Herne Bay (Bishopstone Cliffs) Kent

[TR 193 685]–[TR 224 693]

Highlights

Stratigraphically, Herne Bay is the most important Palaeogene site in the London Basin and is one of the two type sections for the internationally important Thanetian Stage and for the Thanet Sand Formation. Evidence from this site has contributed to a realization that, locally, the base of the Thames Group lies unconformably on older strata. The Oldhaven Beds (Harwich Formation) can be correlated with the A.sh Marker' of the North Sea succession.

Introduction

This site (Figure 3.7) and (Figure 3.8) consists of cliff and foreshore exposures extending from the eastern part of the town of Herne Bay (grid reference [TR 193 685]) north-eastwards towards Reculver [TR 224 693]. The strata dip gently to the west giving continuous exposure from the upper Thanet Sand Formation to the 'London Clay'. Foreshore exposures are particularly important with low-water spring tides providing optimum access (Figure 3.9). In his account of the sections in 1978, Ward described it as 'probably the best and most accessible section of Lower Tertiary strata in the south-east of England'. Over the years, however, coastal 'protection' has affected the extent and quality of exposure. In a paper on local landslides, Bromhead (1978) remarked that 'In recent years these cliffs have been subjected to extensive coast defence and cliff stabilisation work and now bear little resemblance to their former appearance'; although this statement really only applies to the more westerly part of the section. Whilst to the west of Bishopstone Glen (Figure 3.7) much of the cliff is vegetated, good exposures persist further east (Figure 3.8).

In a brief summary of research on the section, Ward (1978) cited the classic early work of Prestwich (1850, 1852, 1854a) followed by that of Whitaker (1866, 1872). Both authors provided faunal lists. Prestwich (1852) included a diagrammatical cliff section, as did Whitaker in the Geological Survey Memoir of 1872. As Ward (1978) pointed out, a later account by Gardner (1883) is hard to follow and his sections are more difficult to interpret.

Twentieth century accounts include those of Dewey *et al.* (1925), Cooper (1934) and that in the Geologists' Association Guide to the area (Pitcher *et al.,* 1958, 1967). Recent descriptions include that by Ward (1978) on the pre-'London Clay' strata and King (1981) on the 'London Clay'. A brief general account appears in Holmes (1981) which, as the Memoir for the local 1:50 000 geological sheet (Faversham), portrays the site in a broader regional Palaeogene context, whilst also providing important lists of references.

Because of its geological importance, Herne Bay has been the venue for a number of field meetings of the Geologists' Association (Dowker, 1864; Whitaker and Dowker, 1885; Leighton, 1894; Whitaker, 1912; Brown, 1936; Stinton, 1965b; Gamble, 1968; Hutchinson, 1968) and the Tertiary Research Group (e.g. Rundle, 1970a). No doubt, the increasing development of coastal defence works for over two decades explains a diminution of such meetings in more recent years.

Palaeontologically, the site has attracted interest since the 19th century. For the 'London Clay', Cooper (1977) summarized previous collecting and provided comprehensive fossil lists. Ward (1978) included similarly comprehensive lists for the 'Lower London Tertiary' (Palaeocene) strata present. Amongst papers making particular reference to the molluscan faunas, are that by Cooper (1934), various papers by Wrigley (including Wrigley, 1949) and King (1981), whilst the vertebrates, particularly fishes, were dealt with by Gurr (1963), Ward (1975, 1978) and Gamble (1979). In addition, various workers have investigated the micropalaeontological remains. Haynes (1956–1958) studied the foraminifera, whilst subsequent attempts to date the section involved research on the dinoflagellates (Costa and Downie, 1976) and calcareous nannoplankton (Martini, 1971; Hamilton and Hojjatzadeh, 1982; Aubry, 1986; Siesser *et al.,* 1987). Non-palaeontological, chronostratigraphical work on the section was included in a wider magnetostratigraphical investigation by Townsend and Hailwood (1985), whose findings were elsewhere integrated with a study of the

nannoplankton biostratigraphy (Aubry *et al.,* 1986).

Relatively few workers have studied the section from a detailed lithostratigraphical and sed imentary facies viewpoint and have done so only as part of broader regional studies (Hester, 1965; King, 1981; Ellison, 1983). Mineralogical work on the section has included a detailed study of glauconite and the problems associated with its use in age determination (Fitch *et al.,* 1978a; Curry *et al.,* 1978), provenance studies using heavy minerals (Blondeau and Pomerol, 1962, 1968; Weir and Catt, 1969; Morton, 1982a) and work investigating the possibility of contemporaneous volcanism (Knox, 1983).

Description

The section between the town of Herne Bay and Reculver to the east [TR 193 685] to [TR 224 693] comprises Palaeogene beds dipping gently westwards at an average angle of 3°. The following units are present in ascending order: Thanet Sand Formation, Upnor Formation, Harwich Formation and London Clay.

