Pegwell Bay, Kent

[TR 350 642]–[TR 355 644]

Highlights

The succession present in the cliffs of Pegwell Bay comprises the oldest part of the Palaeogene succession exposed at outcrop in south-eastern England. It is essentially Upper Palaeocene in age and is one of the two type sections for the Thanet Sand Formation.

Introduction

Although older Palaeocene sediments are present in Norfolk, the oldest to occur at outcrop are those of Pegwell Bay ((Figure 3.4); see Cox *et al.,* 1985; Knox *et al.,* 1990; Jolley, 1992). Hence, as the site where the oldest exposure of Palaeogene rocks in Britain occurs, the importance of Pegwell Bay is indisputable. Formerly, a single continuous section existed on the northern side of Pegwell Bay (see Shepard-Thorn, 1988, plate 7). This was truncated in the 1970s by an access road to the newly developed Ramsgate International Hoverport, leaving two smaller sections, the easterly of which has been called the 'Cliffs End Section' [TR 355 644] and the westerly the 'Car Park Section' [TR 350 642] by Ward (1977). At the former, some 7.5 m of the Thanet Formation rests unconformably on the Upper Cretaceous Chalk, whilst at the latter, a few metres of the upper part of the Formation occur below a drift cover.

The section of Palaeogene sediments in Pegwell Bay has interested geologists since the middle of the 19th century when it was first described by Prestwich (1852). He was the first to use the term Thanet Sands for these sediments, although subsequently, Whitaker (1866, 1872) considered the term Thanet Beds more appropriate to a unit comprising a variety of lithologies, as for example here at Pegwell Bay where muds, silts and sands overlie the basal rudaceous Bullhead Bed.

Other early accounts were given by Gardner (1883), Burrows and Holland (1897), whose paper on the foraminifera of the Thanet Beds included a detailed measured section, and White (1928), who gave an excellent account of the succession and its fauna. After the hoverport was built, the section was re-described by Ward (1977) who summarized earlier work on the section, including the stratigraphical subdivision and nomenclature of earlier authors.

The latter part of the 20th century has witnessed the development of a renewed interest in the micropalaeontology of this site. The foraminifera were studied by Haynes (1955, 1956–1958) and included those reworked from older strata (Haynes and El-Naggar, 1964). The section was sampled by Downie *et al.* (1971) and later by Powell *et al.* (1996) as part of broader studies of dinoflagellate associations in southeastern England, whilst a number of workers have investigated it for calcareous nannoplankton, particularly from a chronostratigraphical point of view (Hamilton and Hojjatzadeh, 1982; Aubry, 1983, 1986; Godfrey and Lord, 1984; Aubry *et al.,* 1986; Siesser *et al.,* 1987). Other palaeontological work includes that of Stinton (1965a), as part of his broader investigation of the 'Lower London Tertiaries', whilst a list and distribution of the macrofauna was given by Ward (1977).

A need to date the oldest of the exposed onshore Palaeogene rocks in south-eastern England led to their radiometric dating, using glauconites from this section (Fitch *et al.,* 1978a, b) and the attention of the magnetostratigraphers and their micropalaeontogical collaborators (Townsend and Hailwood, 1985; Aubry *et al.,* 1986). Other work includes mineralogical studies, including those aspects associated with the determination of possible contemporaneous volcanic activity (Blondeau and Pomerol, 1968; Brown *et al.,* 1969; Weir and Catt, 1969; Knox, 1979; Shepard-Thorn, 1988).

This site was also independently selected for its fossil fishes (Dineley and Metcalf, 1999) and its Quaternary stratigraphy content, a more detailed account of which will be discussed in a future GCR volume.

Description

At Pegwell Bay (Figure 3.5), the Thanet Sand Formation rests unconformably on Upper Santonian Chalk of the *Marsupites testudinarius* Zone (Pitcher, 1958), with the famous Bullhead Bed, comprising unworn, green-coated (by glauconite) flints, at the base (Ward, 1977, fig. 5).

Lithological succession

The Thanet Sand Formation (Figure 3.6) is some 24 m thick in Pegwell Bay and, according to Ward (1977), mainly comprises clays, marls and silts, except immediately above the base, where 0.75 m of glauconitic silty sand overlies the pebbly Bullhead Bed.

