Wittering to Selsey foreshore, West Sussex

[SZ 765 984]–[SZ 845 926]

Highlights

Although comprising intermittently exhumed foreshore exposures, this site is important since it represents the greatest degree of marineness within the Bracklesham Group of the Hampshire Basin. It has a rich macrofauna and microfauna which have enhanced correlation both locally and in an international context.

Introduction

Along the foreshore of Bracklesham Bay, from the entrance to Chichester Harbour immediately west of West Wittering (grid reference [SZ 765 984]) to Selsey [SZ 845 926], fossiliferous, mainly sands and silts of the Bracklesham Group are intermittently exposed below a cover of Pleistocene and present-day beach deposits in a sequence which broadly dips gently to the south ((Figure 6.19), but see also very recent maps produced by Bone and Tracey, 1996). Wittering to Selsey Foreshore is the most easterly (and possibly the most marine) section in the Bracklesham Group in the Hampshire Basin. Following Edwards and Freshney (1987b, p. 57), the most northerly part of the succession has been reassigned to the London Clay, but this is rarely exposed.

The earliest published account of the fossils and deposits of the section was by Mantell (1822) in his *Fossils of the South Downs.* At this time, the Bracklesham Beds were thought to be part of the London Clay and the two were not separated until later (Prestwich, 1847a). Bowerbank's (1840b) paper, 'On the London Clay Formation at Bracklesham Bay' illustrates this early nomenclatural usage.

The first general account of the section was by Dixon (1850) with illustrations of many of the characteristic fossils, whilst in 1862, Fisher described the section in greater detail and introduced a bed numbering system which has continued to be of value up to the present day.

Reid (1897) was the first to describe the older part of the succession to the north-west of Bracklesham Lane [SZ 805 964] which was apparently unknown to Dixon and Fisher. Heron-Allen's (1911) book *Selsey Bill* contains a substantial section on the local geology, but both Curry *et al.* (1977) and Bone and Bone (1985) have pointed out that it is, in places inaccurate and confused. White (1915) added little to previous accounts.

Wrigley and Davis (1937) provided further details of the lower part of the succession. The section was briefly summarized by Curry (1958a) whilst Curry *et al.* (1968, fig. 6) suggested a correlation between this and other contemporary sections further to the west. The description of the section by Curry *et al.* (1977) is one of the most important of relatively recent accounts, in particular since it is based on detailed mapping of the foreshore over some years, mainly between 1969 and 1973.

Considerable attention has focused on the stratigraphical significance of the succession, its correlation with other localities, and its age. Amongst those papers dealing with this aspect of the section are Stinton (1975) and Curry *et al.* (1977) on aspects of the lithostratigraphy and correlation, Odin *et al.* (1969) and Odin *et al.* (1978) on glauconite dating, and Islam (1983a), Townsend and Hailwood (1985), Aubry (1986) and Aubry *et al.* (1986) on the chronostratigraphy.

Until recently (see below), little modern work had been undertaken on the macrofauna from this section, although Bone and Bone (1985) produced a useful illustrated guide to the more common fossils. More emphasis has been placed on aspects of the microfauna (Murray and Wright, 1974) and microflora (Islam, 1983a; Aubry, 1986; Aubry *et al.,* 1986).

After this site description had been submitted to JNCC, volume 16 of the journal *Tertiary Research* was published and dedicated to the memory of a local amateur palaeontologist, Roy Fowler, who had worked on the section for many years.

It contains a number of papers which considerably improve our knowledge and understanding of the geology of the site, including an update on the stratigraphy by King (1996), the results of detailed mapping of the foreshore by Bone and Tracey (1996), various aspects of the molluscan fauna (Tracey *et al.,* 1996; Tracey and Todd, 1996; Tracey *et al.,* 1996), and a review by Collinson (1996) of plant macrofossils from the section in the context of coeval British floras.

Description

Although the section comprises intermittently exposed foreshore exposures, it has long been of considerable significance palaeontologically, stratigraphically and palaeoenvironmentally. Until relatively recently (see above), the only detailed modern description was that of Curry *et al.* (1977) who assigned the sequence to three 'divisions' (see later) of the 'Bracklesham Beds'.