Following the development of coastal defence works, the foreshore exposures (best seen at low-water, equinoctial spring tides) have become an increasing important aspect of the site. Parts of the cliff section are now poorly exposed. For example, King (1981) refers to cliff exposures of 'London Clay' at this site as perhaps, at 35 m, the thickest preservation of the formation in Kent and yet states that little is now visible.

Lithological succession

The succession (Figure 3.10) is about 30 m thick, not counting the poorly exposed London Clay, to which Ward (1978, p. 2) allocated just over 37 m. The Thanet Sand Formation comprises muds (clays, silty and sandy clays) and subordinate glauconitic silty sands. The Upnor Formation above consists of silty sands above a thin silty clay with black pebbles at the base (the Beltinge Fish Bed of Ward, 1977). The Oldhaven Beds have a pebble bed at the base (locally lithified and limonitic but sometimes absent) which is succeeded by silty sands and sands. The succession is completed by the muds of the London Clay.

Lithostratigraphy

The oldest strata present were formerly called the 'Lower London Tertiaries' and comprise here the upper part of the Thanet Sand Formation and the overlying 'Woolwich Beds' of Ellison's (1983, p. 312) Woolwich and Reading Formation. More recently, the latter in Herne Bay have been assigned to the Upnor Formation (Lambeth Group) of Ellison *et al.* (1994). These are overlain unconformably by the Thames Group of King (1981): the 'Oldhaven Beds' (Oldhaven Formation of King, 1981) of the Harwich Formation of Ellison *et al.* (1994) and the succeeding London Clay.

There has been disagreement over where the boundary between the Upnor Formation and the underlying Thanet Sand Formation should be placed. Hester (1965) and Holmes (1981) followed Prestwich (1854a) and Whitaker (1866) in including the *Corbula regulbiensis* Bed in the 'Bottom Bed' of the Woolwich and Reading Formation (as the Upnor Formation was formerly named), whilst by contrast, Ward (1978) and Siesser *et al.* (1987) followed Gurr (1963) in placing the *C. regulbiensis* Bed in the Thanet Sand Formation.

King (1981) made Herne Bay the type section for his Oldhaven Formation and the Herne Bay Member of the latter, the name arising from the use of the alternative locality name Oldhaven Gap for Bishopstone Glen [TR 207 687] towards the western end of the cliff section (Figure 3.9). Earlier, White (1931) had proposed the name 'Bishopstone type' for the sands between the Thanet and Oldhaven Formations, to distinguish the local marine sediments from lagoonal' 'Woolwich-type' strata to the west. Whilst the term 'Bishopstone type' sands has not persisted, they are now recognized formally as a separate formation, the Upnor Formation of Ellison *et al.* (1994).

Palaeontology

Since the 19th century, the site has been considered important palaeontologically. Its fossils are particularly significant since this is one of the very few remaining sections to provide insight into earliest Palaeogene times in the British area.

Ward's (1978) comprehensive list of 'Lower London Tertiary' fossils from the site includes 34 bivalves, 26 gastropods, together with representatives of other invertebrate groups, such as the brachiopod *Lingula,* a bryozoan and three echinoids, and also a large number of fishes.

Certain parts of the sequence have attracted the attention of palaeontologists for many years. Amongst these are the *Arctica morrisi* Bed and the *Corbula regulbiensis* Bed whose faunas, together with those of some newly defined biostratigraphical units, were described by Ward (1978). The Woolwich Beds (as used by Holmes, 1981, but see later discussion) have proved to be particularly important. Hester (1965) considered that 'no other sections in the Bottom Bed have yielded such a prolific fauna as that found at Bishopstone Glen', although this reflects his inclusion of the *C. regulbiensis* Bed in the Woolwich and Reading Formation, contrary to the view of Ward and others (e.g. Ward, 1978). Within this part of the sequence, Ward (1978) found 'an abundant vertebrate fauna consisting of shark's teeth and vertebrae, chimaeroid plates, teleost teeth and bones, crocodile and turtle bones and scutes' in a thin unit defined by him as the 'Beltinge Fish Bed' (= Woolwich Bottom Bed *sensu* Gurr, 1963, p. 419).

The 'London Clay' fossils from the site are discussed by King (1981, pp. 54–56) although little of the formation is now exposed. The most comprehensive record, including fossil lists, is that of Cooper (1977). Most of the macrofauna and macroflora are represented by specimens found loose on the foreshore. The majority of the recorded 'London Clay' molluscs probably came from King's (1981) 'Division B', which a little above its base shows a rapid increase in diversity and abundance of foraminifera representing the so-called 'planktonic datum' (cf. that described by Wright (1972) from the Hampshire Basin).