Dating and correlation

The succession at Pegwell Bay is older than that of the Thanet Sand Formation at Herne Bay. Townsend and Hailwood (1985), following Ward (1978), concluded that an earlier view that there was an overlap of strata between the two sections might not be the case (see later discussion). There is little doubt that a greater part of the Pegwell succession is older. The latter, in particular, has attracted the attention of geologists, since the section provides the opportunity to determine conditions at the time when the Palaeogene sea first began to transgress this part of the south-eastern British area. Dating the succession palaeontologically has not been without difficulty, since the lowest part of the succession contains no fossils suitable for this purpose. Haynes (1956), however, recognized four foraminiferal faunules from the middle and upper strata here and concluded from pelagic foraminiferids found at Reculver [TR 224 693] that the succession was Upper Palaeocene in age (Haynes, 1955, p. 189). He doubted the value of the term Thanetian, suggesting that the Thanet Beds were deposited in the first half of the Landenian cycle and should be referred to the Lower Landenian Substage (lower Upper Palaeocene) (see also further discussions of the Thanetian in the account of Bishopstone Cliffs, Herne Bay).

Aubry (1986) found only reworked Cretaceous nannoplankton at Pegwell Bay. However, towards the top of the section in the Reculver Silts, both Hamilton and Hojjadzadeh (1982) and Godfrey (1984) found *Heliolithus riedeli,* whose first occurrence defines the base of calcareous nannoplankton Zone NP8. Prior to the investigations of Siesser *et al.* (1987), no indigenous nannoplankton had been found below this level, but these authors obtained the latter from a 4 cm band near the top of the Stourmouth Clays Member (almost certainly from the 'Crepidula Band' at the base of the Pegwell Marls, according to D.J. Ward, pers. comm.) and from their findings determined an NP6/7 date. Apart from this occurrence, no other indigenous nannoplankton have been found here below the Reculver Silts. More recently, comparisons with richer and better preserved material from coeval strata in the Bradwell (Essex) borehole led Knox *et al.* (1994) to conclude that the basal part of the succession at Pegwell lies within the upper part of NP6.

Pegwell Bay has also provided an opportunity for dating these oldest exposed Palaeogene strata of Britain by other techniques. Using glauconites from the 'basal' Thanet Beds of Pegwell, Fitch *et al.* (1978a) obtained an age of 59.5 ± 0.9 Ma. Townsend and Hailwood (1985) found that all samples from the Thanet Sand Formation in Pegwell Bay have a normal polarity magnetization and from this evidence established the Thanet magnetozone. Subsequently, with Aubry (Aubry *et al.,* 1986), they concluded that this normal polarity magnetozone may be correlated with zones NP6–NP7 and Chron 26N. Knox *et al.* (1994) believed that the base of the succession lies somewhere within the lower part of the latter.

Local hinterland

Derived fossils are not without their uses and their occurrence in the strata at Pegwell Bay has provided some insight into the nature of the hinterland at the beginning of Palaeogene times. Haynes and El-Naggar (1964) found that the microfauna of the Bullhead Bed was entirely silicified and derived from the Campanian Chalk with no derived material from the Danian. More recently, Siesser *et al.* (1987) found the nannoplankton species *Biantholithus sparsus* in a number of samples from this locality. Since this species is thought to have become extinct in Zone NP4, derivation from earlier, but locally non-surviving, Palaeocene strata is implied.

Recent work by Powell *et al.* (1996) recognized the presence of two dinoflagellate cyst 'sequences' in the Pegwell Bay section, from which they concluded that the Reculver Silts lie unconformably on the Pegwell Marls.

Contemporary vulcanism

A number of mineralogical studies of Pegwell Bay material have provided information on contemporary volcanic events. The lowest Thanet Beds here contain euhedral, and hence non-detrital, crystals of the zeolite mineral clinoptilolite, a mineral often formed by the alteration of glassy and other volcanic minerals (Brown *et al.,* 1969; Weir and Catt, 1969). In a later study, Knox (1979) identified igneous grains in association with these zeolites at this locality and concluded that both had originated from contemporary ash falls comparable in age to tuffs from the North Sea and to the main phase of Hebridean vulcanism. The 45–65% of smectite (Ca-montmorillonite) reported by Wheatley (in Shepard-Thorn, 1988) from the Basal Thanet Beds is compatible with this suggestion (cf. discussion in Gilkes, 1968).

