Cudmore Grove (East Mersea) cliffs and foreshore

[TM 068 146]

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Highlights

A highly fossiliferous Middle Pleistocene channel-fill, underlying gravels of post-diversion Thames-Medway origin, has been revealed here in recent years by coastal erosion. The deposits at Cudmore Grove include estuarine and freshwater beds. They are probably equivalent in age to the fossiliferous deposits at Clacton and Swanscombe, which have been interpreted as part of the same interglacial Thames channel-fill. The tracing of this channel from the Lower Thames valley through eastern Essex charts the course of the Thames during the period that followed the Anglian glaciation. The Cudmore Grove site has produced the most extensive small-vertebrate fauna from the British Pleistocene.

Introduction

The Pleistocene interest of Mersea Island has long been overshadowed by the richly fossiliferous Middle Pleistocene channel deposits at Clacton-on-Sea, situated only 9 km to the east. However, the gravels covering parts of the island were the subject of discussion by early workers (Wood, 1866b; Dalton, 1908; Anon., 1913). Furthermore, records of Pleistocene fossils discovered at East Mersea can be traced back for at least 80 years (Dalton, 1908; Warren, 1917, 1924b, 1933; Cornwall, 1958; Zeuner, 1958; Sutcliffe, 1964; Spencer, 1966). Today three separate Pleistocene localities are recognized here (Bridgland *et al.,* 1988) within a single, complex GCR site. Pleistocene channel-fills occur at all three sites (Figure 5.22), (Figure 5.23) and (Figure 5.24), exposed by present-day marine erosion. At Cudmore Grove two channels of different ages are recognized, the Cudmore Grove Channel, which is attributed to the Thames-Medway and is the subject of the present report, and a later feature, the sediments in which yield hippopotamus. The latter, at the Cudmore Grove Hippopotamus Site, is closely associated with the third East Mersea locality, the Restaurant Site, 1 km to the west. The sediments at the Hippopotamus Site and the Restaurant Site are attributed to a later tributary river, rather than the main Thames-Medway, and are thus described below in Part 3 of this chapter.

Most early records of fossils from East Mersea seem to be related to the later tributary deposits, but there is one probable reference to the Cudmore Grove Thames-Medway sediments. A Pleistocene estuarine deposit with shells of *Cerastoderma* and *Scrobicularia* was encountered in 1906 in an excavation for a well in a small pit 'one mile east by north of East Mersea church' (Dalton, 1908, p. 136).

At that time there was, to the south of Cud-more Grove, a tract of well-established saltmarsh, still remembered by local inhabitants, between the high, gravel-covered land and the sea. Subsequent destruction of the saltmarsh has led to the formation of cliffs at the edge of the higher land. These had reached a height of just over 3 m in 1971, when they were described by Tucker and Greensmith (1973). Greatly accelerated erosion in recent years has doubled their height and given rise to fine cliff and foreshore exposures in the fossiliferous deposits and the overlying gravel. It seems likely that the pit referred to by Dalton was situated within the present Country Park at Cudmore Grove, where there is a small overgrown hollow [TM 065 148]. This lies *c.* 300 m from the present cliffs, so, if the channel deposits are continuous between the two, they are of considerable extent.

Description

The cliffs at Cudmore Grove expose fossiliferous estuarine deposits beneath up to 4 m of well-bedded gravel and sand (Figure 5.24). These deposits occupy a channel deeply excavated into the London Clay, the southern edge of which can be traced across the foreshore (Figure 5.23). The base of the channel has been reached in a borehole in the central part of the outcrop at –11 m O.D., where some 3 m of gravel underlie the fossiliferous sediments (Roe, in Bridgland *et al.,* 1988). The sequence can be summarized as follows:

		Thickness
5. Gravel and sand, well-bedded	(Mersea Island Gravel)	up to 4 m
4. Organic clay with wood fragments, especially at its base		up to 3 m
3. Shelly 'detritus mud', richly fossiliferous	(Cudmore Grove Channel Deposits)	0–0.3 m
2. Homogeneous clayey silt with estuarine Mollusca		up to 10 m
1. Gravel	(Cudmore Grove Channel Gravel)	3 m
London Clay		

The channel deposits (1–4) and the overlying gravel (5) thin rapidly to the south-west and are replaced in the cliffs by London Clay (Figure 5.22). This allows an attenuated representation of the channel sequence to be observed in exposure; the rapid coastal erosion and the periodic cliff collapses that it causes have provided opportunities to study different parts of the succession at different times. At the boundary between the channel deposits and the London Clay is a lag gravel', only 0.2–0.3 m thick, composed largely of rounded London Clay pebbles set in a clay matrix. Scattered durable clasts also occur, however, which resemble the material in the gravel overlying the channel sequence (Table 5.5). A Palaeolithic flake in very fresh condition has been recovered from this basal deposit (Bridgland *et al.,* 1988; see below).

The homogeneous clayey silt (bed 2) constitutes the bulk of the channel-fill (Figure 5.24). It contains abundant molluscs, mostly hydrobiids and *Cerastoderma,* indicative of brackish or intertidal conditions. From its 'feather-edge', in the cliffs, this bed yields a rich ostracod assemblage dominated by the brackish species *Cyprideis torosa,* the valves of which have well-formed nodes, thought to indicate low salinity. Other ostracod taxa recorded U.E. Robinson, pers. comm.) are *Candona neglecta* Sars, *C. caudata* Kaufmann, *C. marchica* Hartwig, *Loxoconcha elliptica* (Brady), *Cythere lutea* (Müller), *Darwinula stevensoni* (Brady and Robertson), *Herpetocypris reptans* (Baird), *Cypridopsis vidua* (Müller), *Cytheromorpha fuscata* (Brady), *Ilyocypris gibba* (Ramdohr) and *Limnocythere inopinata* (Baird). The majority of the above are freshwater species, but *L. elliptica, C. lutea* and *C. fuscata* live in marine or brackish conditions. The deposit also contains pollen from trees such as oak, elm and hazel, implying fully temperate conditions (Roe, in Bridgland *et al.,* 1988).

Above the estuarine silt, but apparently of restricted lateral extent, occurs the most richly fossiliferous of the Cudmore Grove deposits, the shelly 'detritus mud' (bed 3). This bed is usually only *c.* 0.3 m thick, but it is packed with shell fragments and is very rich in small vertebrate remains. The molluscan fauna is dominated by *Corbicula fluminalis* and a hydrobiid referred to in the British literature as *Paladilhia radigueli.* Other freshwater taxa occur, including *Bithynia, Valvata, Pisidium* and fragments of freshwater mussels. These taxa occur in proportions suggestive of brackish conditions, but with a lower salinity than the environment indicated by the underlying homogeneous silt (Bridgland *et al.,* 1988).

Thanks to the efforts of a number of collectors (notably J.D. Clayden, D. Harrison, M. Warren and R. Wrayton), who have sieved huge volumes of sediment from the foreshore exposures, bed 3 has produced a wealth of small vertebrate remains that is unparalleled in the British Middle Pleistocene. The rodents include *Apodemus sylvaticus* (L.) (wood mouse), *Clethrionomys glareolus* (bank vole) and *Microtus agrestis* (short-tailed field vole); the insectivores *Neomys fodiens* (water shrew) and *Crocidura* sp. (white-toothed shrew) are also present, the former in some abundance. Larger mammals include quite common remains of *Castor fiber* (beaver), much rarer *Ursus* sp. (bear), and a tooth of *Macaca sylvanus* (*macaque*)*,* a species known only from pre-Ipswichian interglacial deposits in Britain. Other vertebrate remains discovered in this bed include *Emys orbicularis* (pond tortoise), *Bufo bufo* (L.) (toad), *Rana* sp. (frog), *Eptesicus* sp. (bat) and several species of birds and fish. Several elements of the herpeto-fauna are new to the British Pleistocene (Holman *et al.,* 1990). The palynological sequence from the site places this bed in the late temperate phase of the interglacial; it has been attributed to Hoxnian biozone HoIIIb (Roe, in Holman et al*,* 1990).