Macrofora

Plant macrofossils have been found at a number of horizons (Chandler, 1961b). Bearing in mind the prolific London Clay flora mainly found at Sheppey but also from this locality (see list in Cooper, 1977), it is the plants from the Thanet Sand Formation that provide a particular local interest. According to Chandler (1961b, p. 17), only two genera have been recognized: *Pinus* (two species) and the fern *Osmundites.* However, Ward (pers. comm.) has pointed out that *Picea* (larch) occurs in both the *Astarte tenera* Bed and the Beltinge Fish Bed, and that the former also contains a rich seed flora.

Insect remains

An unusual aspect of the fauna is the occurrence of rare pyritized insects from the 'London Clay', most readily obtained from pyritic debris on the foreshore. Rundle (1970a, p. 8) obtained a limited fauna of taxa almost identical to that of the 'Beetle Bed' of Bognor Regis (Venables, 1963) but with beetle fossils probably more common here than at Bognor. Perhaps even more unusual is the presence of a pyritized coleopterid larva from the 'London Clay' (Rundle and Cooper, 1971).

Chronostratigraphy

With the section at Pegwell Bay, Herne Bay has been designated the co-stratotype for the Thanetian Stage (Pomerol, 1982).

In the search for a reliable chronostratigraphical scheme based on microfossils, the Herne Bay section has not been neglected. Three zones based on the dinoflagellate *Wetzeliella* have been recognized: the *W.* (*Apectodinium*) *hyperacantha* Zone (the top of which lies in the basal few metres of the 'London Clay' here), the *W. meckelfeldensis* Zone (5–18 m above the base) and the overlying W *varielongituda* Zone (Costa and Downie, 1976).

Unlike Pegwell Bay, where indigenous nannofossils are uncommon, rich and moderately well-preserved nannofossil assemblages have been found at all but the uppermost levels of the Thanet Sand Formation in Herne Bay. The whole of the latter is considered to have an NP8 age (Aubry, 1986, pp. 277–8; Siesser *et al.,* 1987), as suggested previously by Martini (1971). Hamilton and Hojjatzadeh's (1982) report of *Discoaster multiradiatus,* a nannofossil defining the base of NP9, being found in the uppermost part of the Thanet Formation at Reculver, was questioned by Aubry (Aubry, 1986;

Aubry *et al.,* 1986). An examination of earlier samples and newly collected material by Siesser *et al.* (1987) has found no trace of this species in the Thanet Sand Formation.

Age-diagnostic microfossils are absent from the Oldhaven Beds here, but since this unit is both underlain and overlain by beds of the *W.* (*Apectodinium*)*hyperacantha* Zone, it is clearly of this age (Knox *et al.,* 1983). A more recent study of the dinoflagellate cyst sequence biostratigraphy has been undertaken by Powell *et al.* (1996).

Magnetostratigraphy

The importance of the section for magnetostratigraphical work was stressed by Townsend and Hailwood (1985, p. 969). The Thanet and Woolwich Formations and the 'London Clay' were deposited during a period of reverse polarity. However, for the Oldhaven Beds, the situation is a little more complicated. Up to the lower part of Unit M of Ward (1978) (Figure 3.10) reverse polarity is represented, but in the upper part of M and above (i.e. some 90% of the Oldhaven Beds), normal polarity is indicated. On the basis of the latter, Townsend and Hailwood (1985) established the Oldhaven magnetozone for which Herne Bay is the type locality, recognizing that it is incomplete since its upper boundary coincides with the sharp and presumably erosional surface at the base of the overlying 'London Clay'. More recently, Ali *et al.* (1996, p. 202) have raised questions concerning the reliability of this magnetozone and have suggested that the section be restudied to assess its validity.

Glauconite dating

The presence of glauconite in the succession in Herne Bay has allowed various researchers to date the Thanet Sand Formation radiometrically (Odin *et al.,* 1969, 1978; Fitch *et al.,* 1978a, b; Odin and Curry, 1985). Ages determined (in millions of years) include: 68.1 ± 4 (Odin *et al.,* 1969; Thanet Beds, 2 m below the Woolwich Bottom Bed); 53.1 ± 3.3 and 56.0 ± 3.2 (Odin *et al.,* 1978; Thanet Beds, Corbula Bed and 'near top' respectively); 56.8 ± 0.6 and 60.2 ± 2.7 (Fitch *et al.,* 1978a; 5 m below top of Reculver Sands and 2 m above base of Oldhaven Beds respectively). In a later paper, Fitch *et al.* (1978b) suggested an age range of 60.95 to 57.6 Ma for the Thanet Beds of East Kent as a whole.

Sedimentology

Although generalized lithological descriptions of the site appear in numerous publications, the sedimentological aspects of the section have not received the same degree of attention as have the fossils. King (1981, p. 54), for example, pointed out that there is no published description of the lithostratigraphy of the 'London Clay' and, nowadays, little of the 35 m originally exposed remains visible. Other parts of the sequence have however received greater attention, particularly the Lambeth Group (formerly the Woolwich and Reading Formation). In a broad study of the facies distribution of the latter, Ellison (1983) considered that of six major lithofacies, the 'Glauconitic sand' was best represented in the Herne Bay section. These sediments are the 'Bottom Bed' of Hester (1965), now the Upnor Formation, and were thought by Ellison (1983) to represent a littoral deposit in a barrier sand complex.