Interpretation and evaluation

The exposures of the Thanet Sand Formation on the northern side of Pegwell Bay are of considerable significance. The section here provides the earliest onshore evidence of the beginnings of the long period of elastic sedimentation in southern England extending from Palaeocene to at least Oligocene times. Moreover, Pegwell Bay exposes part of the first of the many transgressive units that characterize the Palaeogene succession of southern England.

The Thanet Sands Formation may be seen elsewhere, such as Herne Bay and Lower Upnor, but at neither of these localities are the lower beds and the unconformable contact with the underlying Chalk exposed. Both Ward (1977) and Shepard-Thorn (1988) referred to Pegwell Bay as the type locality, although, as the former author pointed out, it can only be inferred that it is the original type section for the Thanet Sands since Prestwich (1852) did not overtly cite it as such.

Dating the succession

Determining the age of the Pegwell Bay section is very important regarding an interpretation of British Palaeogene history, since it includes the oldest Palaeocene exposed at outcrop of the British 'onshore' succession. The precise age of the formation, particularly its lower part, was for some time disputed (see discussion in Aubry *et al.,* 1986), but moved closer to resolution following the work of Siesser *et al.* (1987) and was recently resolved by Knox *et al.* (1994). There is now no doubt that the upper part of the succession at Pegwell Bay is entirely of NP8 age, since the suggestion by Godfrey and Lord (1984) that NP9 was present at the top of the sequence here was based on their incorrectly identifying a single specimen of *Heliolithus* as the NP9 zone fossil *Discoaster multiradiatus* (Siesser *et al.,* 1987, p. 95). However, the fossil composition of the lower 4 cm nannoplankton band of the latter authors was ambiguous. The problem was that whilst this band has nannoplankton indicative of NP6, they were unable to find any trace of *Discoaster mohleri,* the species whose first occurrence indicates NP7. Their conclusion was that this band was either in NP6 or was in NP7 with *D. mohleri* absent for environmental or diagenetic reasons. In fact, Siesser *et al.* (1987) concluded that they would choose 'to make a conservative assignment' of this horizon to NP6/7, since their material did not enable them to resolve the matter further. These authors suggested that at least the lowermost 4.2 m of the succession be similarly assigned.

In a subsequent paper on Thanetian and early Ypresian chronostratigraphy, Knox (1990) proposed that the basal 8 m of the formation at Pegwell be assigned to NP6/7 whilst preferring an NP7 age with the second of Siesser *et al.'s* (1987) alternatives above invoked to explain the absence of the characteristic zone fossil. Only more recently has the age been confirmed as NP6 by Knox *et al.* (1994) (see above).

Origin and age of the Bullhead Bed

The Bullhead Bed at the base of the succession has generated a great deal of discussion over many years. Although Gardner (1883), Boswell (1917) and Wooldridge (in Dewey *et al.,* 1925) considered it a basal conglomerate, it is not in the conventional sense of this term. It does not comprise the round, and hence transported, often black, flints that characterize most of the pebble beds in the remainder of the Palaeogene of south-eastern England, but instead consists of flints that are green-coloured and unabraded.

Such features have caused a great deal of speculation over its origin (see discussion in Smart *et al.,* 1966, p. 177). Hughes (1866) held the view that it was formed by solution of the Chalk after the deposition of the Thanet Beds. Dowker

(1864) believed the flints of the Bullhead Bed resulted from the subaerial solution of the Chalk prior to the deposition of the Thanet Beds and, later, Wrigley (1949) and Haynes (1958, p. 87) expressed similar opinions. Wrigley regarded it 'as a gentle redisposition, by an advancing sea, of clay-with-flints which had accumulated on a long exposed land surface'. Weir and Catt (1969, p. 29) found material in the matrix of the Bullhead Bed that was possibly derived from the dissolution of the immediately subjacent Chalk, but also detrital material introduced from elsewhere. Later, Knox (1979) found igneous grains in this matrix which he considered originated in ash falls of Thanetian age. The significance of a detrital component of the matrix is however complicated by the possibility of downward infiltration of granular material from above or the 'piping down' of the latter by burrowers such as those referred to by Knox (1979).