The overlying organic clay (bed 4) lacks calcareous fossils, but contains, except in the oxidized upper few centimetres, abundant wood fragments and well-preserved pollen. The latter is similar to that in the homogeneous silt (bed 2), with the addition of substantial hornbeam and alder, small amounts of silver fir (*Abies*) and occasional records of the palynomorph 'Type X' (Roe, in Bridgland *et al.,* 1988). At the base of this bed is a layer of compressed wood (Figure 5.24) and (Figure 5.25) that includes large fragments. Two tree-trunks, one with roots attached, have been observed at different times protruding from this bed and forming prominent features on the modern beach and foreshore (Figure 5.26).

The gravel that overlies the channel deposits contains a mixture of local, southern and exotic clasts similar to those in the Clacton Channel Gravel and in the Low-level East Essex Gravel south of the Blackwater (Bridgland, 1980, 1983a, 1983b, 1988a; Bridgland *et al.,* 1988; (Table 5.5)). Excellent exposures in this deposit are provided by the cliffs at Cudmore Grove, allowing sedimentary and post-depositional structures to be observed. At the western end of its exposure in the cliffs, as it thins against rising London Clay bedrock, the gravel is interbedded with steeply dipping beds of redeposited clay (Figure 5.24), thought to represent lobes of colluvial material at the edge of the contemporary floodplain. Towards the opposite end of the exposure, the gravel is disrupted by numerous near-vertical structures resembling ice-wedge casts, but often with a slight downthrow on their eastern side. The underlying organic clay is diapirically uplifted beneath a number of these features, which might result from cambering rather than (or as well as) ground-ice development (Bridgland *et al.,* 1988).

Interpretation

Although research on the Cudmore Grove site is still in progress, sufficient information has already come to light to indicate that this is an extremely important Middle Pleistocene locality. Much of the site's significance results from its exceptional wealth of faunal evidence, the interest of which is enhanced (as at Clacton) by the fact that the deposits are a component part of the Thames-Medway terrace sequence.

The palaeontology of the channel deposits provides information about the palaeoenvironment as well as evidence for relative dating and correlation with other sites. The sequence records a change from a fluvial channel-fill, as evidenced by the thick basal gravel, to an estuarine environment, indicated by the characteristics and faunal content of the homogeneous silt (bed 2). Later deposits suggest a tendency towards marine regression, with a decrease in salinity indicated by the fauna of the 'detritus mud'. The overlying gravel (bed 5) presumably marks a return to a fluvial environment, very possibly coupled with a climatic deterioration, major gravel units normally being regarded as cold-climate deposits (see Chapter 1). However, there is nothing to suggest a lengthy hiatus between the organic clay and the overlying gravel. In fact the lower part of the gravel comprises a series of low-angle cross sets (Figure 5.24), dipping south-eastwards, that may represent deltaic progradation over the estuarine sequence, perhaps in response to an increased supply of sediment, prior to any major fall in sea level (Whiteman, in Bridgland *et al.,* 1988).

The channel sediments above the basal gravel are of clear interglacial character. The rodent assemblage in the 'detritus mud' (bed 3), for example, is typical of the temperate woodland phases of the Middle and Late Pleistocene (Currant, 1986; Bridgland *et al.,* 1988). The pollen and fossil wood further indicate that deciduous woodland was established in the region. The fact that sea level was sufficiently high to allow estuarine deposition within the present land area is also indicative of an interglacial, as sea levels during cold episodes were many metres below that at the present time.

The overlying Mersea Island Gravel is of sedimentological interest, comprising a varied sequence displaying a number of different types of bedding structure. These range from small-scale cross-stratification to the large foresets mentioned above. Several of the sandier horizons show evidence of penecontemporaneous deformation, suggesting that they were highly saturated when the overlying beds were laid down above them. Palaeocurrent measurements from small-scale foresets are widely distributed ((Figure 5.23), inset), giving rise to a radial distribution that is somewhat difficult to interpret. A south-south-east mean direction can be calculated, if the largest gap in the distribution is taken as a 'false origin', but this is of dubious value. It fails to take into account the strong double-peaked concentration of dips to the south-west. Double peaks of this type are typical in braided river gravels, in which they are believed to represent deposition on either side of lozenge-shaped bars (see Reading, 1978). These peaks appear to indicate that a river flowing towards the south-west deposited at least some parts of the gravel sequence.

The Mersea Island Gravel was excluded by Wood (1866b) from his original definition of the East Essex Gravel and was mapped as 'Glacial' by the early officers of the Geological Survey (Old Series, Sheet 48SW). However, Dalton (1908) decided that the gravel must be 'Post-glacial', following the discovery of fossiliferous deposits beneath it (see above), and it was subsequently described as a Thames-Medway deposit (Anon., 1913). Wooldridge (1927b), perhaps swayed by the Geological Survey mapping, interpreted the gravel as glacial outwash. The palaeocurrent evidence, which suggests that all or part of the gravel sequence at Cudmore Grove represents a braided river floodplain trending towards the south or southwest, would appear to support its interpretation as outwash. The composition of the gravel, however, provides important evidence precluding a provenance from the north. The deposit bears no resemblance to outwash, even of distal type, and it contains little of the quartzose exotic material that a river from the north or north-east would have reworked from the pre-diversion Thames gravels of the Tendring Plateau (Bridgland *et al.,* 1988; (Table 5.2)). Instead, its clast composition implies parity with the Low-level East Essex Gravel deposits to the south of the Blackwater estuary (Table 5.5), which are interpreted as the products of the post-diversion Thames-Medway. Thus the south-westward palaeocurrents from the Cudmore Grove cliffs, if correctly interpreted, must be a localized trend, possibly representative of a braided floodplain that followed a sinuous course across the area of Mersea Island. The gravel is considered to be part of a single, thick aggradational unit, the Mersea Island Gravel, that also includes the much higher remnants at West Mersea and on the eastern side of the Colne estuary at Point Clear (Bridgland, 1983a, 1988a; (Figure 5.2) and (Figure 5.27).

Correlation

In what appears to be the first record of their existence, Dalton (1908, pp 136–7) compared the Cudmore Grove deposits with those at Clacton: 'the silt much resembles the unweathered condition of the Clacton Postglacial deposit, as found below the beach; it is there full of land and freshwater shells and plant remains, though of estuarine character at a higher level, as seen in the cliffs. Possibly a similar sequence obtains in East Mersea, the estuarine passing down into a lacustrine deposit'.

Dalton's suggestion, made before the complexity of climatic fluctuations during the Pleistocene was widely accepted and based largely on the character of the sediments, is supported by much of the scientific evidence gathered in recent years. Most palaeontological indications of the age of the deposits suggest that they, like the Clacton Channel sequence, are of Hoxnian (*sensu* Swanscombe) age. Amongst the rich vertebrate fauna from Cudmore Grove, the vole *Arvicola cantiana* has a restricted occurrence within the Pleistocene between the late 'Cromerian Complex', where it replaces the earlier form *Mimomys savini* (see Chapter 1), and the Ipswichian (*sensu* Trafalgar Square), in which it in turn is replaced by the modern water vole *Arvicola terrestris* (Hinton) (Sutcliffe and Kowalski, 1976).