Lithological succession

Except for the lowest few metres which Edwards and Freshney (1987b) assigned to the London Clay, the succession (Figure 6.20) comprises Bracklesham Group strata (in ascending order, the Wittering Formation, the Earnley Sand, the Marsh Farm Formation and the Selsey Sand). Measurement derived from fig. 6 of Curry *et al.* (1977) gives a thickness for the total succession of a little in excess of 93 m, although a summation based on measurements given for the three 'divisions' described from the same paper indicated around 120 m, a thickness greater than that of the Bracklesham Group for this locality given in Edwards and Freshney (1987b). As Fisher (1862) pointed out, it is difficult to determine the thickness of the succession and, interestingly and unusually, each of his subdivisions (pp. 74–5) is labelled not in feet but in paces!

The succession comprises a complex, more or less fossiliferous alternation of muds, silts and sands with occasional pebble beds. Glauconitic lithologies characterize much of the section. The strata present are mainly unlithified but a few horizons are more indurated and this may be reflected by the presence of low 'reefs' or 'nodules' on the foreshore.

Stratigraphy

In his classic paper, Fisher (1862) considered the importance of this locality in his study of the 'Bracklesham Beds' and concluded that 'Bracklesham Bay, both for interest and display of the beds, undoubtedly holds the highest place'. The significance of the section has been recently reiterated by Edwards and Freshney (1987b) who have designated Bracklesham Bay as the hypostratotype for all four formations within their Bracklesham Group.

The hypostratotype for the Wittering Formation is that part of the foreshore from [SZ 765 984] to [SZ 808 961] and is equivalent to Beds W9–17 of Curry *et al.* (1977). That for the Earnley Sand extends from [SZ 808 961] to [SZ 823 950] and comprises Beds E1–8 of Curry *et al.* (1977). This formation is the Earnley Formation of King and King (1977) who also designated this section as the hypostratotype. These authors defined the section from [SZ 823 950] to [SZ 825 946] as their hypostratotype for the overlying Marsh Farm Formation, equivalent to Beds E9–12 of Curry *et al.* (1977). The uppermost formation of the Bracklesham Group, the Selsey Sand, has the section from [SZ 825 946] to [SZ 845 926] as its hypostratotype and consists of Beds S1–11 of Curry *et al.* (1977).

Biostratigraphy

As well as being lithostratigraphically significant, these Bracklesham Group strata are of chronostratigraphical importance. Both *N. laevigatus* and *N. variolarius* horizons and the presence of dinoflagellates and calcareous nannoplankton have contributed to a better understanding of the correlation of these strata.

Islam (1983a) was able to recognize three of the dinoflagellate assemblage zones of Bujak *et al.* (1980) in the section. Zone B-2 includes W10–15, but may extend further down the sequence; Zone B-3 includes Beds W16 to E4; Zone B-4 extends from Bed E5 to at least S3, the highest unit sampled.

Calcareous nannoplankton, although not particularly common in the local Palaeogene succession, have been reported at three levels in the Bracklesham Bay section by Aubry (Aubry, 1986; Aubry *et al.,* 1986), although D. Curry (pers. comm.) has found that they occur at at least six horizons. The upper part of Zone NP12 is indicated by nannofossils from below Fisher Bed 1 (probably Bed W14 of Curry *et al.,* 1977). The upper part of Zone NP14 is probably represented by assemblages from Bed E7 (Fisher Bed 6). Aubry *et al.* (1986) pointed out the particular significance of the very abundant nannoflora from Fisher Beds 19, 20 and 21 (more or less equivalent to Beds S8–10 of Curry *et al.* (1977). Here, the last occurrence of *Rhabdosphaera gladius* in Fisher Bed 20 led Aubry (1986) to place the Zone NP15/NP16 boundary between Fisher Beds 20 and 21. The reference by Aubry *et al.* (1986) to scarce nannofossils representing Zone NP12 from 'glauconitic clayey silts which underlie Fisher Bed 1' (implying Bed E3 of Curry *et al.,* 1977) is misleading, as is their reference to the recording of the normal polarity event at this level, for the latter (from Townsend and Hailwood, 1985, p. 968) was in fact recorded from Beds W7–8 of Curry *et al.* (1977) around 35 m further down the succession. The bed Aubry sampled was in fact Bed W14 (D. Curry, pers. comm.).