On balance, the Bullhead Bed appears to be a Chalk residuum that was altered and supplemented in a low-energy marine environment. Detritals, including igneous grains, were introduced and there may have been minimal reworking at the same time or prior to a period of glauconitization that stained the flints and altered some of the detrital, including igneous, grains. Precisely when the process started is not clear. A lack of Danian microfossils led Haynes and El-Naggar (1964) to suggest that land might have existed here from the Maastrichtian to the Danian and the residuum could have started to form as early as this. No contemporaneous microfauna occurs in the Bullhead Bed to determine when the submarine phase of the Bullhead Bed development occurred, though glauconites from 'the Thanet base bed at Pegwell Bay' (Fitch *et al.,* 1978a, p. 10) indicate a 59.5 ± 9 Ma age.

Comparison with the section at Herne Bay

From stratigraphical evidence alone, it is clear that most, if not all, of the Thanet Sand Formation section here is older than that at Herne Bay. Ward (1978) referred to a lithological resemblance between the uppermost part of the Pegwell Bay succession and his unit A (*Eutylus* Bed) at Herne Bay but conceded that there were also differences. His conclusion that there is no overlap has been supported by recent magnetostratigraphical work by Townsend and Hailwood (1985) who found that samples from the main 'Cliff End Section' at Pegwell Bay gave normal polarity magnetization (on which they established the Thanet magnetozone) whilst samples from the Thanet Beds in Herne Bay all show reverse polarity. As these authors point out, future sampling of the youngest beds at Pegwell Bay (in the 'Car Park Section') and the oldest beds at Herne Bay may allow the polarity transition between the two magnetozones to be located. Knox *et al.* (1994, fig. 4) in fact show the uppermost part of the Pegwell Bay section as having reverse polarity. Recent dinoflagellate work by Powell *et al.* (1996) supports the view that there is no overlap of the Thanet Sand Formation of Pegwell Bay with that in Herne Bay.

Palaeoclimatology

The fossils from Pegwell Bay represent the earliest marine transgression in this area in Palaeogene times. Ward's (1977) faunal list includes invertebrates and vertebrates (fish), with the most diverse faunas obtained from the Reculver Silts. What is particularly interesting about the fauna is that it provides an insight into the climate of the times. Haynes and El-Naggar (1964) noticed the absence of certain foraminiferids, for example the typically tropical, keeled *Globorotalia,* and suggested that, since such forms only penetrated high latitudes during climatic optima, the climate was likely to be cooler than the preceding Dano-Montian or the succeeding Eocene. Stinton (1965a), who described five new species of otolith from the section, commented that the fish fauna implied that the local Thanetian Sea was at least temperate if not definitely boreal. Such conclusions support the view that world climates in the Palaeogene were relatively cool (cf. Axelrod and Bailey, 1969).

Contemporaneous vulcanism

The mineralogy of the lower part of the Pegwell Bay succession has turned out to be palaeogeographically significant in indicating contemporaneous igneous activity. Where Pegwell Bay is particularly important is that it shows that pyroclastic events occurred in south-eastern England prior to 'London Clay' times (Elliot, 1971a; Knox and Ellison, 1979) and before the deposition of the ash-bearing Herne Bay Member of King's (1981) Oldhaven Formation (now the Harwich Formation) in Herne Bay (Aubry *et al.,* 1986, p. 731). That ash falls occurred whilst the Thanet Sands were accumulating is also supported by the work of Morton (1982b), who recognized euhedral (and hence non-detrital) grains of the igneous minerals aegirine, arfvedsonite and apatite from, in particular, the offshore borehole 79/7A. The Pegwell Bay volcanic

material is most closely correlatable with the earlier of the two pyroclastic phases that are represented in the North Sea Basin (Knox and Morton, 1988). However, Knox (1984) referred to this earlier phase as probably spanning the interval from late Zone NP8 into early Zone NP9. From earlier discussion of the age of the Thanet Beds in Pegwell Bay, it seems likely that this Pegwell material represents an even earlier pyroclastic phase. Such an earlier phase is indicated by a tuff band in the North Sea referred to by Fitch *et al.* (1978a, fig. 9).