The pollen record from the Cudmore Grove channel sequence is also of particular value for relative dating, in that it resembles those from Hoxnian sites in the general area, such as Marks Tey (Turner, 1970) and Clacton (Pike and Godwin, 1953; Turner and Kerney, 1971; see above, Clacton). The detailed analysis of pollen and spores from Cudmore Grove is as yet unpublished, but preliminary observations have already proved informative (Roe, in Bridgland *et al.,* 1988; in Holman *et al.,* 1990). Of considerable significance is the occurrence of 'Type X', which is generally regarded as an indicator of the Hoxnian Stage (see above, Clacton). Correlation of the Cudmore Grove sequence with the Hoxnian (*sensu* Swanscombe) would support recent palaeogeographical reconstructions of the various Pleistocene deposits in eastern Essex, based on terrace stratigraphy (Bridgland, 1988a; (Figure 5.5)A and (Figure 5.5)B. This reconstruction involves a correlation of the Cudmore Grove and the Clacton channels. There are, however, a number of uncertainties to overcome before detailed correlation between the sequences at the two sites can be established.

The estuarine character of the deposits at Cudmore Grove would seem to indicate that they post-date the most fossiliferous part of the Clacton sequence, which is of freshwater origin (see above, Clacton). The Clacton Estuarine Beds were regarded by Warren (1955) as representing a period of declining sea level following a marine transgression. The palynological record from Clacton places this transgression between biozones HoIIIa and IIIb, the Estuarine Beds being ascribed to IIIb (see above, Clacton and (Figure 5.19)). The fossiliferous sequence at Cud-more Grove also appears to record a period of declining sea level, as suggested by the molluscan fauna of the detritus mud. The pollen from Cudmore Grove indicates that biozone HoIIIb is also represented there. The fact that deposits of this age occur at a lower elevation at Cudmore Grove than at the Clacton West Cliff site (the transgression is represented at *c.* 3 m in the

West Cliff section — see (Figure 5.19)) lends support to the suggestion that there was a period of erosion between the deposition of the Freshwater and Estuarine Beds at Clacton (see above, Clacton). Thus the lower part of the estuarine sequence at Cudmore Grove probably has no equivalent in the Clacton West Cliff section, but may correlate with the lower-level estuarine deposits in other parts of the Clacton site, such as Warren's Channel vi at Lion Point (Figure 5.18).

The basal gravel and the peripheral 'lag' gravel at Cudmore Grove are probably fluviatile, but these have yet to yield any palaeontological evidence and therefore cannot be related to the standard Hoxnian pollen sequence. The flake found in the 'lag gravel' may, however, indicate an upstream continuation of the industry at Clacton, where artefacts are concentrated in the Freshwater Beds. The flake was found *in situ* during sampling for clast-lithological analysis; this involved removing only a very small volume of the deposit, so a rich Palaeolithic content may be indicated. Wymer (1985b) recorded an earlier discovery of a flake at the site. This was found in 1978 'in the top of an orange clay with large flint pebbles', at [TM 067 144] (Vincent and George, in Wymer, 1985b, p. 258). The grid reference closely coincides with the outcrop of the 'lag gravel' at the western edge of the channel and the description also suggests that this artefact (now in the Passmore Edwards Museum) came from this deposit. Two further flakes, again in fresh condition, have been found on the beach in close proximity to the exposure of the lag gravel'. It is likely that these specimens, one found by D. Maddy during the Geologists' Association excursion to East Mersea in May 1987 and the other by P. Spencer in February 1989, were derived from the Cudmore Grove deposits, possibly the basal gravel. Unfortunately, because of the location of these deposits, at (and below) foreshore level beneath actively eroding cliffs, it will be difficult to verify that an important Palaeolithic industry is present.

The reconstruction of post-Anglian palaeodrainage in eastern Essex (Bridgland, 1980, 1983a, 1983b, 1988a; (Figure 5.5)A and 5.5B) also supports the correlation of the Cudmore Grove and Clacton sediments. This reconstruction, based on terrace stratigraphy and aided by gravel clast analyses, suggests that the Thames-Medway river only flowed as far north as Mersea Island and Clacton for the period of a single terrace cycle, that during which the Asheldham/Mersea Island/Wigborough Formation was deposited (see (Figure 5.5)). Subsequent formations are only found to the south of the Blackwater, their distribution reflecting the progressive south-eastward migration of the river. The ages attributed to these various formations ((Table 1.1) and (Table 5.3)) imply that the course across Mersea Island to Clacton persisted, following the Anglian Stage diversion of the Thames, until Oxygen Isotope Stage 10. During the latter stage, rejuvenation to the Barling Formation level coincided with a southward shift in the course of the Thames-Medway. This means that, unless this interpretation is incorrect, all interglacial deposits of post-diversion Thames-Medway origin to the north of the Dengie Peninsula must date from Oxygen Isotope Stage 11. Such deposits, which include the sediments filling parts of the Southend/Asheldham Channel ((Figure 5.5)A) as well as those at Cudmore Grove and Clacton, are therefore seen as downstream equivalents of the deposits at Swanscombe (Bridgland, 1983a, 1988a; see Chapter 4).

A view contradictory to this interpretation has, however, been expressed by Currant (1989), in an appraisal of small-mammal faunas in Britain. Currant noted that there are many similarities between the rich assemblage of small mammals at Cudmore Grove and that from Grays in the Lower Thames (see Chapter 4, Globe Pit). The shrew *Crocidura,* several specimens of which have been recovered from the 'detritus mud' (bed 3) at Cudmore Grove, is a very rare element of the British Pleistocene mammalian fauna, but it has also been recorded from the Orsett Road section at Grays (Hinton, 1901; Bridgland *et al.,* 1988). An abundance of water shrew (*Neomys fodiens*) is another rare phenomenon, but this species is also well-represented at Grays (Hinton, 1911). Currant placed both Cudmore Grove and Grays within his Group 2 assemblages, along with Aveley (see Chapter 4). He regarded this group as intermediate in age between Hoxnian stage assemblages (his 'Group 3'), in which he included Swanscombe and Clacton, and the last interglacial *'Hippopotamus* fauna', his 'Group 1'. There is a recognizable weakness in Currant's groupings, however; this stems from the fact that the assemblages he discusses have very different levels of richness. Thus the Grays and Cudmore Grove faunas are both from prolific sites that have yielded large numbers of specimens. The assemblages from Clacton and Swanscombe, differentiated from Cudmore Grove by Currant, are sparse by comparison. It is possible, therefore, that the strong similarities between the Grays and Cudmore Grove assemblages, and their distinction from Currant's 'Group 3 assemblages', merely result from the relative richness of these two faunas and are of no stratigraphical significance.

The interpretation of the Lower Thames sequence proposed in this volume (Chapter 4) also fails to conform with Currant's groupings. Sites from two aggradational formations (the Corbets Tey and Mucking Formations) appear within his Group 2 assemblages, representing, according to the evidence presented in Chapter 4, warm Oxygen Isotope stages