Detrital mineralogy

Mineralogical work on the section has been concerned with the glauconites (see earlier and also later discussion), sediment provenance and a search for evidence of contemporary ash falls. Amongst provenance studies were those of Blondeau and Pomerol (1962, 1968) and Weir and Catt (1969). The source of the Thanet Beds according to these workers was a garnet-epidote-amphibole terrain, and a northerly, Scottish Highland source seems possible (Morton, 1982a, p. 268).

Vertical mineralogical variation of the Thanet Sand Formation, reported by Blondeau and Pomerol (1968) (diminishing-upwards proportions of such minerals as epidote, sphene, etc.), was interpreted by Morton (1982a) as evidence for pre Woolwich and Reading Formation weath ering of the Thanet Beds. These minerals and others which he records as diminishing upwards (garnet, apatite, hornblende) are moderately to strongly etched towards the top of the Thanet sequence, the product, in his view, of a response to acidic groundwater circulation.

The mineralogy of the succeeding strata at Herne Bay is broadly similar to that of the Thanet Sand Formation. Weir and Catt (1969) stated that 'The mineral composition of the marine Woolwich Beds at Bishopstone Point is exactly the same as that of the underlying Thanet Beds'. However, from samples taken elsewhere, Morton (1982b) found that the Woolwich Bottom Bed has a mineralogy indicative of an Armorican or Ardennes–Rhenish massif source, unlike the remainder of the succession both stratigraphically above and below.

Contemporary vulcanism

The Herne Bay section has made an important contribution to our knowledge of early Palaeogene volcanic activity. At one time, the Herne Bay section was considered to contain no evidence of contemporaneous volcanic events. Knox and Harland (1979) found no trace of ash in the Woolwich and Reading Beds or the Oldhaven Beds, whilst Knox and Ellison (1979) found none in the 'London Clay'. Material from unweathered foreshore sections, however, subsequently enabled Knox (1983) to recognize well-preserved volcanic grains from the Oldhaven Beds, albeit comprising a small proportion (1–5%) of the sand fraction. This discovery was to have considerable stratigraphical significance (see next section).

Interpretation and evaluation

The Herne Bay section provides us with particular insight into the early Palaeogene history of south-eastern England. It comprises the best record of the upper part of the Thanet Sand Formation, 'Woolwich Beds' (now the Upnor Formation) which contrast markedly with much of the Lambeth Group sequence further west, and evidence from the Oldhaven Beds that clarifies stratigraphical relationships of the early Thames Group strata.

Comparison with other localities

The Thanet Sand Formation is best developed and thickest in north-eastern Kent (see isopachyte map in Hester, 1965). By contrast, the Woolwich and Reading Formation (the Lambeth Group) is thin in this area. Ellison (1983, p. 312) referred to a 5 m thickness compared to around 30 m near Chertsey and 20 m as a general rule elsewhere. The significance of the thin 'Woolwich Beds' sequence in Herne Bay is that it represents the remnant of a once thicker succession, which, in the eastern part of the London Basin, was uplifted and eroded prior to the deposition of the Thames Group. In the London Basin, the Oldhaven Beds is virtually confined to northern Kent and south Essex, and Herne Bay provides the only complete extant section. At one time regarded as older than the Harwich Member of the 'London Clay', it is now, on the basis of evidence from Herne Bay (see later discussion), thought to be its lateral equivalent (Ellison *et al.,* 1994).

Palaeoclimatology

There seems little doubt that the rich fossil assemblages at certain horizons will continue to make Herne Bay attractive to palaeontologists. That the section includes fossiliferous Thanet Beds renders it particularly interesting palaeoenvironmentally and palaeogeographically, albeit that the evidence is somewhat equivocal particularly regarding climatic implications. Gardner's (1878) view that the Thanet Beds represent a temperate climate was 'regarded with suspicion' by Chandler (1964), although Haynes (1956–1958) concluded from his work that the sea in which this formation accumulated was shallow and cool. Wrigley (1949) found both cold water (e.g. *Arctica*) and warm water elements in the molluscan fauna, but concluded that the indications 'point to a subtropical rather than a temperate or boreal climate'. This is compatible with White's (1931) reference to the occurrence of subtropical and tropical fish in these strata and Curry's (1965a) mention of calcareous algae in the highest Thanet Beds near Bishopstone Glen. Such apparent palaeoecological dissonance remains an interesting aspect of the section.