Conclusions

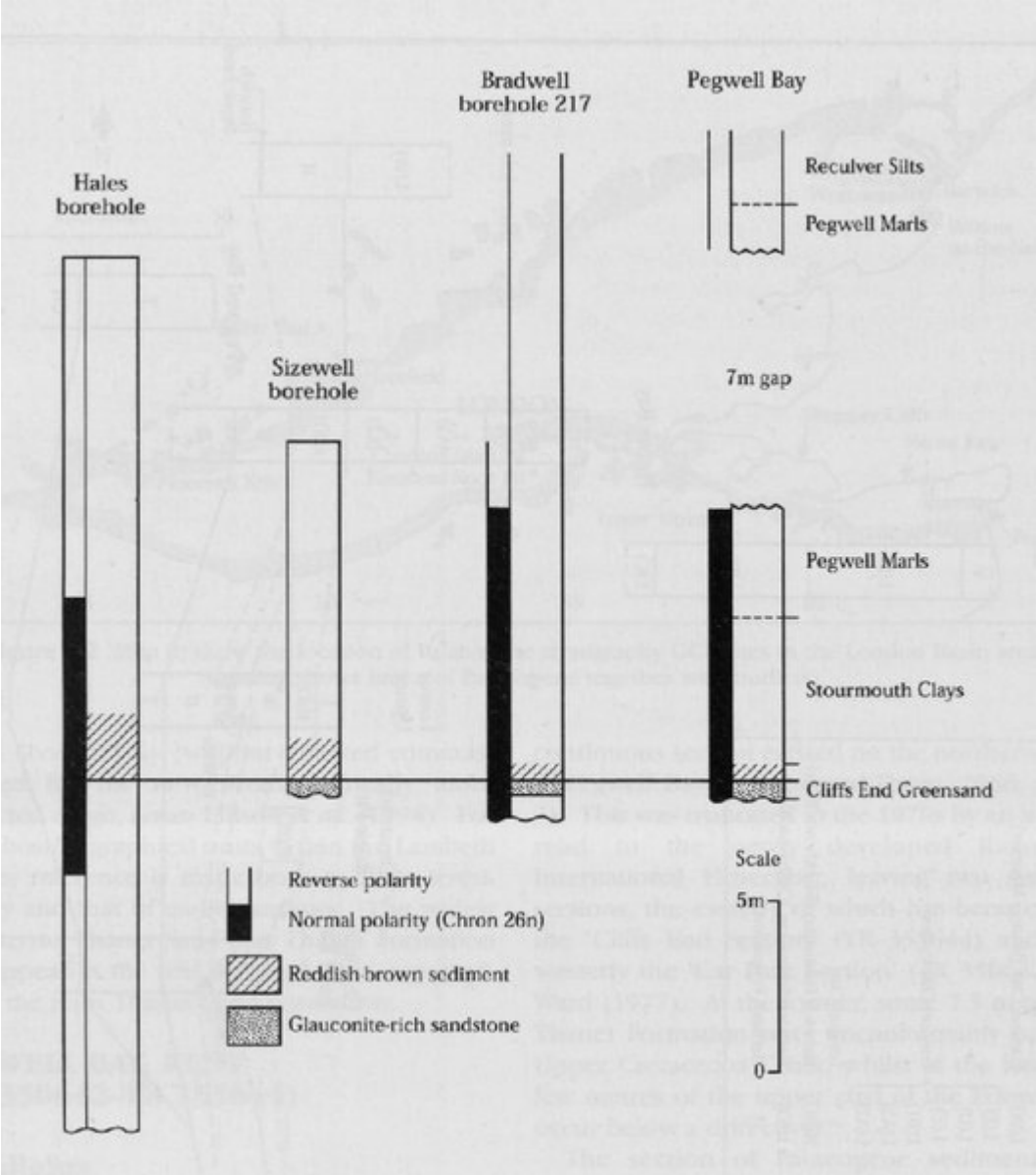
Pegwell Bay has attracted geologists since the middle 19th century, not surprisingly, since it comprises the oldest part of the Palaeogene exposed at outcrop in south-eastern England. Although somewhat older Palaeogene sediments are now known from boreholes in eastern East Anglia, the importance of the succession here is that it represents the earliest of the transgressive events that characterize much of the British onshore Palaeogene. Whilst it is essentially of Upper Palaeocene age, the Bullhead Bed at the base may be older. As it consists, in part, of a residual deposit derived from the underlying Chalk, its formation may have commenced in earlier Palaeogene or even late Cretaceous times.