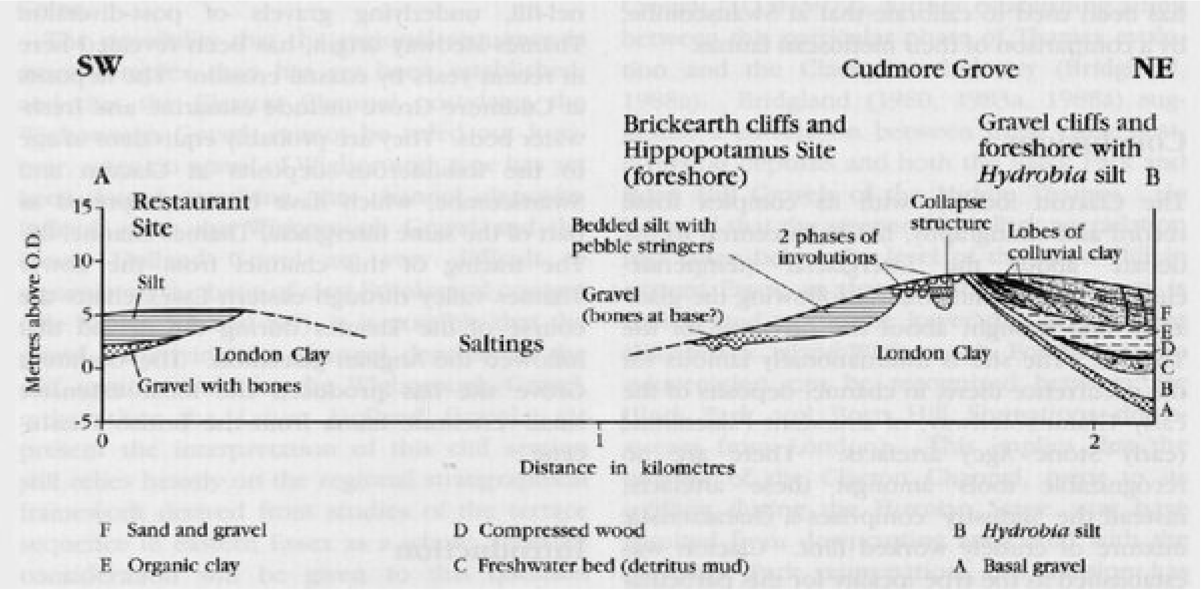
9 and 7. This suggests that evidence from small-mammal assemblages (in common with other biostratigraphical evidence — see Chapter 4) does not allow at present a distinction to be made between faunas from Stages 9 and 7. It therefore seems wise to give precedence to the evidence from terrace stratigraphy and palaeo-drainage reconstruction, which provide the most reliable framework for interpreting the fluvial record in the lower reaches of the Thames Basin and for correlation with the deep-sea record (see Chapter 1 and (Table 1.1)). In the absence, thus far, of a complete analysis of the Mollusca and pollen from Cudmore Grove, or of amino acid ratios from the former, the principal evidence for correlation with other sites comes from the reconstruction of terrace formations in eastern Essex.

Conclusions

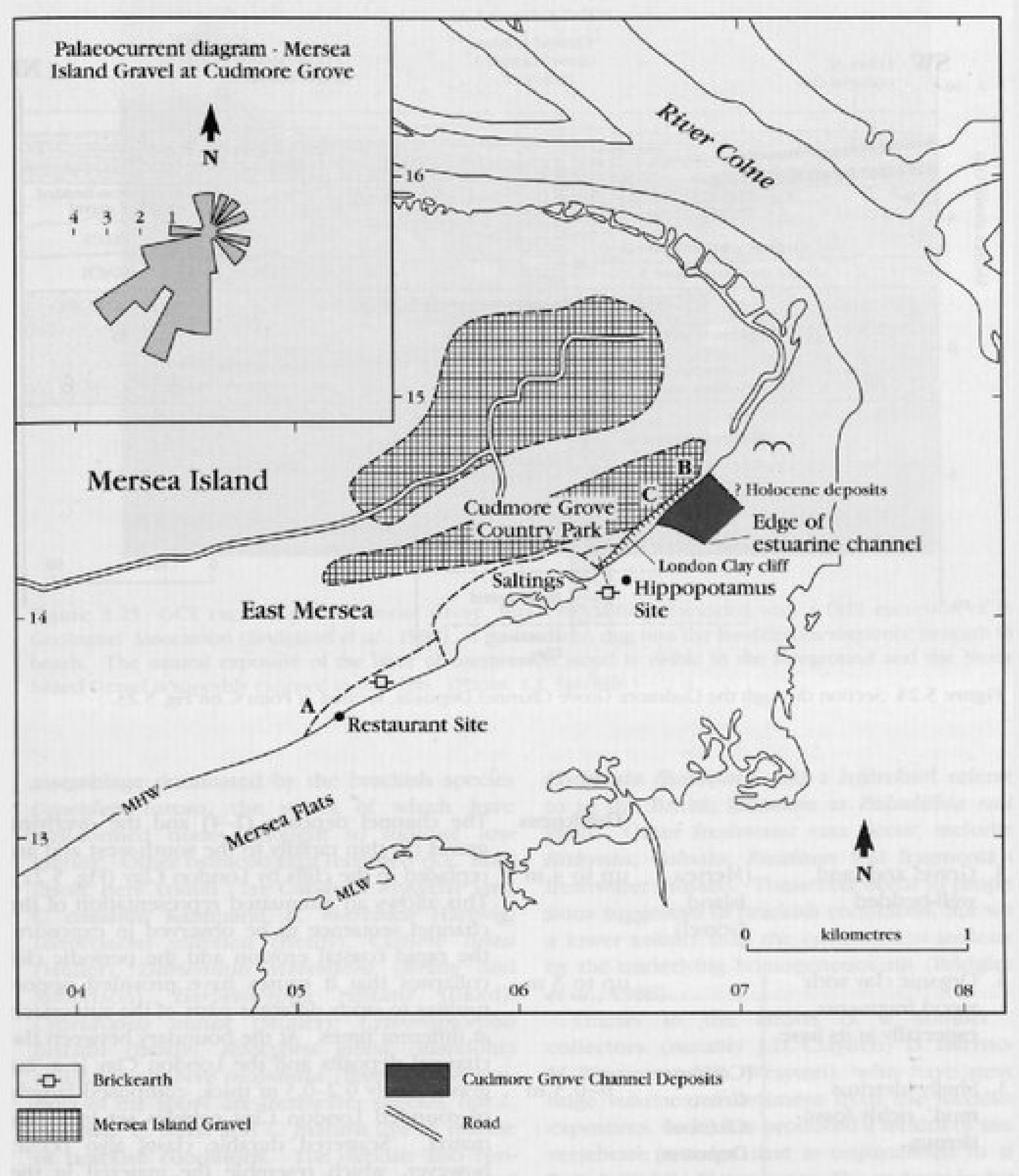
Evidence from the sequence at Cudmore Grove, only revealed by coastal erosion during the last decade, shows this to be an extremely important Pleistocene locality. The site yields a wealth of palaeontological information that is of great importance for reconstructing the contemporary environment and for dating the deposits. This evidence indicates warm (interglacial) conditions and a Middle Pleistocene age. The plant and animal remains in the Cudmore Grove channel sediments provide a picture of life during this interglacial period. A huge range of fossils are included — molluscs, ostracods (microscopic crustaceans), pollen, other plant fossils, mammals (including monkey, beaver, bear, bat and extinct voles), reptiles, birds, amphibians and fish. In fact the fauna of small vertebrates is considered to be the richest ever found in Britain.

Pollen preserved in the fine-grained sediments suggests a correlation with the nearby (Hoxnian Stage) fossiliferous sediments at Clacton. The latter suggestion conforms with reconstructions of the course taken by the Thames-Medway after the Thames was diverted by ice during the most severe Middle Pleistocene glaciation. This course took the river through both East Mersea and Clacton. The Cudmore Grove sediments are thus interpreted as part of an interglacial channel-fill that can be recognized widely within the lower reaches of the Thames system. This channel-fill, which includes the well-known fossiliferous and artefact-bearing deposits at Swanscombe as well as at Clacton, is believed to have been laid down during Oxygen Isotope Stage 11 (Hoxnian *sensu* Swanscombe), *c.* 400,000 years ago.

