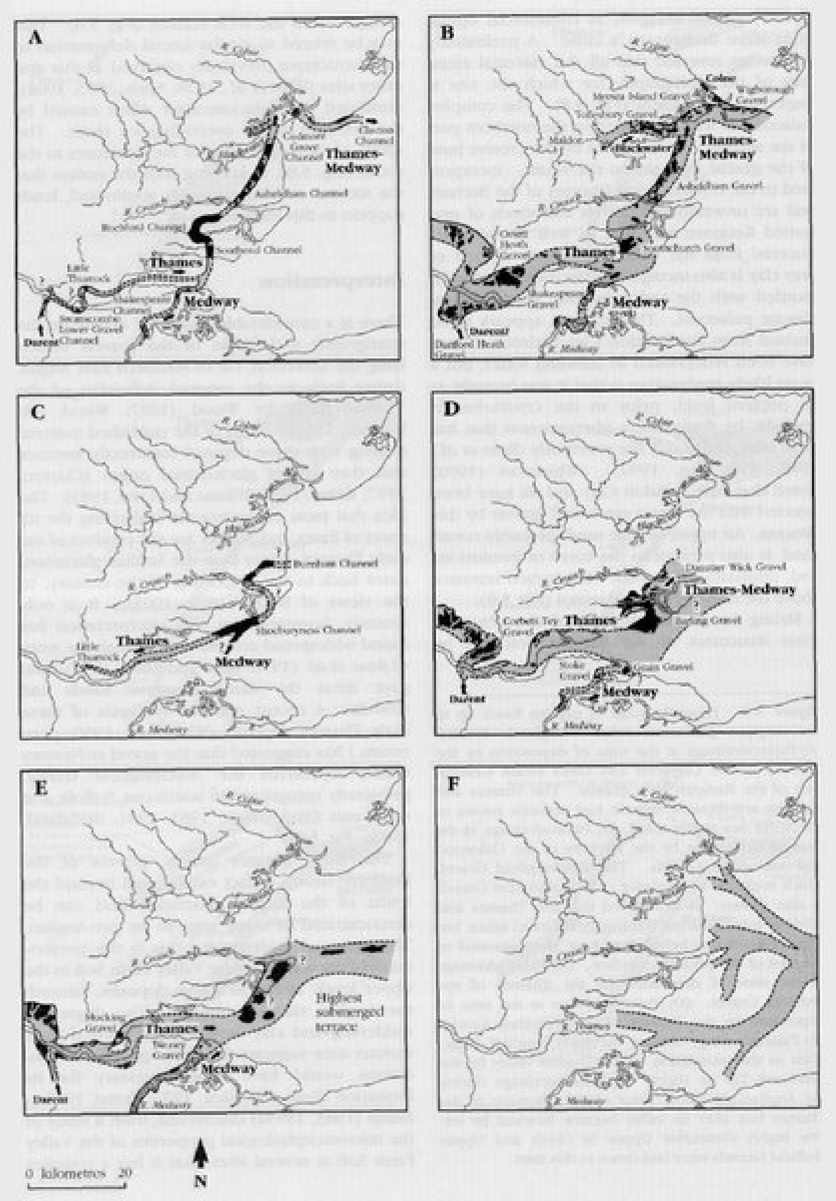
Conclusions

The Clacton locality, with its complex fossil record and stratigraphy, has been central to the debate about the interglacial (temperate-climate) period immediately following the glaciation that brought about the diversion of the Thames. The site is internationally famous for the occurrence there, in channel deposits of the early Thames-Medway, of abundant Palaeolithic (early Stone Age) artefacts. There are no recognizable tools amongst these artefacts; instead the 'industry' comprises a characteristic mixture of crudely worked flint. Clacton was established as the type locality for this particular type of industry in 1926. The Clacton sections also yield the remains of terrestrial, fluvial and marine faunas and floras. These illustrate life in and around the river during the early part of this temperate interval and, higher in the sequence, an influx of marine species marks a change to estuarine conditions as the sea level rose. The Thames at this time flowed in its modern valley, through what is now London, but turned northwards to rejoin its old pre-diversion valley just upstream from Clacton. There is widespread agreement that the Clacton sequence can be correlated with sediments at Swanscombe, in the Lower Thames valley, both being attributed to the interglacial (around 400,000 years BP) that immediately followed the major glaciation during the Anglian Stage. The Clacton sediments have also been equated, on the basis of similarities in pollen content, with lake sediments at Hoxne in Suffolk, the type locality for the Hoxnian interglacial.