Chronostratigraphy

Herne Bay is significant internationally as the co-chronostratotype for the Thanetian Stage (Pomerol, 1982b). Its value is reiterated by Siesser *et al.* (1987) in their statement that 'Any correlation of rock sequences from elsewhere in the world to the Thanetian Stage depends on an accurate knowledge of the biozonation of the Thanetian stratotype and reference sections'. In a paper that contains an excellent and comprehensive discussion of the concept, history and usage of the

Thanetian (and the Thanetien), these authors (p. 95) give the Thanet Formation, the Woolwich Bottom Bed and the Oldhaven Beds as the lithostratigraphical units comprising the Thanetian Stage in the type area. They further point out that since the youngest Thanet Formation strata here date as NP8 and the other two units are barren of nannofossils, Zone NP9 which is included in the Thanetian Stage elsewhere is not therefore proven to be present in the chronostratotype locality. Gamble (1983), in an earlier discussion of the Thanetian chronostratotype, pointed out that in fact the stratotype 'spans the smallest proportion of its intended chronostratigraphical time division application among all the eight principal (Palaeogene) stages' and suggests that 'either the Selandian or Landenian Stages more closely approximate to the ideal for a single late Palaeocene Stage division'.

The occurrence of glauconite at various horizons in Herne Bay led to its use for absolute age dating. Indeed, Fitch *et al.* (1978b) suggested that since the Thanet Formation was neither deeply buried nor more than gently warped, its glauconites should provide ideal samples for dating by the K–Ar method. Many workers followed Everden *et al.* (1961) in attempting to date the Thanet Beds and other horizons in Herne Bay, but with a considerable scatter of results (see Odin *et al.,* 1978, p. 489). The glauconite dating method in general is now much better understood and the techniques considerably refined (Fitch *et al.,* 1978a; Odin *et al.,* 1978), with material from Herne Bay making a considerable contribution to this end.

Palaeogeography

Whilst no detailed sedimentological study has been published on the section, aspects of the lithostratigraphy (e.g. Ellison, 1983; Ellison *et al.,* 1994) together with mineralogical and palaeomagnetic research have contributed greatly to our understanding of early Palaeogene correlation and palaeogeography. Morton's (1982a) findings (see earlier) regarding the provenance and contemporaneous weathering of the Thanet Sand Formation is an example.

The difference between the nature and thickness of the Woolwich and Reading Formation here and elsewhere at more western localities has attracted attention over many years. The fact that at Herne Bay the formation was a glauconite sand led early workers to conclude that, in the east Kent area, the whole of the Woolwich and Reading Formation was of marine origin. However, work by such authors as Hester (1965) and Ellison (1983) confirmed a view that it represents the 'Bottom Bed' of the formation, elsewhere comprising a transgressive sand sheet extending as far west as Dorset. The thinness of the glauconitic sands in Herne Bay simply reflects pre-Oldhaven Beds uplift and erosion. Ellison (1983, fig. 3) implied that they were originally thicker and succeeded in this area by other facies, possibly including lagoonal deposits. However, he also pointed out (p. 312) that the glauconitic sands reach 10 to 15 m in the east of the London Basin and suggested that this thicker occurrence represents a barrier sand complex to the west of which lagoonal 'Woolwich Beds' developed.

Solving the 'Oldhaven' problem

The stratigraphical affinities of the Oldhaven Beds were established by two separate yet complementary pieces of research on the Herne Bay section: one on its mineralogy and the other on its palaeomagnetic attributes. King (1981) regarded his Oldhaven Formation (Herne Bay Member) as older than his Harwich Member, which forms the base of the 'London Clay' elsewhere, partly on the basis of faunal differences. Knox and Harland (1979) concurred with this, since in the 'Oldhaven Formation', they found none of the volcanic ash present throughout the Harwich Member. However, volcanic material later found in the Oldhaven Beds of Herne Bay is closely comparable to that of the Harwich Member in comprising both partly glauconitized and unaltered volcanic grains (Knox, 1983).

The conclusion arising from such mineralogical work has facilitated the interpretation of palaeomagnetic data derived from the site. Townsend and Hailwood (1985) recognized strata with normal polarity both in all but the lowest Oldhaven Formation of Herne Bay and in the upper part of the Harwich Member at Wrabness and Harwich to the north. Both occurrences were confidently assigned to the Oldhaven Magnetozone, which would probably not have been the case had the Herne Bay succession been devoid of volcanic material. These complementary studies indicated that the Oldhaven Formation here is a lateral correlative of the earliest 'London Clay' to the north, now formally designated the Harwich Formation (Ellison *et al.,* 1994). It represents not a separate sedimentary cycle but a nearshore facies of the initial 'London Clay' transgression and is the equivalent in time to the 'Ash Marker' of the Balder Formation in the North Sea.

The variations in fauna between the Oldhaven Formation and the 'London Clay' referred to by King (1981) are consequently now interpreted as a reflection of differences in facies (Knox *et al.,* 1983). Recent doubts cast on the reliability of the Oldhaven Magnetozone do not detract from the above, since other evidence remains uncompromisd by such a view.