Radiometric dating and magnetostratigraphy

The presence of glauconitic sands permits a radiometric age determination. Two attempts have been made on glauconites from the section, both using material from Fisher Bed 2 (Bed E4 of Curry *et al.,* 1977). Odin *et al.* (1969) gave an age of 49.4 ± 3 Ma, whilst Odin *et al.* (1978) made it 46.4 ± 1.5 Ma.

More recently, Townsend and Hailwood (1985) established that two normal and one reverse polarity magnetozones could be recognized in the Bracklesham Bay succession. In Aubry *et al.* (1986), the two normal polarity zones were referred to as the Wittering magnetozone and the Earnley magnetozone respectively. Relating the magnetostratigraphy to the nannofossil biostratigraphy, these authors were able to establish that both Chron C23N and Chron C21N are represented in the Bracklesham Bay section.

Sedimentology

Apart from the logs in Curry *et al.* (1977) and useful albeit brief summaries in Edwards and Freshney (1987b), very little has been published on the sedimentary features of the succession. Plint (1983a) apparently did not study the section in detail as part of his sedimentological study of the Bracklesham Formation (sic). Glauconitic sediments are represented in all four formations and testify to the marine nature of much of the sequence.

Macrofossils

Both the Earnley Sand and Selsey Sand are dominated by glauconitic deposits and are rich in marine fossils. The other two formations contain both marine and brackish water assemblages. Both the lower and upper parts of the Wittering Formations are lignitic to some extent and oyster-rich molluscan faunas are characteristic of these parts. *Nipa* fruits occur near the base of this formation, whilst the higher beds contain an important vertebrate fauna (see Moody and Walker, 1970), most of which is as yet undescribed.

Foraminifera

Murray and Wright (1974) made a detailed study of the foraminifera of the section as part of a broader investigation of these microfossils from the Palaeocene of the Hampshire Basin. The majority of assemblages found fall just within the field of normal saline shelf seas. That from Fisher Bed 21 (Bed S10 of Curry *et al.,* 1977) proved to be particularly important. Murray and Wright (1974) found it to be characterized by many species not present at any other level in the English Eocene and also of special significance both biostratigraphically and ecologically. Such species are indicative of shallow waters with fully marine salinity and represent much warmer conditions than the other Eocene faunas which these authors examined.

Interpretation and evaluation

Although poorly and intermittently exposed, the Wittering to Selsey Foreshore section in Bracklesham Bay is of considerable stratigraphical and palaeoenvironmental importance. It is the most easterly exposure of the Bracklesham Group and, with Whiteliff Bay, it represents a higher degree of marineness compared with coeval sections found further to the west. Its rich invertebrate macrofauna continues to provide opportunities for research into the more marine assemblages preserved in this part of the Hampshire Basin. Work also needs to be undertaken on what Curry *et al.* (1977) called 'important vertebrate fauna' in the Wittering Formation.

Stratigraphical significance

The section is stratigraphically significant. It provides the name for the Bracklesham Group of Edwards and Freshney (1987b), although neither this nor any other locality was defined as stratotype for this unit. Curry *et al.* (1977) recognized the importance of the section by naming three of their informal 'divisions' from localities adjacent to the site, but prior to the publication of this paper, Stinton (1975) had given these formation status and Cooper (1976b) had referred to parts of the section as the stratotype for the Wittering Formation' and the 'Selsey Formation'. King and King (1977) subsequently pointed out that their 'divisions' represented sedimentary cycles and were not intended to be formations. In contrast with the above, the Wittering Formation, the Earnley Sand and the Selsey Sand of Edwards and Freshney (1987b) are valid and Bracklesham Bay is correctly given as the hypostratotype for all these formations, as well as for the fourth from the Bracklesham Group, the Marsh Farm Formation.