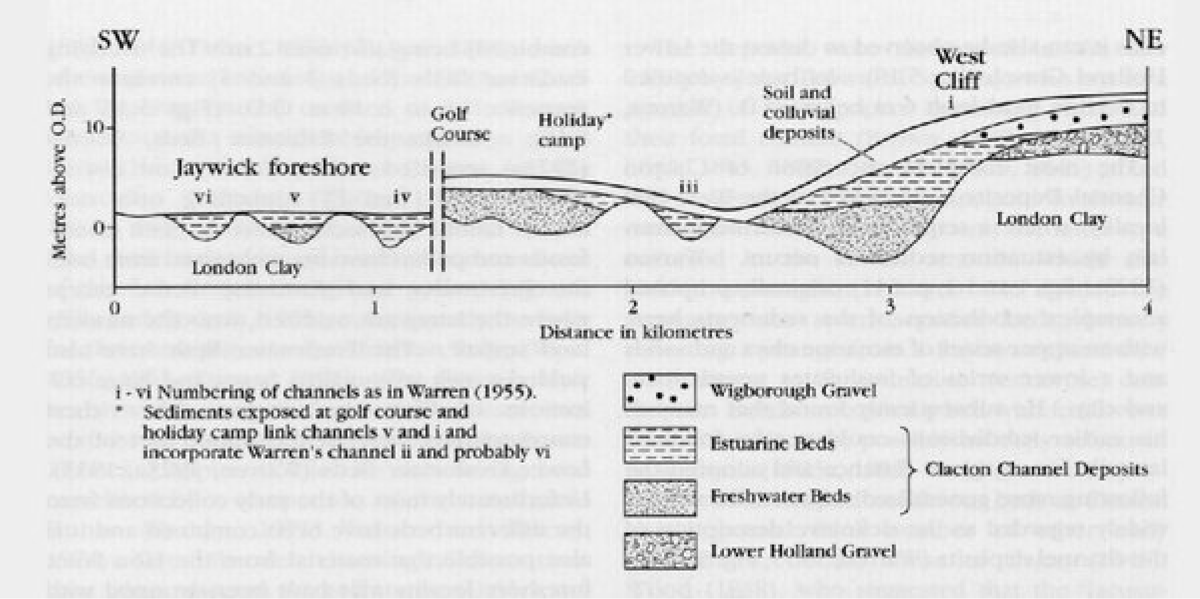
References



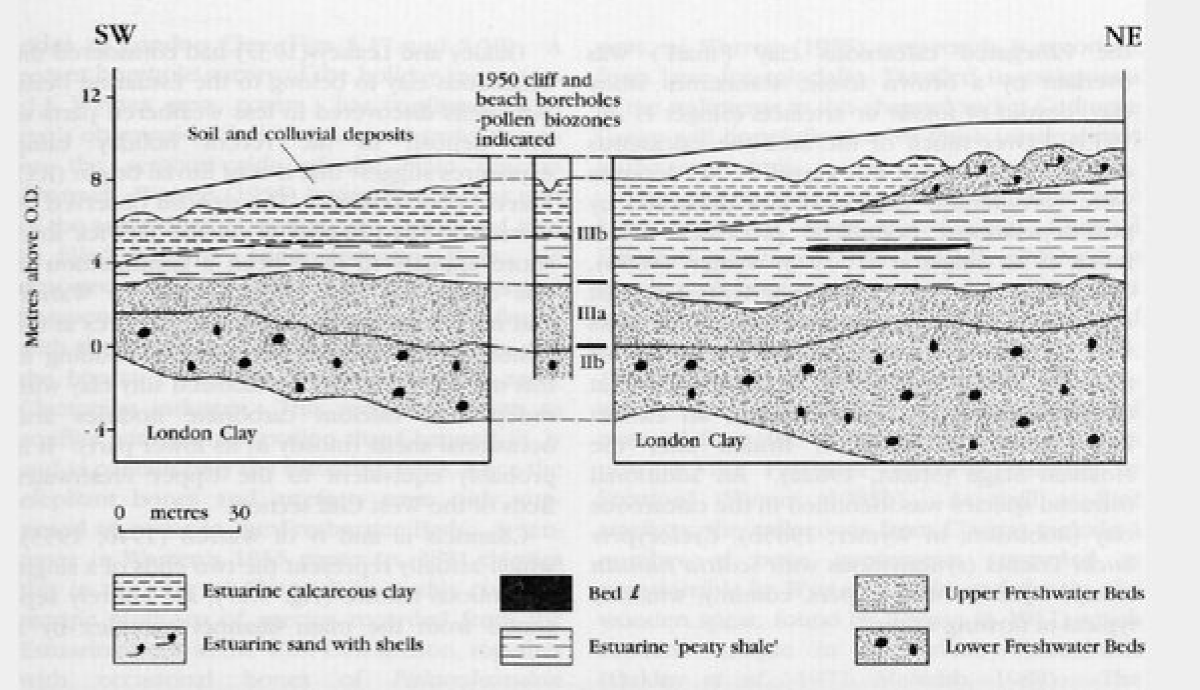
(Figure 5.17) Map showing the distribution of Pleistocene deposits in the region of Clacton and the location of the various sites mentioned in the text.