Conclusions

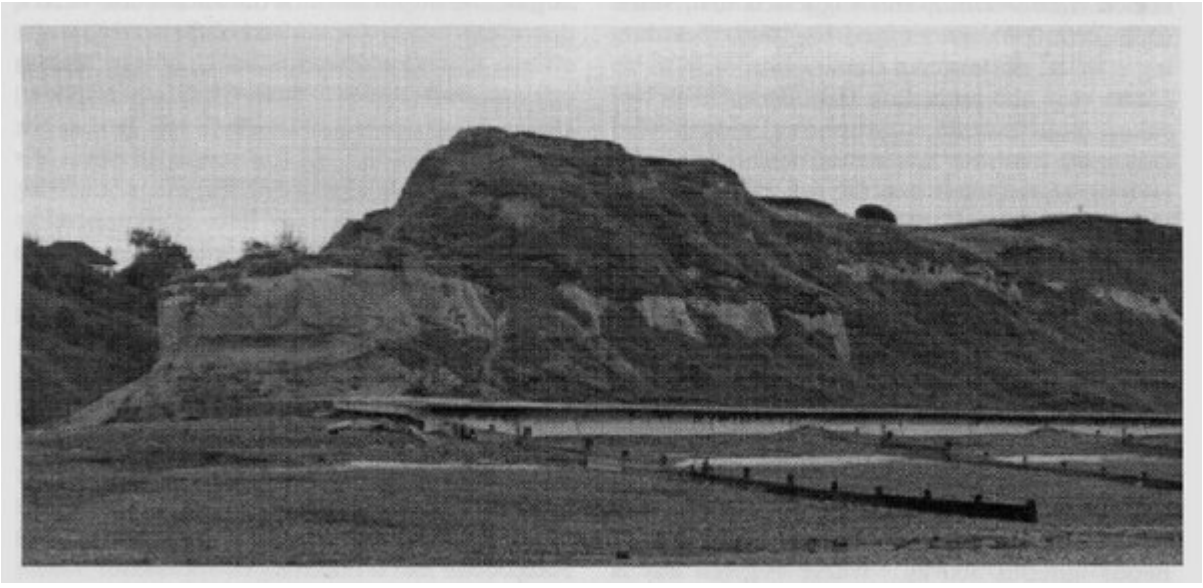
Herne Bay is stratigraphically the major Palaeogene site in the London Basin. Furthermore, it is the most important Palaeocene site of the British onshore succession, since both the Thanet Sand Formation and the Lambeth Group are exposed here.

The site is lithostratigraphically, chronostratigraphically and magnetostratigraphically significant, in that it provides the type sections for the Thanet Sand Formation, the internationally important Thanetian Stage and the Oldhaven Magnetozone.

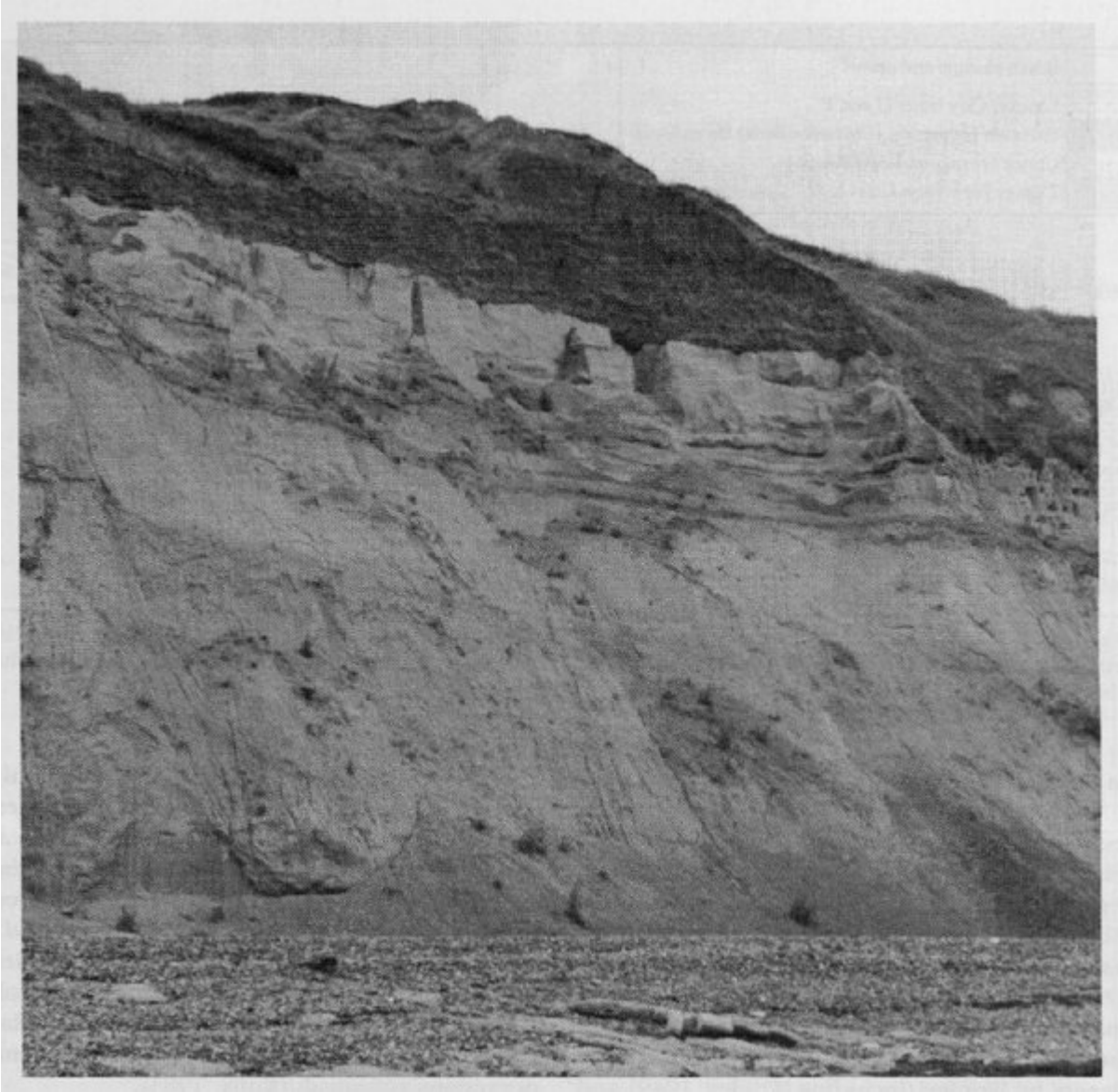
The site provides insights into a number of aspects of Palaeogene history and palaeoenvironments. A considerable contribution to our understanding of Thanetian times in southern England comes from this locality and that in Pegwell Bay. The Upnor Formation of the Lambeth Group is well developed here and the thinness of the formation as a whole is testament to a period of uplift and erosion leading to an unconformable relationship with the overlying Thames Group. Mineralogical and palaeomagnetic work on the Herne Bay succession has established that the Oldhaven Beds represent a nearshore facies equivalent to the offshore former Harwich Member elsewhere. Furthermore, since it contains similar volcanic material to the latter, it has been correlated with the 'Ash Marker' of the North Sea succession.