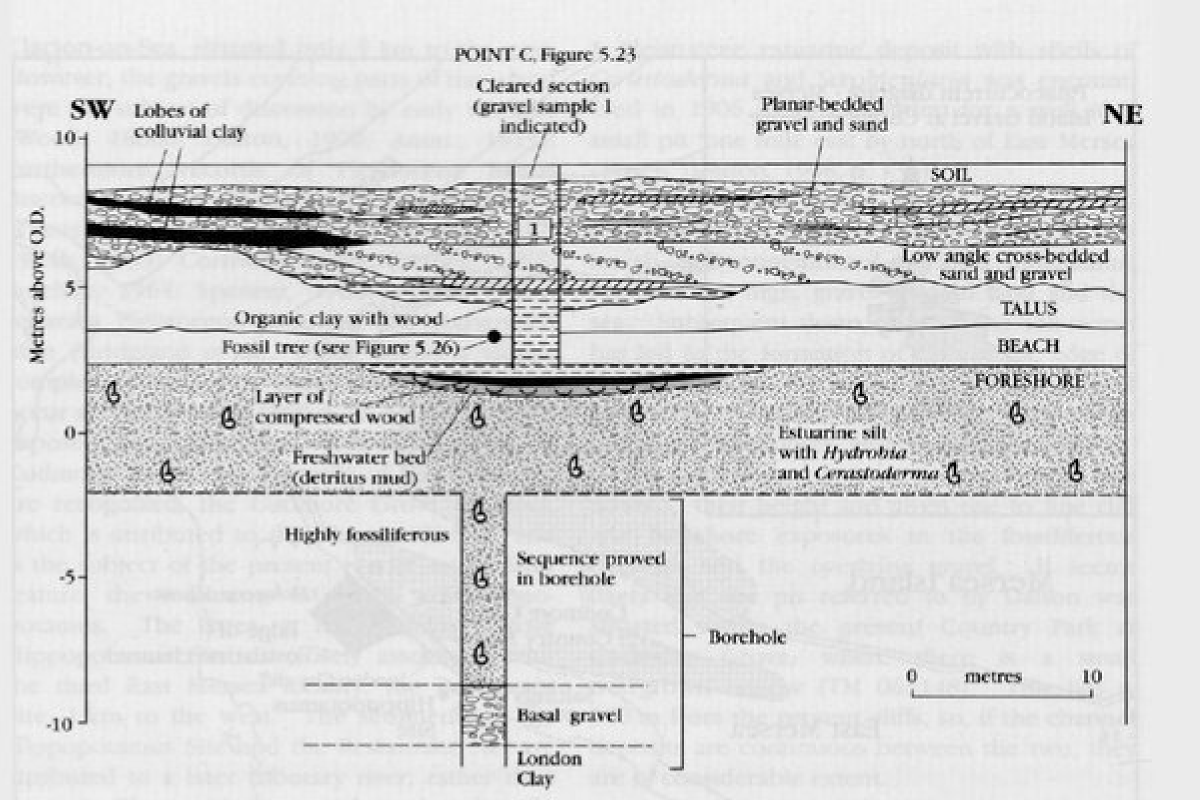
[References](#)



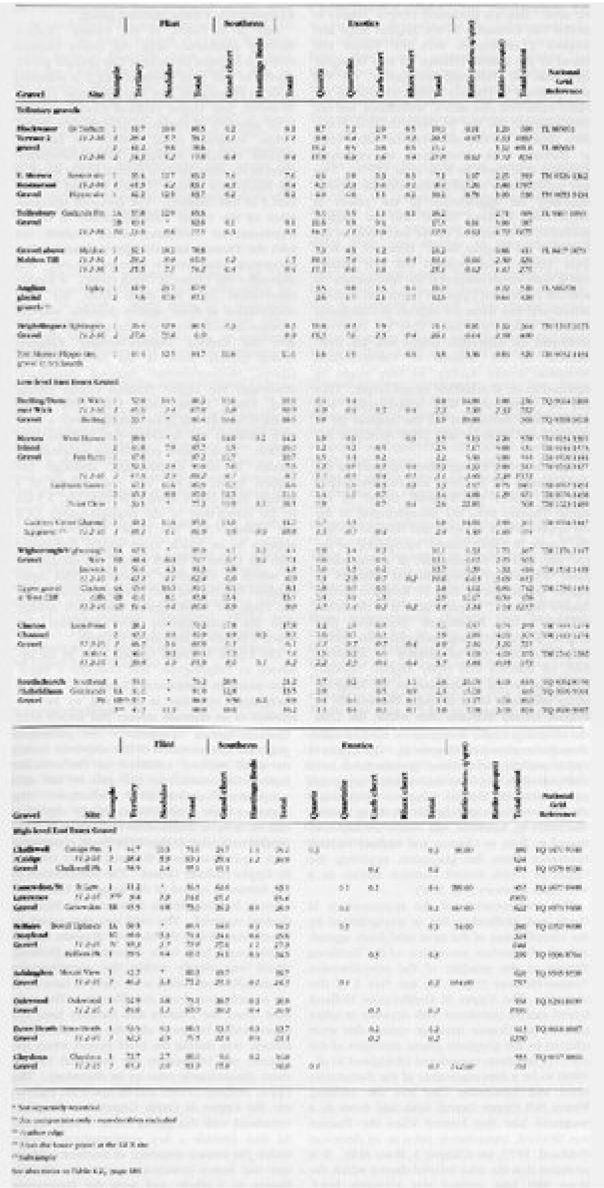
(Figure 5.22) SW–NE section through the deposits at East Mersea, showing the relations of the Cudmore Grove Channel to the Blackwater deposits at the Hippopotamus and Restaurant Sites. Points A and B are indicated on (Figure 5.23).



(Figure 5.23) Map showing the Pleistocene deposits of East Mersea (after Bridgland et al., 1988). The points A and B refer to the ends of the section in (Figure 5.22). Point C is the location of the section in (Figure 5.24).



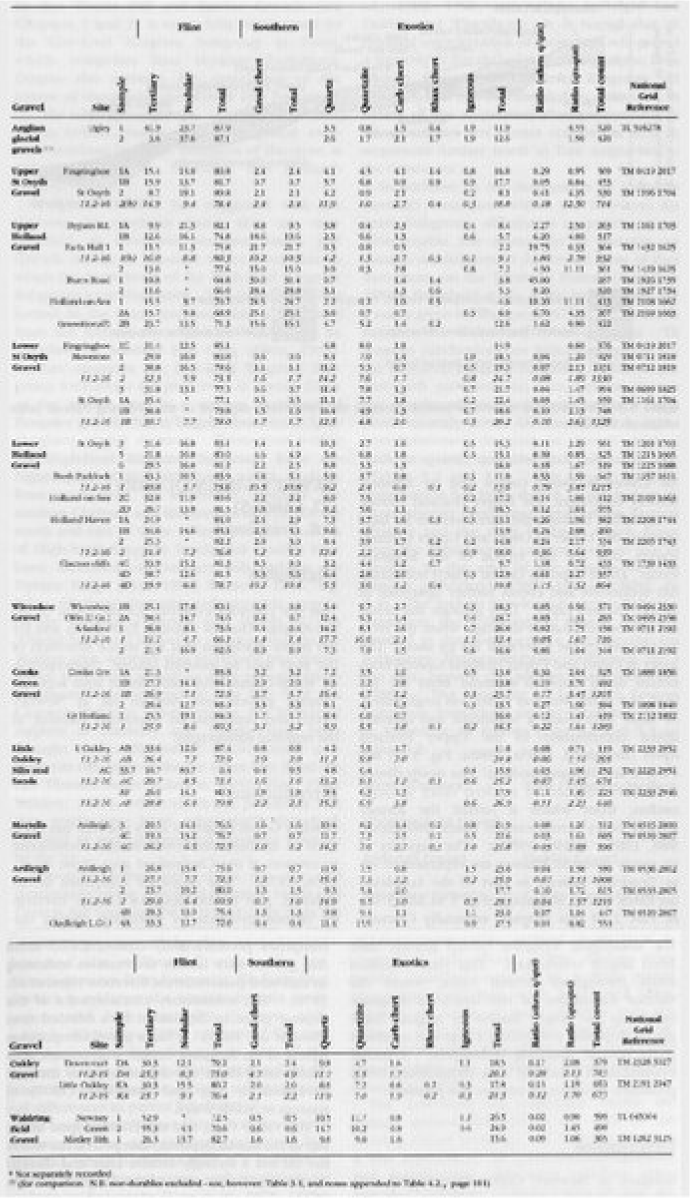
(Figure 5.24) Section through the Cudmore Grove Channel Deposits, located at Point C on (Figure 5.23).