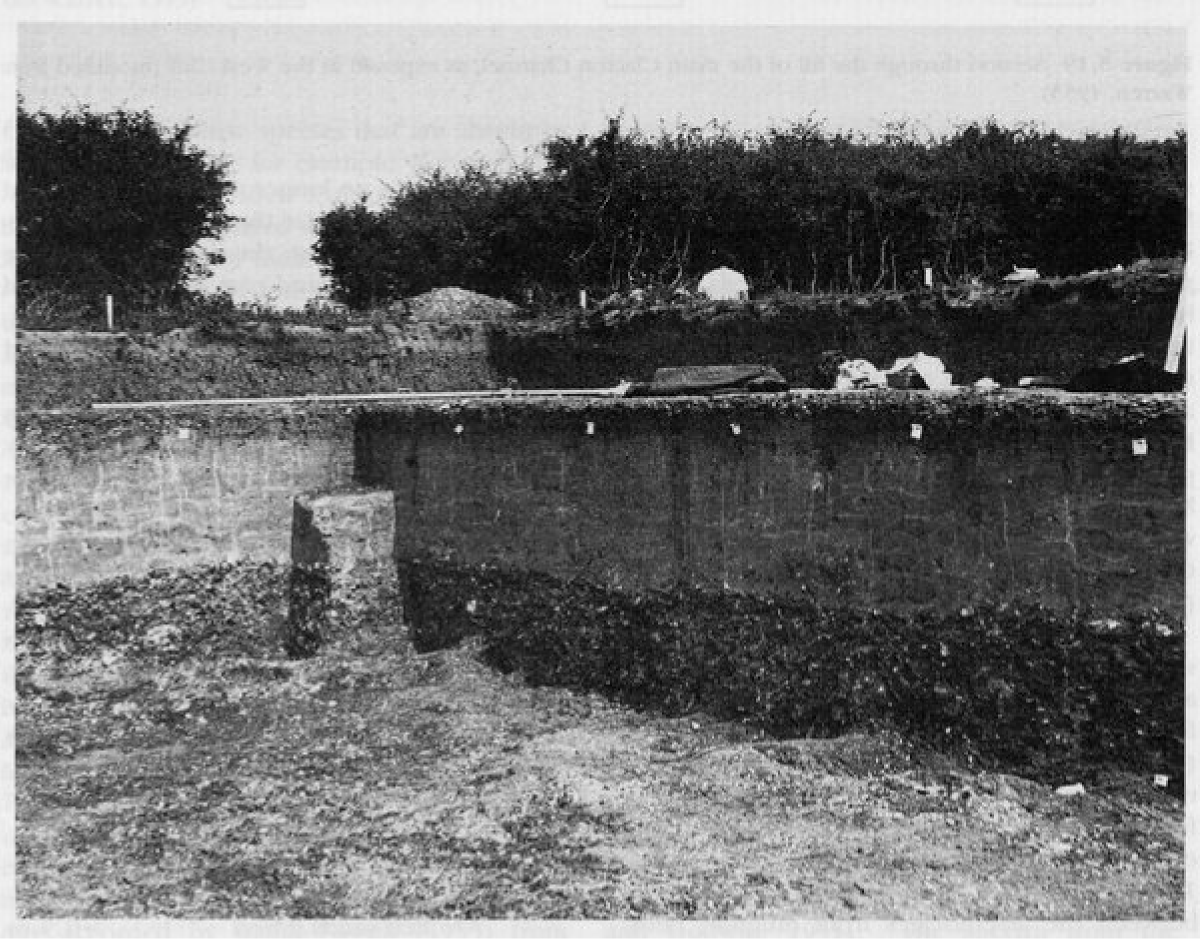
(Figure 5.5) Palaeodrainage of Essex following the Anglian glaciation (modified from Bridgland, 1988a). (A) Palaeodrainage during the filling of the Southend/Asheldham/Clacton Channel. The Swanscombe Lower Gravel Channel and the Cudmore Grove Channel are both thought to be lateral equivalents. The Rochford Channel is now thought to represent an overdeepened section of the same feature (see text). This channel was excavated in the late Anglian by the newly diverted Thames and filled during the Hoxnian Stage (sensu Swanscombe). (B) Palaeodrainage during the deposition of the Southchurch/Asheldham Gravel.. This aggradational phase is believed to have culminated during the earliest part of the Saalian Stage, early in Oxygen Isotope Stage 10. (C) Palaeodrainage during the filling of the Shoeburyness Channel. The channel beneath the Corbets Tey Gravel of the Lower Thames is believed to be an upstream equivalent of this feature. It is thought that both the excavation and filling of the channel were intra-Saalian events, dating from Oxygen Isotope Stages 10 and 9 respectively. (D) Palaeodrainage during the deposition of the Barling Gravel. This is regarded as an intra-Saalian deposit, aggraded during Oxygen Isotope Stage 8. (E) Palaeodrainage during the deposition of the Mucking Gravel of the Lower Thames. The Thames-Medway equivalent of this formation is buried beneath the coastal alluvium east of Southend and can be traced offshore (Bridgland et ed., 1993). This aggradational phase occurred towards the end of the complex Saalian Stage, culminating early in Oxygen Isotope Stage 6. (F) Palaeodrainage during the last glacial. The submerged valley of the Thames-Medway has been recognized beneath Flandrian marine sediments in the area offshore from eastern Essex (after D'Olier, 1975).