Palaeontologically, the site continues to maintain the significance which became apparent early in the 19th century, with various horizons such as the C. *regulbiensis* Bed, having more prolific faunas in their Herne Bay development than elsewhere. Recent years have seen the considerable amount of micropalaeontological work on the section contribute to establishing a sound correlation of Palaeogene strata both locally and beyond the British area.

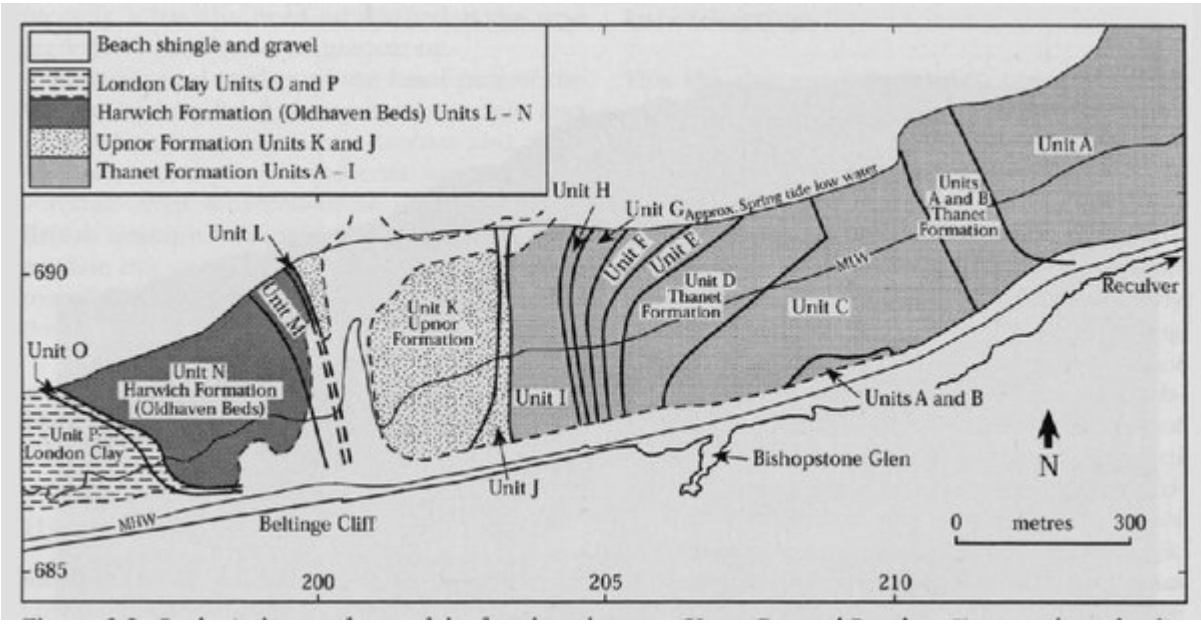
References



(Figure 3.7) Herne Bay, Kent. General view of the cliff section to the west of Bishopstone Glen (extreme left of photograph). At the seaward end of the glen, the Upnor Formation (near vertical formation) rests on the Thanet Formation. Above, the partly vegetated Oldhaven Beds (Harwich Formation) extend westwards to Beltinge Cliff where they are succeeded by the darker-coloured London Clay. (Photograph: courtesy of D.J. Ward.)