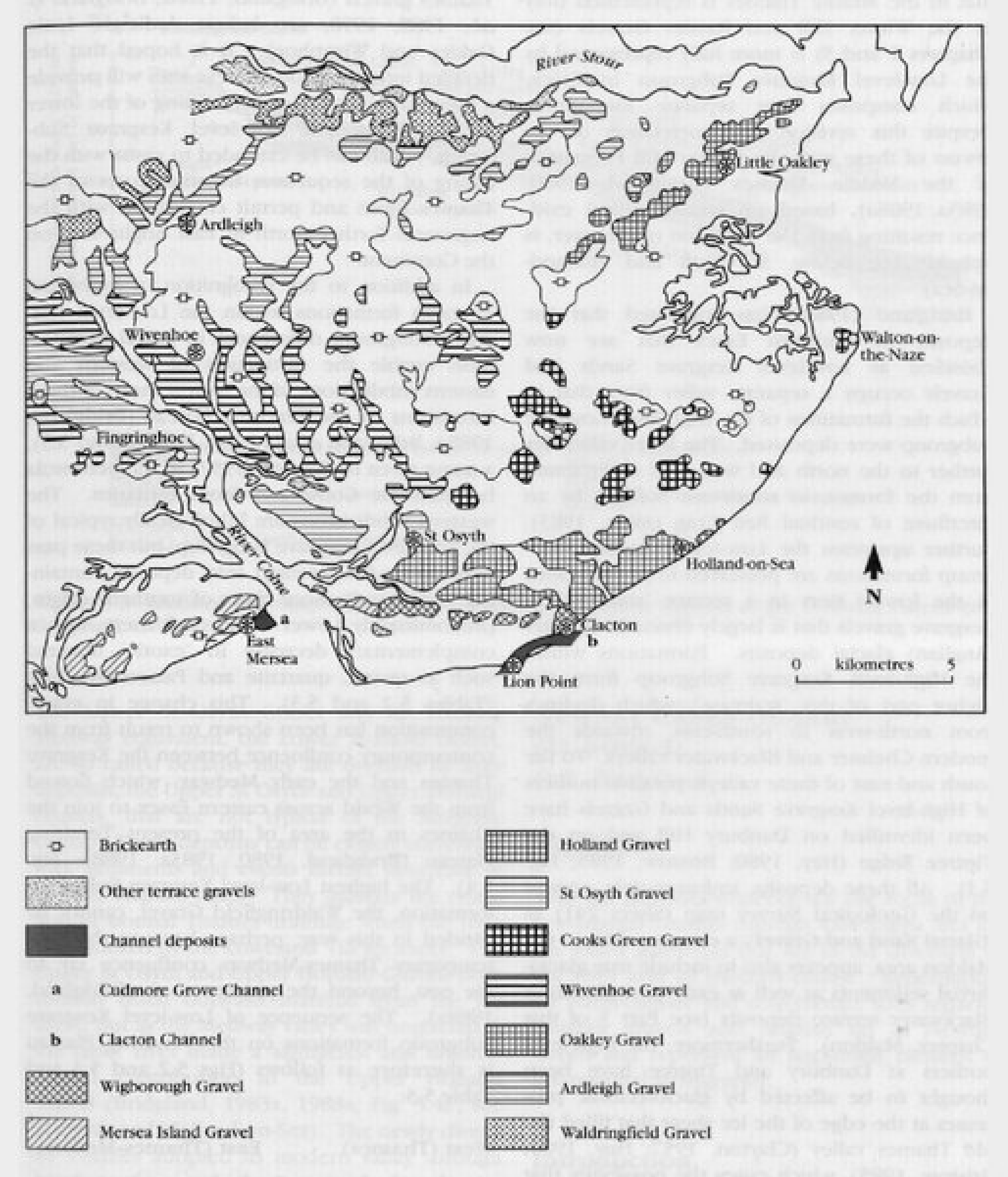
(Table 5.5) Clast-lithological composition of gravels described in Chapter 5, Parts 2 and 3.

(Figure 5.25) GCR excavation at Cudmore Grove, May 1987, which coincided with a field excursion of the Geologists' Association (Bridgland et al., 1988). A pit has been dug into the fossiliferous sequence beneath the beach. The natural exposure of the layer of compressed wood is visible in the foreground and the Mersea Island Gravel is superbly exposed in the cliffs. (Photo: AJ. Sutcliffe.)

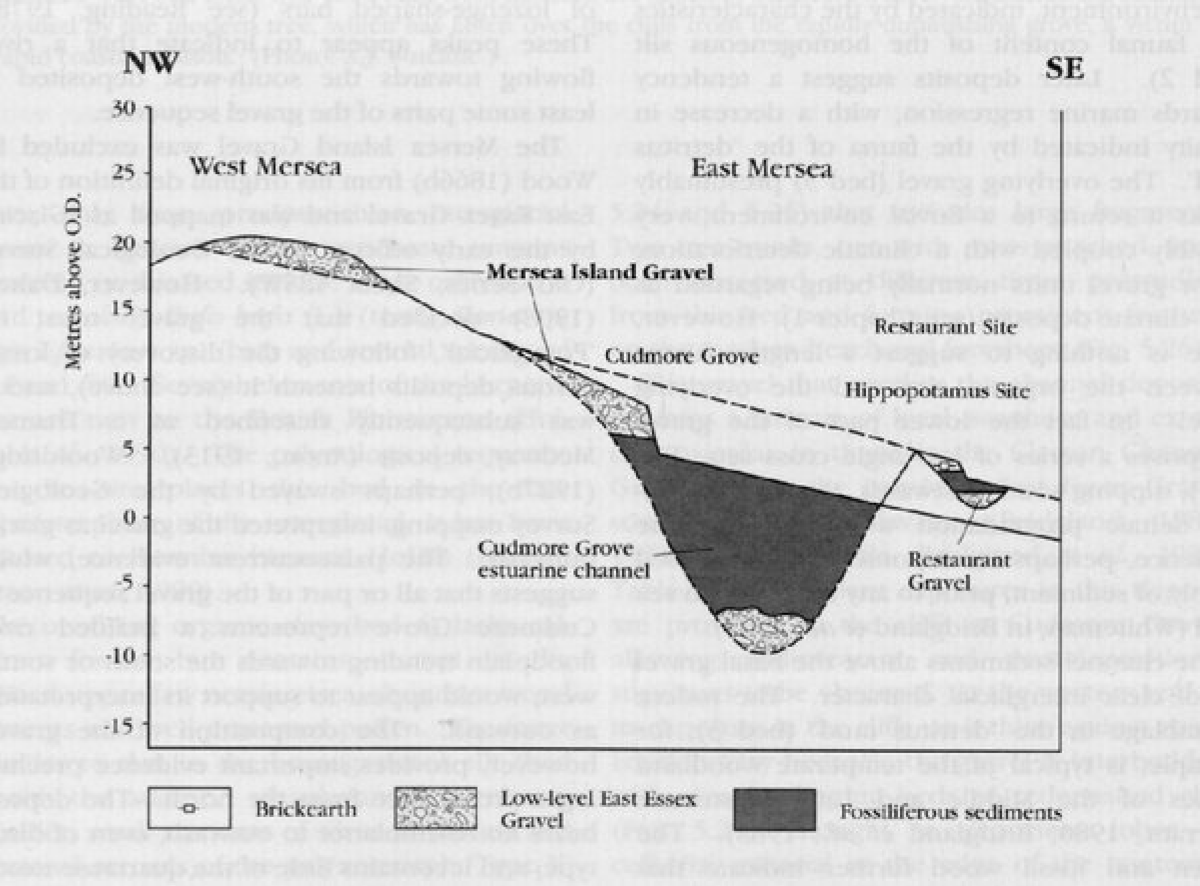
(Figure 5.26) Part of a fossil tree protrudes from beneath the beach at Cudmore Grove. An interesting analogue is provided by the modern tree, which has fallen over the cliffs from the rapidly diminishing grove, a victim of the rapid coastal erosion. (Photo: A.J. Sutcliffe.)