(Figure 5.18) Section through the Clacton area, showing the various Clacton Channel occurrences (modified from Warren, 1955).



(Figure 5.19) Section through the fill of the main Clacton Channel, as exposed at the West Cliff (modified from Warren, 1955).

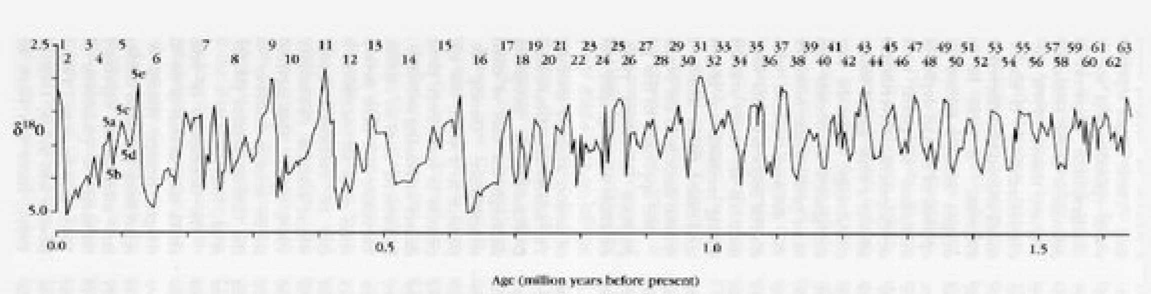


(Figure 5.20) Photograph of the second archaeological excavation at Clacton, taken in 1970. The Clacton Channel Gravel is clearly seen, beneath calcareous silt (marl). London Clay forms the floor of the excavated area; careful removal of the overlying gravel has revealed undulations in its surface, probably scour features. (Photo: J.J. Wymer.)

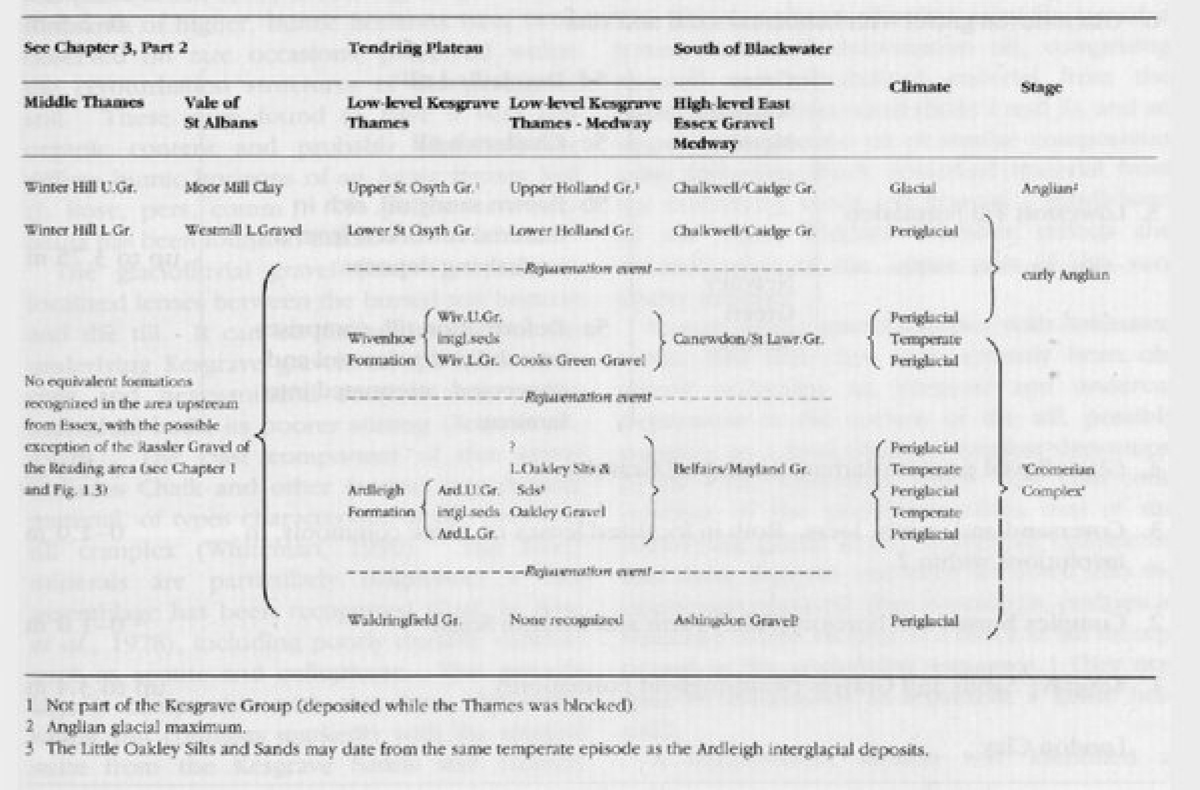
Age (in thousands of years)	Upper Thames	Middle Thames	Lower Thames	Essex	Stage	^{18}O
10	Recent floodplain and channel deposits. Holocene alluvium of floodplain and coast				Holocene	1
	Northmoor Gravel	Shepperton Gravel	Submerged	Submerged	late Devensian	2-4
71	Rejuvenation event					
?		Temperate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