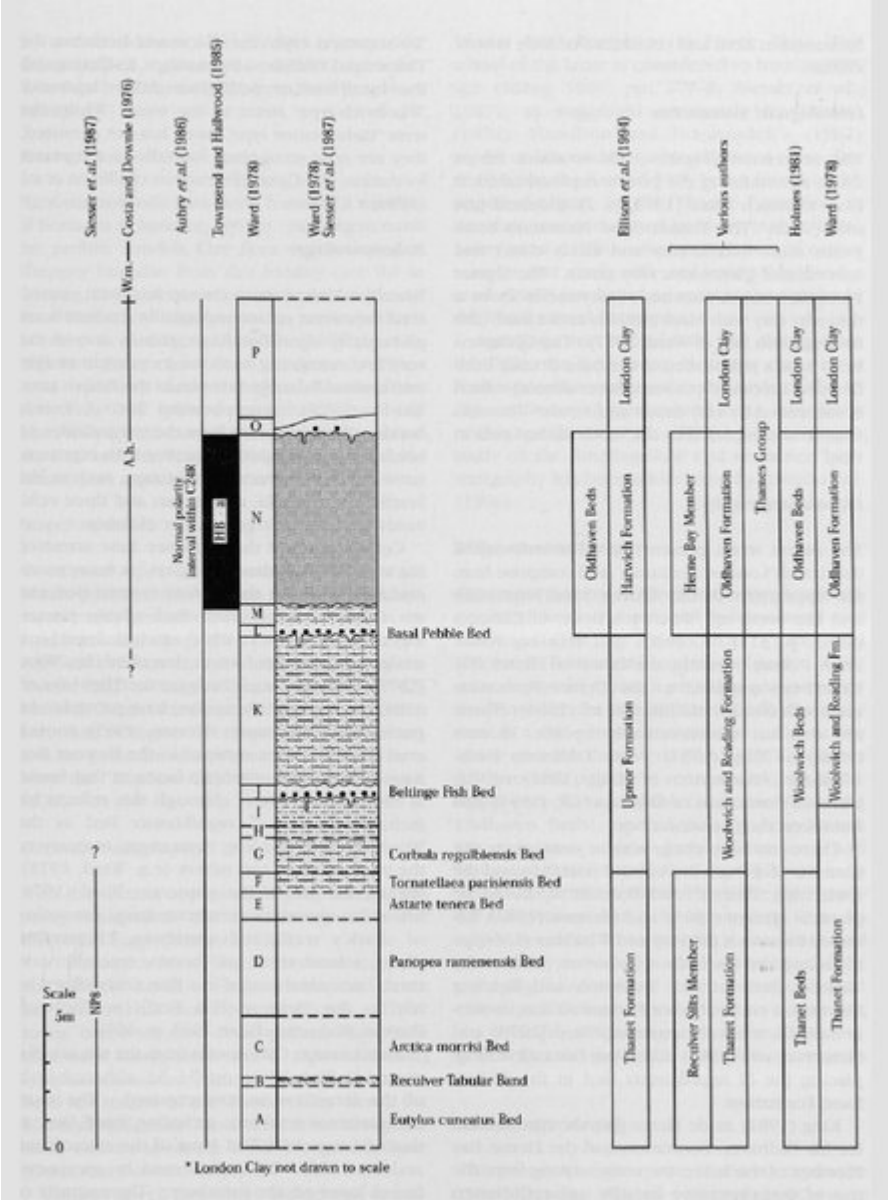


(Figure 3.8) Herne Bay, Kent. The section below the Coastguard Station, where the Thanet and Upnor Formations (difficult to distinguish on this photograph) are overlain by the more obviously bedded Oldhaven Beds (Harwich Formation) and the darker London Clay above. (Photograph: courtesy of D.J. Ward.)



(Figure 3.9) Geological map of part of the foreshore between Herne Bay and Reculver, Kent, to show the distribution of units within the Thanet Formation, Upnor Formation, Harwich Formation (Oldhaven Beds) and the London Clay (after

Ward, 1978, fig. 2).



(Figure 3.10) Lithostratigraphical, biostratigraphical and magnetostratigraphical succession of the Thanet Formation to London Clay at Herne Bay, Kent (after Ward, 1978, fig. 1; Siesser et al., 1987, fig. 5, and other authors).