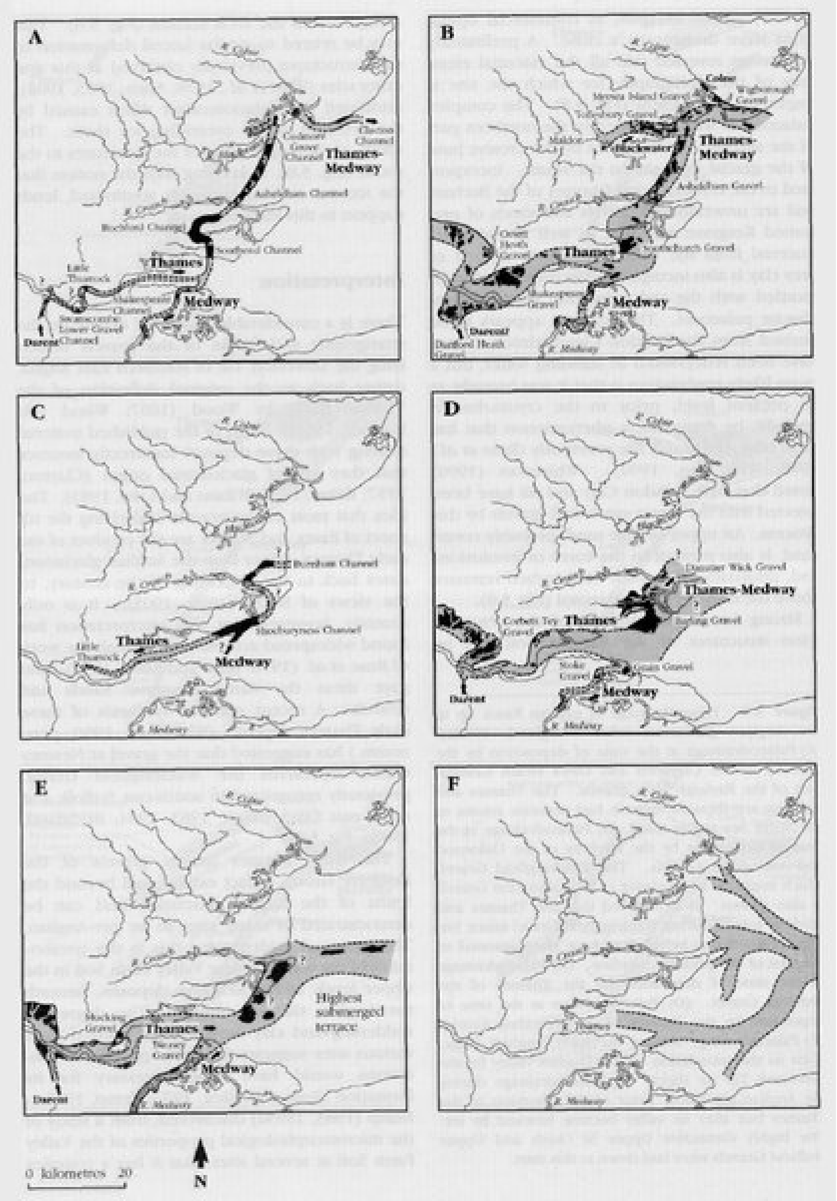
(Table 5.2) Clast-lithological composition of the gravels described in Chapter 5, Part 1.



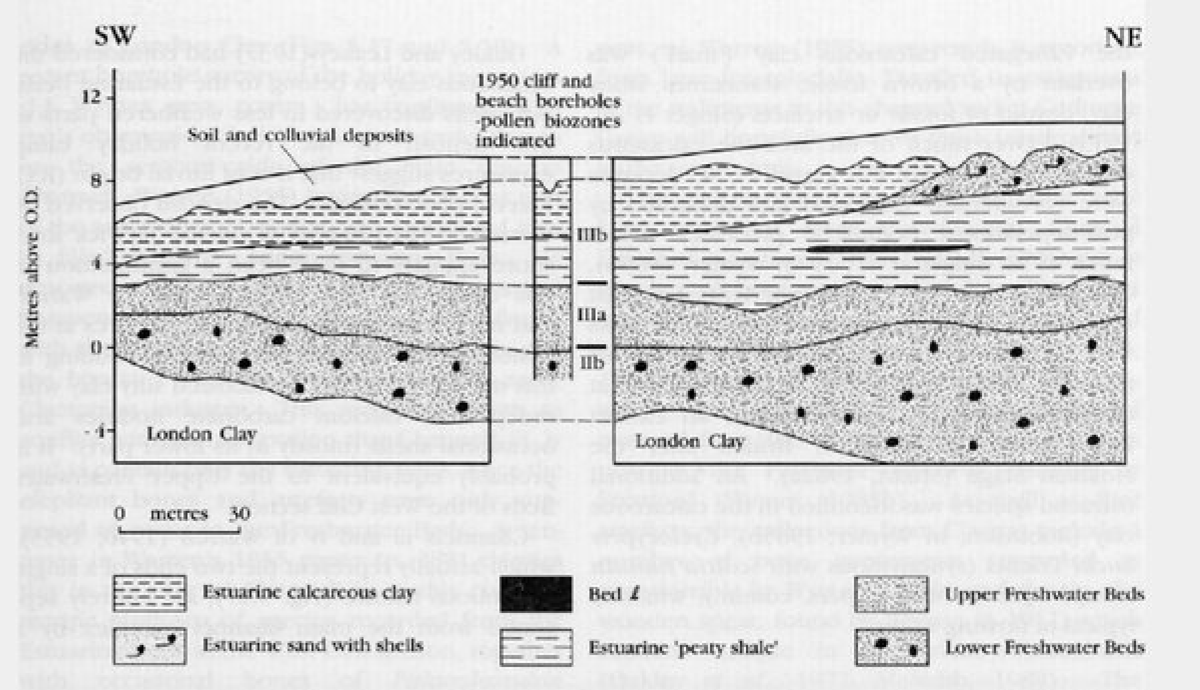
(Figure 5.2) Pleistocene gravels of the Tendring Plateau (after Bridgland, 1988a).