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

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



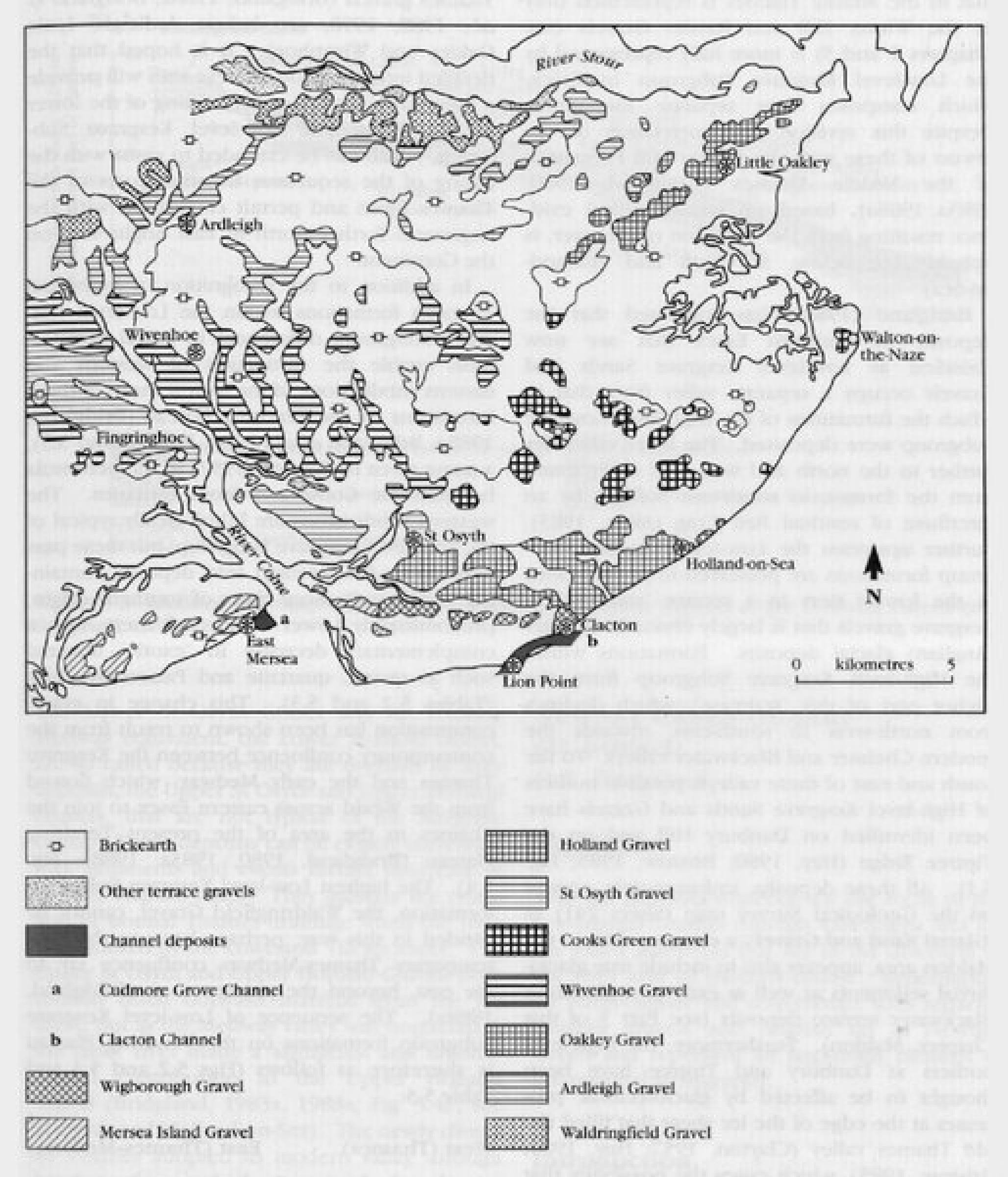
(Figure 1.2) The oxygen isotope record, as represented in a borehole (Site 607) in the mid-Atlantic at latitude c. 41°N. Numbered stages are shown at the top; even-numbered ones are relatively cold (more ice) and odd-numbered ones relatively warm (less ice). Note that the amplitude and wavelength of the curve increases at around 0.7 million years ago (the δ^{18}O scale is a ratio obtained by comparing the proportion of ^{18}O to ^{16}O in samples to that in a mean sea-water standard). Compiled from data published by Ruddiman et al. (1989).