Whilst the lower part of the succession is poorly fossiliferous, aspects of the palaeontology have shed some light on both contemporary and earlier geography. Derived fossils from the Chalk suggest the possibility that land may have existed in the area in Maastrichtian and Danian times, whilst the nature of the foraminiferal and otolith assemblages supports the view that the Palaeocene had a relatively cool climate.

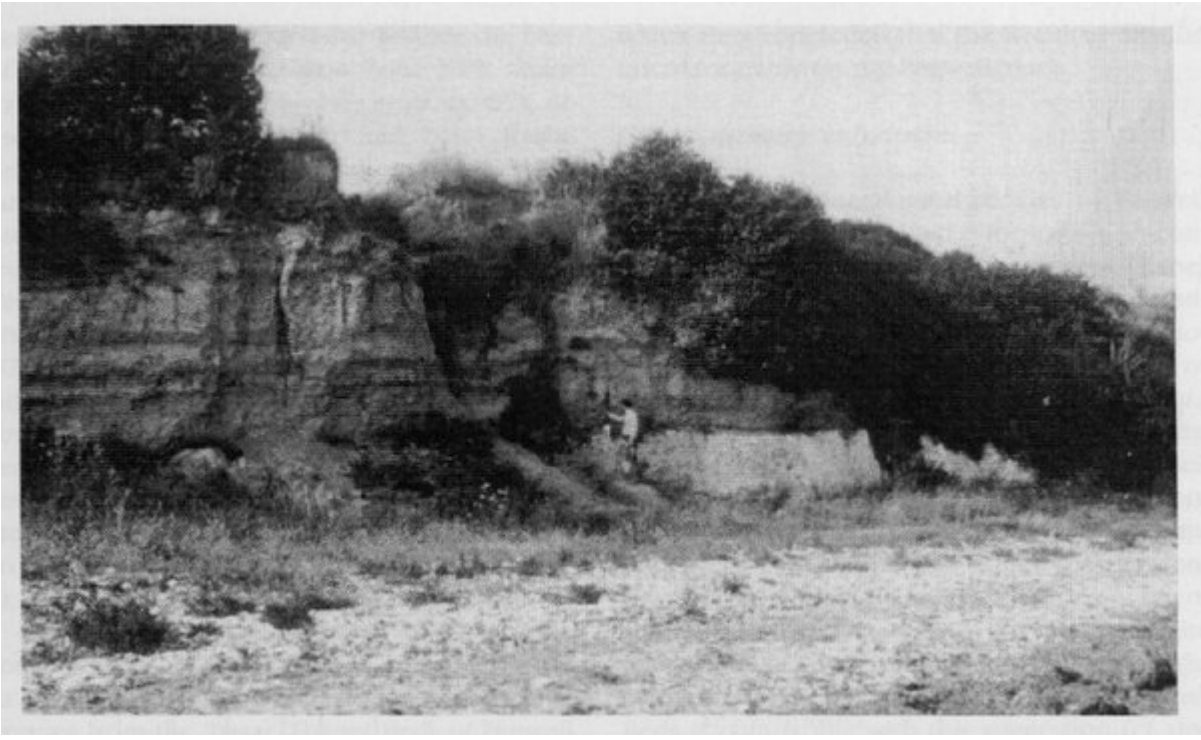
The stratigraphical importance of the section at Pegwell Bay is recognized in its being one of the two type sections for the Thanet Sand Formation and for the Thanetian Stage. More recently, it has also been established as the type section for the Thanet magnetozone.

Mineralogical studies of the basal part of the succession here have given a useful insight into early Palaeogene vulcanism. Zeolites and other minerals found provide evidence for the oldest volcanic event recorded in an exposure of the British onshore Palaeogene and one which may predate the earliest of the two major phases of pyroclastic activity represented in the North Sea Basin.