Comparison with other localities

Using the lithostratigraphical definitions of Edwards and Freshney (1987a,b) and data from these papers, it is possible to compare formation thicknesses in the section considered here with those of the other Hampshire Basin localities. Although the approximately 29 m for the Witt-ering Formation in Bracklesham Bay may be an underestimate reflecting an incompletely exposed section, the succession is far thinner than the 53 m of Whitecliff Bay, although within the 23–57 m range given by Edwards and Freshney (1987a, p. 38) for the Southampton area. At around 22 m, the thickness of the Earnley Sand is not very different from that of Whitecliff Bay (25 m) but thicker than what is generally found further to the west. By contrast, the Marsh Farm Formation, at around 12 m (13.5 m in Whitecliff Bay), is relatively thin compared with more westerly localities, such as 21.3 m at Gosport (King and Kemp, 1982) and between 18 and 25 m in the Southampton district (Edwards and Freshney, 1987a, p. 48). For the Selsey Sand, the thickness of 24.7 m in the Bracklesham Bay section is only slightly less than the 27 m of Whitecliff Bay but considerably thinner than the 30–50 m of the Southampton area.

Correlation with other sections in the eastern part of the Hampshire Basin is not difficult. The recognition of the Wittering, Earnley and Selsey cycles here facilitates 'event stratigraphy' correlation with Whitecliff Bay and further west. The bases of these cycles reflect transgressions Ti, T3 and T4 of Plint (1983a), whilst his transgression T2 probably coincides with the base of Bed W11 of the Wittering formation in the Bracklesham Bay section. Higher up the latter, Beds 15 to 17 correlate with the lignite and seatearth found within the unit in Whitecliff Bay (the Whitecliff Bay Bed' or 'Coal Bed'; part of Fisher Bed V) and elsewhere and reflecting a major regressive phase over a wide area (Edwards and Freshney, 1986, p. 62).

International correlation

For some years, it has been clear that, with Whitecliff Bay, the fossiliferous Bracklesham Bay section has provided an opportunity for international correlation, which has proved difficult or impossible from the coeval, more westerly Hampshire Basin sections. Curry *et al.* (1978, p. 42), for example, referred to planktonic foraminifera from their Wittering Formation that are found throughout the Sables de Cuise in the Paris Basin, whilst *N. laevigatus* from the Earnley Sand is abundant in the lower part of the Calcaire Grossier from the latter area, and also occurs in the Brussels Sand in Belgium.

Palaeoenvironmental significance

Although this poorly exposed section is stratigraphically complex, Plint (1983a) recognized it as a cyclic sequence and that four distinctive erosional surfaces represent transgressive events. In a later paper (Plint 1988a, fig. 3), he interpreted

some units as estuarine or lagoonal and that surfaces associated with these represent periods of marine lowstand. That there were regressive periods when salinities were lower is supported by the occurrence of more restricted or brackish water faunas as, for example, near the top of the Marsh Farm Formation. However, the general predominance of glauconitic sands and muds, rich in marine fossils, makes this the most fully marine of the Bracklesham Group sections within the Hampshire Basin.

The intra-Bracklesham Group unconformity

Work, including that which has combined magnetostratigraphical data with that of nannofossil biostratigraphy, has clarified the relationship of the succession at Bracklesham Bay with other localities. Here, too, is the apparent major hiatus identified elsewhere in the Hampshire, London and Paris basins and referred to by Aubry *et al.* (1986), Plint (1988a) and others. Its occurence is demonstrated by the absence of a record of Chron C22N and its commonly associated NP13 flora. Disregarding the anomolous reference by these authors to NP12 fossils in the 'glauconitic' clayey silts that underlie Fisher Bed 1, which would indicate that the missing Chron occurred in the lower part of the Earnley Sand, it is clear from evidence they provide elsewhere (including in Townsend and Hailwood, 1985) that the 'gap' occurs somewhere between Bed W8 of Curry *et al.* (1977) and Bed E7 (Fisher Bed 6). Islam's (1983a) suggestion that the distinctly regressive Whitecliff Bay Bed' is represented in Bracklesham Bay by Bed W15, suggests that it occurs around this stratigraphical level. Aubry *et al.* (1986, p. 733) consider it to be equivalent to the well-known unconformity between the upper Cuisian (NP12) and the basal Lutetian (Upper NP14) which has been interpreted as reflecting a major eustatic sea-level fall (Vail *et al.,* 1977). Neither Neal *et al.* (1994) or Neal (1996) discussed the section in their consideration of the level at which the hiatus should be placed in the Hampshire Basin succession (see description of Whitecliff Bay, this volume).