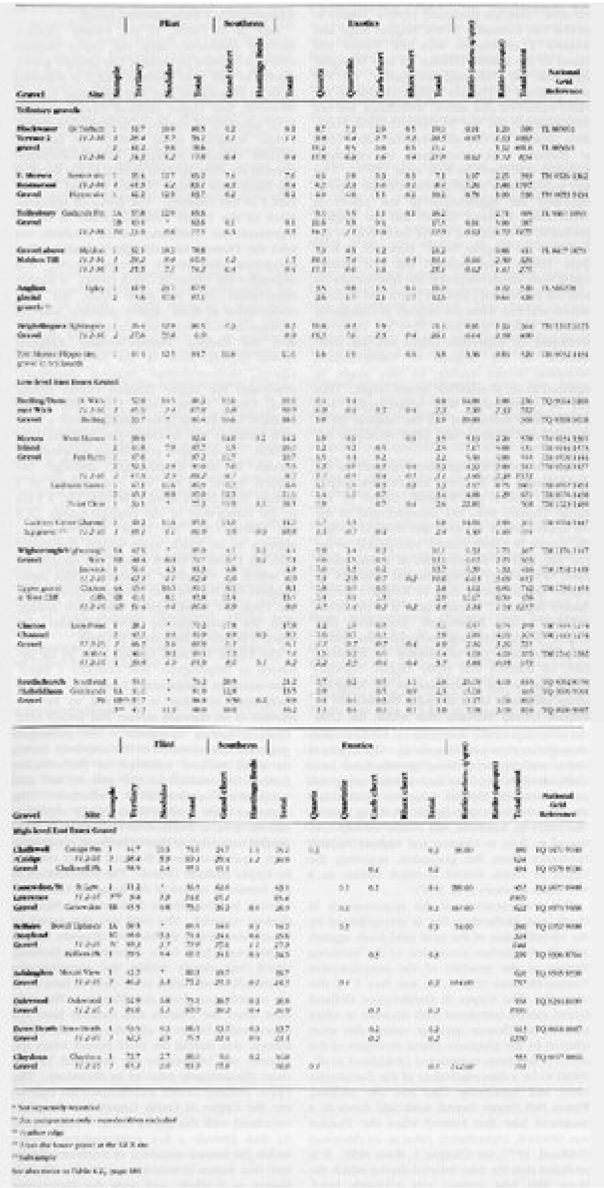
See Chapter 3, Part 2		Tendring Plateau		South of Blackwater		
Middle Thames	**Vale of St Albans**	**Low-level Kesgrave Thames**	**Low-level Kesgrave Thames - Medway**	**High-level East Essex Gravel Medway**	**Climate**	**Stage**
Winter Hill U.Gr.	Moor Mill Clay	Upper St Osyth Gr.[1]	Upper Holland Gr.[1]	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
		----------------------*Rejuvenation event*	-----------------------------			
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)		Wivenhoe Formation Wiv.U.Gr. intgl.seds Wiv.L.Gr.	Cooks Green Gravel	Canewdon/St Lawr.Gr.	Periglacial Temperate Periglacial	'Cromerian Complex'
		----------------------*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	
		----------------------*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.