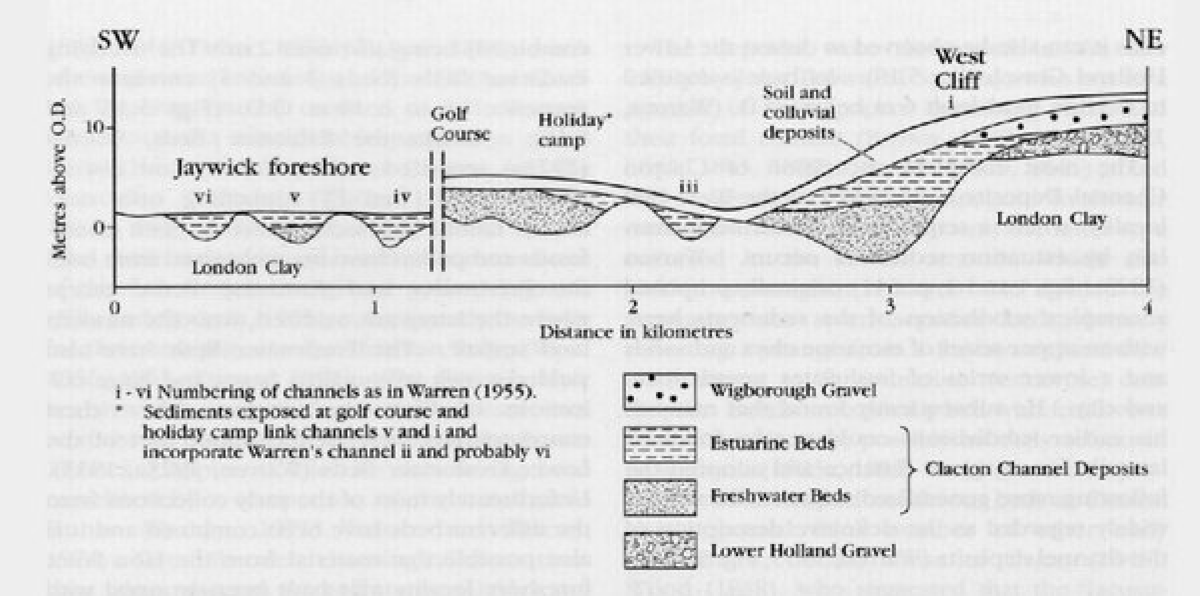
(Figure 5.27) Idealized transverse section through Mersea Island (after Bridgland et al., 1988).



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

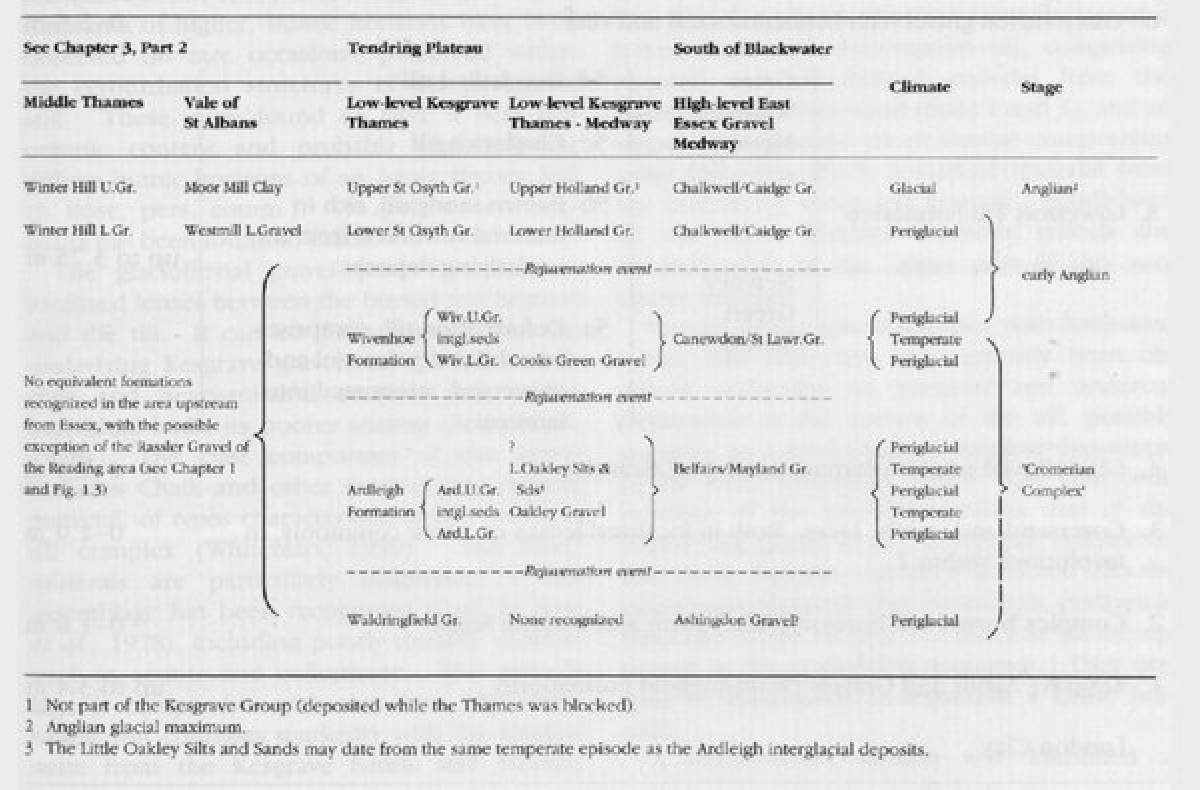


(Figure 5.18) Section through the Clacton area, showing the various Clacton Channel occurrences (modified from Warren, 1955).

Age (in thousands of years)	Upper Thames	Middle Thames		Lower Thames	Essex	Stage	^{18}O
	Recent floodplain and channel deposits: Holocene alluvium of floodplain and coast					Holocene	1
10	Northmoor Gravel	Shepperton Gravel		Submerged	Submerged	late Devensian	2-4
	Rejuvenation event						
71		Temperate climate deposits at South Kensington (Ismaili centre), Isleworth and Kempton Park		Submerged	Submerged	early/mid-Devensian? interstadial(s)	5a &/or 5c?
?		**Reading area**	**Slough area**				
	Cold climate gravels above Eynsham Gravel	U. levels of Taplow Gravel	Kempton Park Gravel	East Tilbury Marshes Gravel	Submerged	early-mid Devensian	5d-2
122	Eynsham Gravel	Within Taplow Formation	Trafalgar Square and Brentford deposits	Below floodplain	Submerged	Ipswichian (sensu Trafalgar Square)	5e
128	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					
		Taplow Gravel		Mucking Gravel			
186	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
245	Basal Summertown-Radley Formation at some sites?	Basal Taplow Gravel?		Basal Mucking Gravel	Submerged		
	Rejuvenation event					mid-Saalian	8
	Wolvercote Gravel at some sites?	Lynch Hill Gravel		Corbets Tey Gravel	Barling Gravel		
303	Wolvercote Channel Deposits			Interglacial deposits at Ilford (Cauliflower Pit), Belhus Park, Purfleet and Grays	Shoeburyness Channel interglacial deposits	intra-Saalian temperate episode	9
339	Basal Wolvercote Gravel	Basal Lynch Hill Gravel?		Basal Corbets Tey Gravel	Shoeburyness Channel - basal gravel		
	Rejuvenation event					early Saalian	10
	? Moreton Drift (Arkell, 1947a)						
	Hanborough Gravel	Boyn Hill Gravel		Orsett Heath Gravel	Southchurch/Asheldham/Mersea Island/Wigborough Gravel		
?	Reworked mammalian fauna in Hanborough Gravel			Swanscombe deposits	Southend/Asheldham/Cudmore Grove/Clacton Channel Deposits	Hoxnian (sensu Swanscombe)	11
423	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				Anglian	12
	Moreton Drift?	Anglian glacial deposits		Hornchurch Till	U. St Osyth/U. Holland Gravel		
	Freeland Formation	Winter Hill/Westmill Gravel		Valley did not exist as a Thames course prior to this	St Osyth/Holland Formation		
478	Sugworth Channel Deposits	Rassler Gravel?			Wivenhoe/Cooks Green Fm 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.



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.