Conclusions

Whilst the foreshore exposures from Wittering to Selsey on the eastern side of Bracklesham Bay are of an intermittent nature, the section has proved to be of considerable palaeontological and stratigraphical significance since the time it was first described in the 19th century up to the present day.

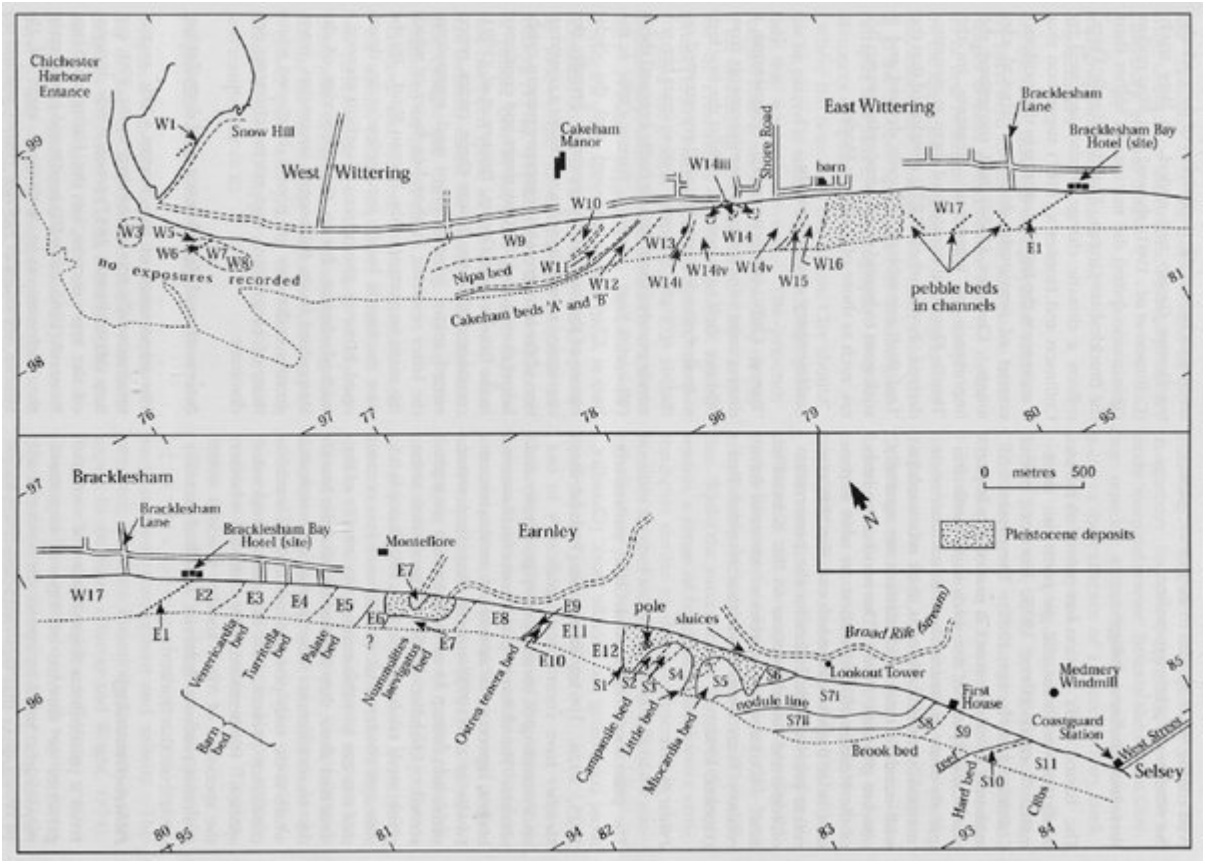
Over a period of many years, these foreshore deposits have yielded a wide variety of fossils. It has a rich marine molluscan fauna together with vertebrate and some macrofossil material, whilst in more recent years the presence of various microfossils has enhanced the value of the section. Nummulitids have been known from the site for many years; latterly, other foraminifera, dinoflagellates and calcareous nannoplankton have proved particularly useful.

This site is palaeogeographically important as it is the most easterly section of its age in the Hampshire Basin. Its particular value is that its mainly glauconitic strata with their clearly marine fossils, represent a clear contrast with the inshore to non-marine, relatively poorly fossiliferous facies found further west at such localities as Alum Bay and Bournemouth. It is therefore the most marine section of its age in the Hampshire Basin.