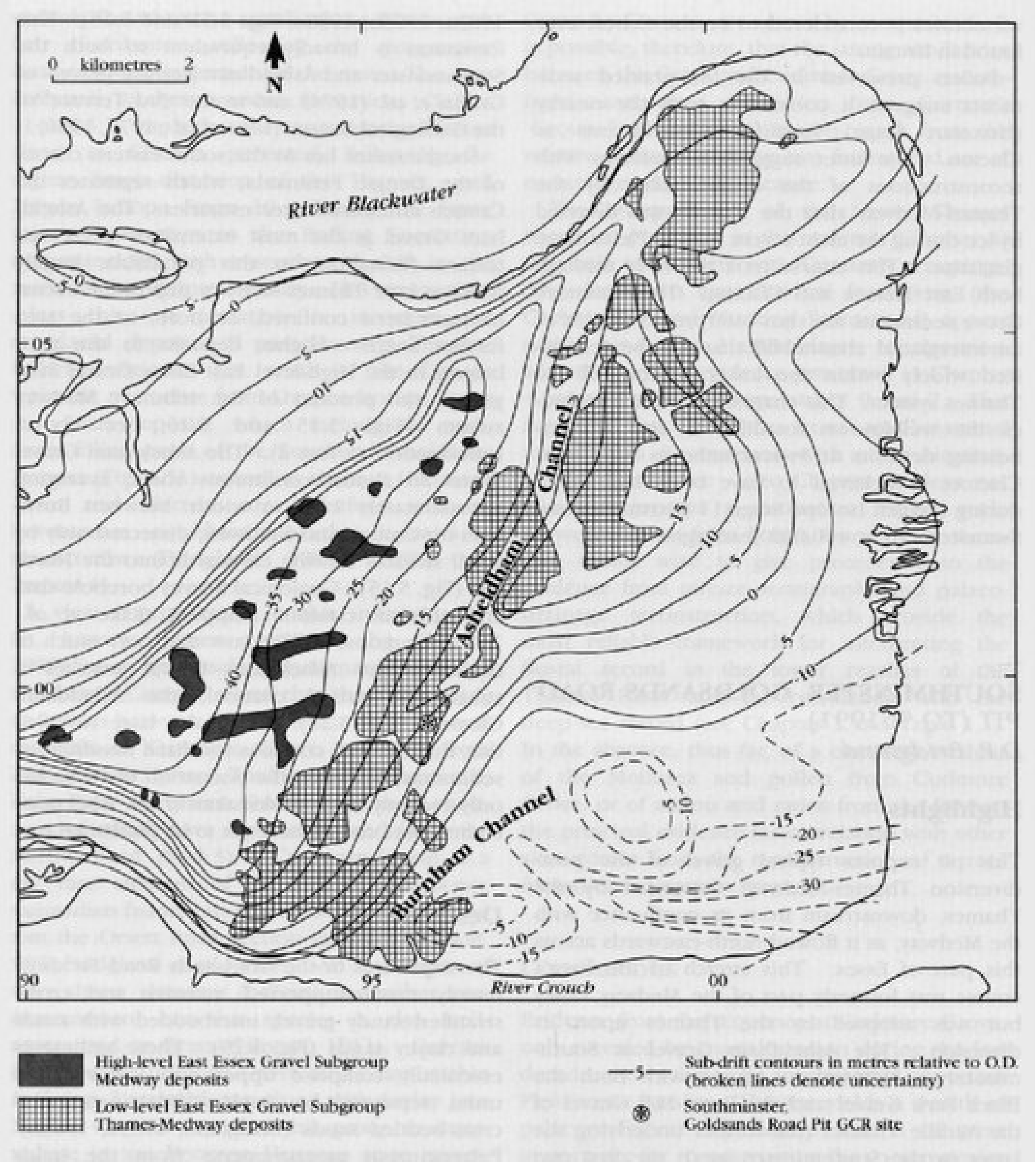
(Table 5.3) Correlation of gravel formations in Essex within the Kesgrave Group with deposits in other areas.