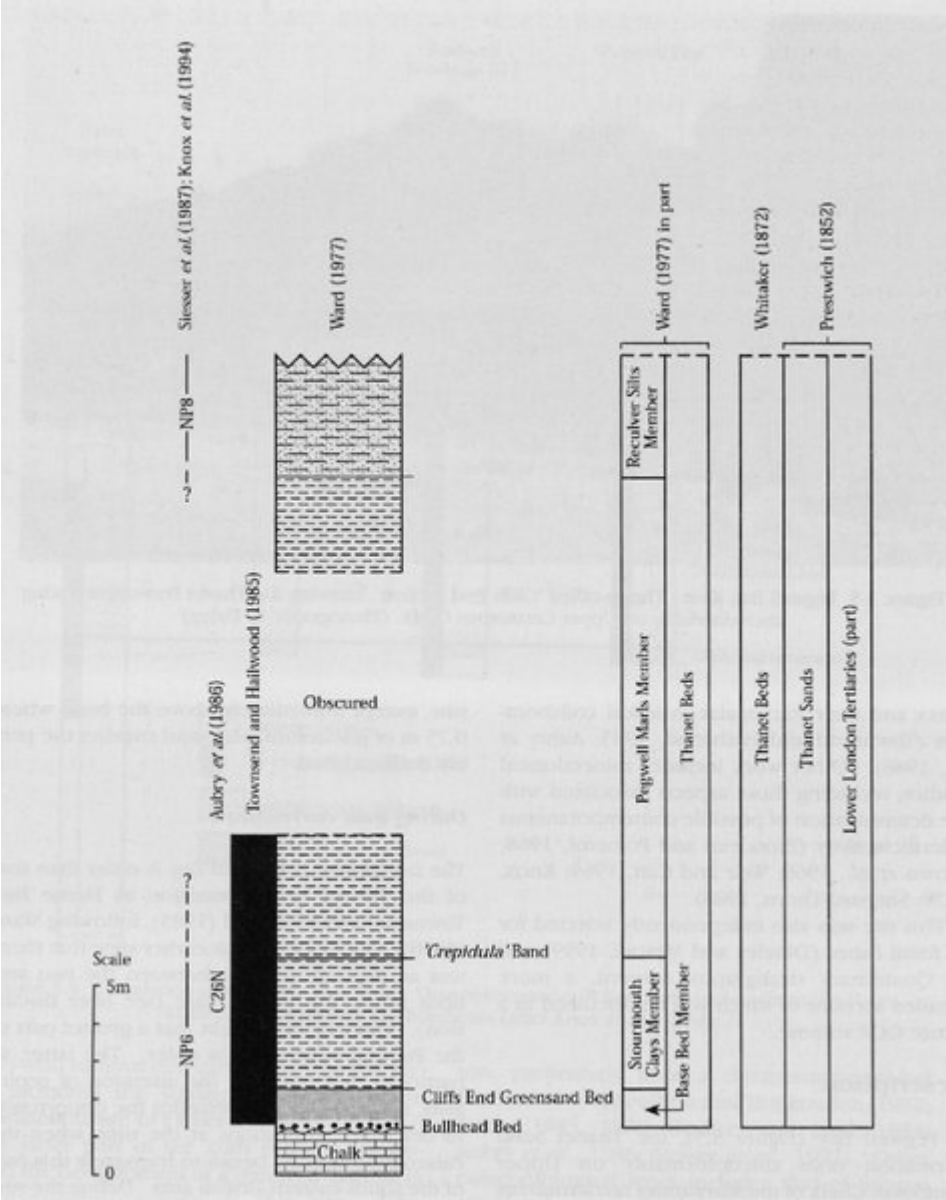
References



(Figure 3.4) Correlation of the lower part of the Thanet Formation in Kent with sediments in the Hales, Sizewell and Bradwell 217 boreholes (after Knox et al., 1994).



(Figure 3.5) Pegwell Bay, Kent. The so-called 'Cliffs End Section', showing the Thanet Formation resting unconformably on Upper Cretaceous Chalk. (Photograph: B. Daley.)



(Figure 3.6) Lithostratigraphical, biostratigraphical and magnetostratigraphical succession of the Thanet Formation at Pegwell Bay, Kent (after Ward, 1977 and other authors).