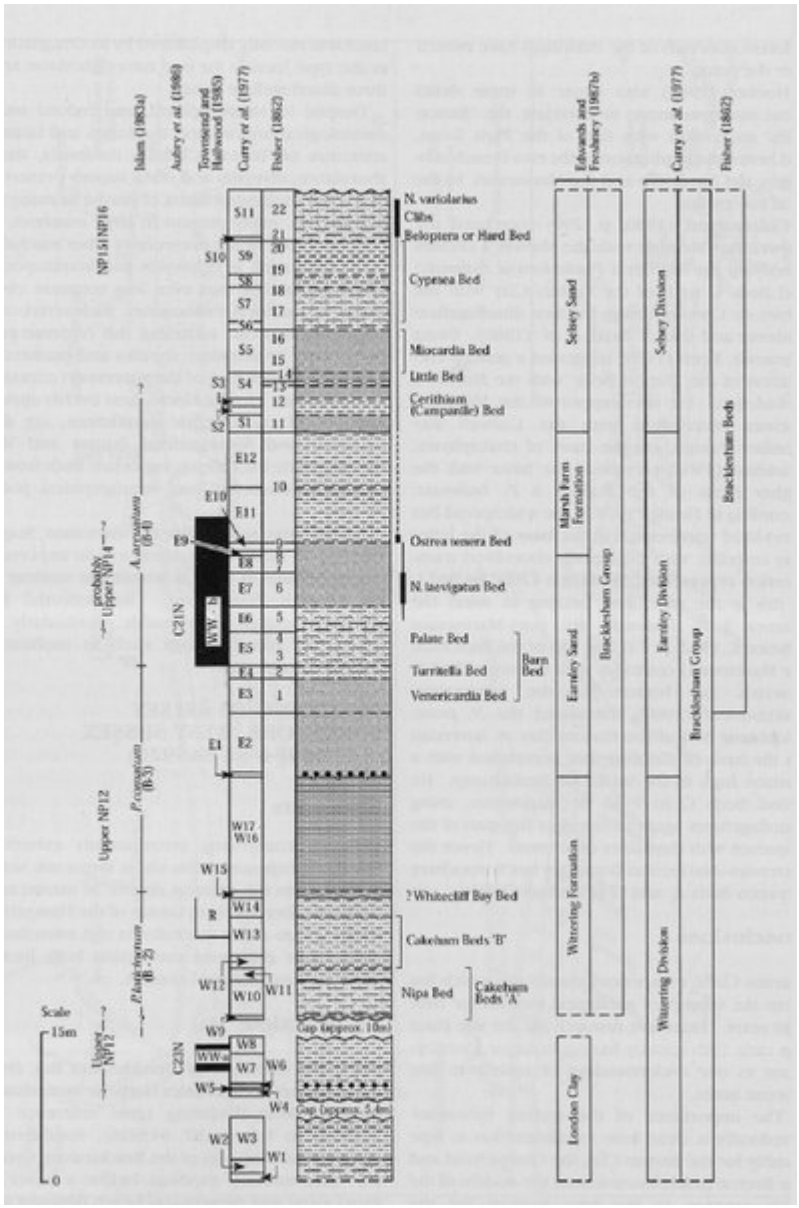
Although not formally designated as its type locality, the section provides the name for the Bracklesham Group. It has, however, been selected as the hypostratotype for all four formations of the Group. Hence, its lithostratigraphical credentials are sound.

Within recent years, the chronostratigraphical importance of the site has become increasingly apparent. Three dinoflagellate assemblage zones are represented and facilitate local correlation, whilst the presence of nannoplankton Zones 12, 14, 15 and 16 is indicative of the site's correlative value internationally. Furthermore, the Wittering and Earnley magnetozones both take their name from parts of the Bracklesham Bay site.

References



(Figure 6.19) Map of the foreshore exposures from Wittering to Selsey, Bracklesham Bay, West Sussex (from Curry et al., 1977, fig. 4). For the stratigraphical relationships of the beds prefixed W, E and S, see (Figure 6.20).



(Figure 6.20) Bracklesham Group succession from Wittering to Selsey, Bracklesham Bay, West Sussex (after Curry et al., 1977 and other authors).