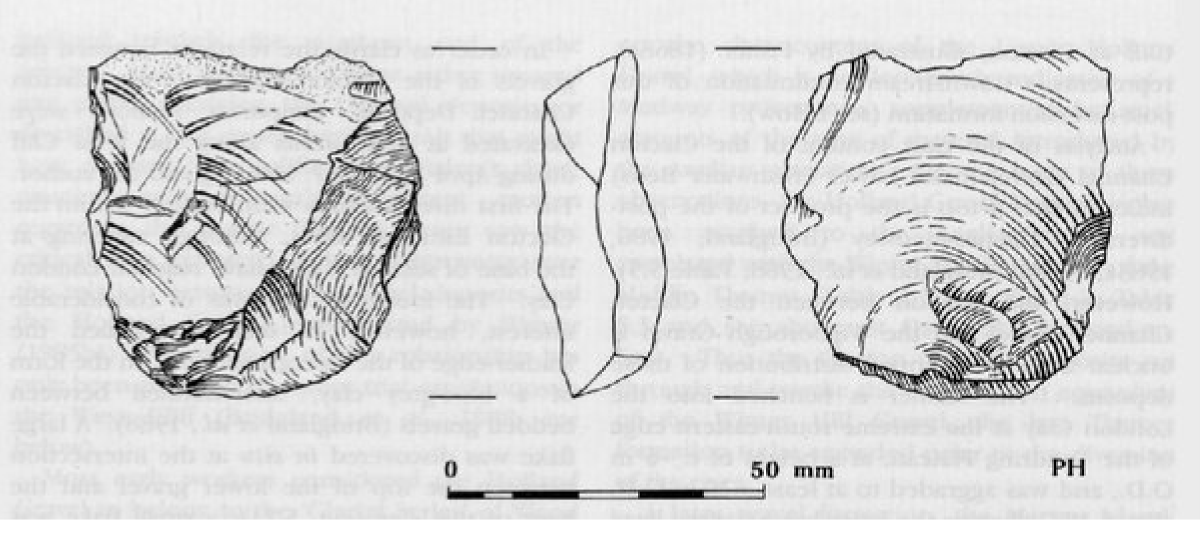
(Figure 5.2) Pleistocene gravels of the Tendring Plateau (after Bridgland, 1988a).



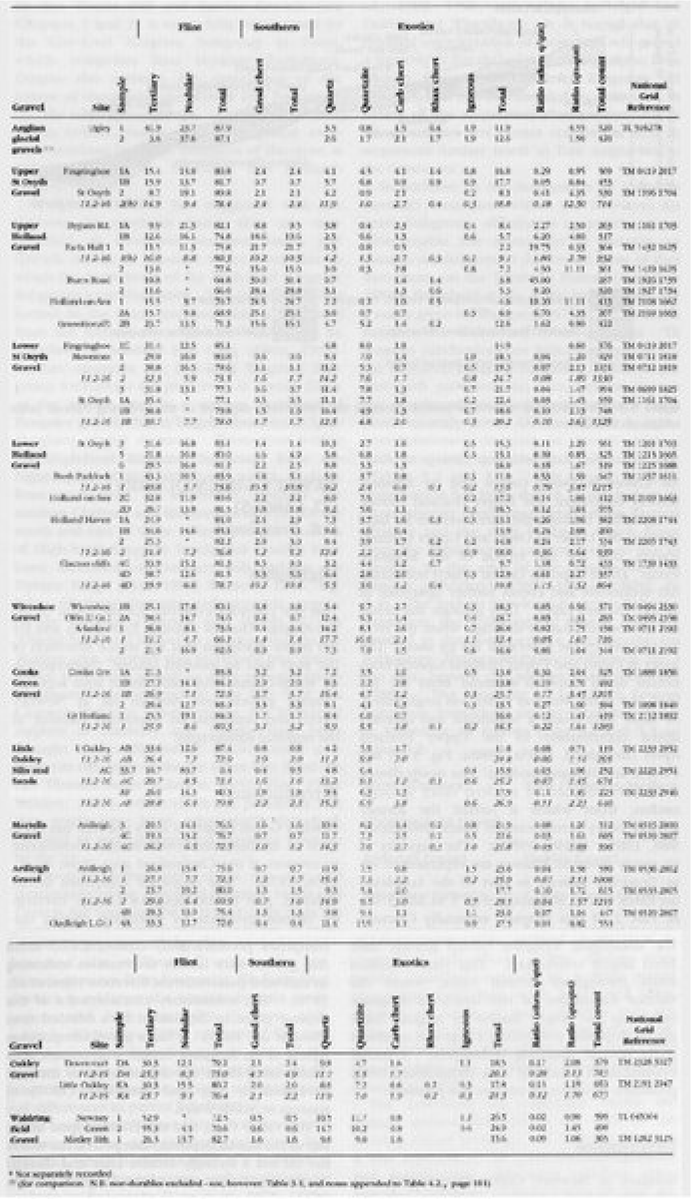
(Table 5.5) Clast-lithological composition of gravels described in Chapter 5, Parts 2 and 3.



(Figure 5.28) Map showing the outcrop of the Asheldham Gravel and bedrock surface contours, revealing the form of the Asheldham Channel (modified from Lake et al., 1977).



(Figure 5.21) Flint flake from the West Cliff at Clacton, found in situ in GCR Section 4 in April 1987, at c. 9.9 m O.D. This flake was lying immediately below the wedge of blue-grey clay, interpreted as the feather-edge of the Clacton Channel Deposits. This is probably the highest point at which an artefact has been found in the Clacton deposits, although stratigraphically it was at the same level as the earlier Palaeolithic finds. (Drawing by P. Harding.)



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