Headon Hill, Isle of Wight

[SZ 310 862]

Highlights

This is the best exposure of the Headon Hill Formation in the west of the Isle of Wight and is the type locality for the formation and three of its members. A wide variety of fossils are present and represent various brackish and freshwater environments. Particularly interesting is the Hatherwood Limestone, only developed well here, with its calcrete and palaeokarst features.

Introduction

This section of the review deals with the succession in Headon Hill (Figure 5.26), the part of Totland Bay–Alum Bay SSSI to the north of Alum Bay Chine [SZ 305 856] where the strata are mainly near-horizontal. The Becton Sand (Barton Sand of earlier authors) occurs at the base and is succeeded by part of the Solent Group up to and including the Bembridge Limestone Formation. Most of the section comprises the Headon Hill Formation. Although this unit is predominantly elastic, the presence of freshwater limestones such as the Hatherwood Limestone Member provide a particular focus of interest. Whilst much of the succession is obscured by vegetation, there are some good exposures such as that above Hatherwood Point (Figure 5.27) whilst, at some horizons, the near-horizontal strata provide a considerable opportunity to study lateral facies variation.

Amongst those who made early studies of the section were Webster (1814, 1816), Forbes (1853) and Keeping and Tawney (1881), whose stratigraphical successions were reproduced in Bristow *et al.* (1889) and White (1921).

For many years, little was published on the section, but over the last three decades or so there has been a considerable rebirth of interest. An extensive stratigraphical and palaeoenvironmental study was undertaken by Edwards (1967) whilst other descriptions are given in Stinton (1971a), Insole (1972), Daley and Edwards (1972) and Daley and Insole (1984) and the comprehensive recent review by Daley (1999, pp. 40–45). The macroinvertebrate faunas of the Headon Hill Formation and the Bembridge Limestone Formation were reviewed by Edwards (1967), whilst, more recently, Paul (1989) made a detailed study of the freshwater molluscs from the Hatherwood Limestone Member. The foraminifera have been studied by Murray and Wright (1974) and the Ostracoda by Keen (1977). Vertebrate work has concentrated on the mammalian fauna, including that of Cray (1964, 1973), Insole (1972), Bosma and Insole (1972), Bosma (1974), Hooker (1992) and Hooker *et al.* (1995). Fossil reptiles from the locality have been studied by Rage and Ford (1980). The most important palaeobotanical research undertaken on the section was that by Feist-Castel (1977) on the Charophytes.

Relatively little has been published on the sedimentology, although some descriptions and interpretations occur in the theses of Edwards (1967) and Insole (1972).

This site was also independently selected for its fossil plant, reptiles and mammal content, a more detailed account of which can be found elsewhere in the GCR series (*Mesozoic to Tertiary Palaeobotany of Great Britain* (Cleal and Thomas, in prep.); *Fossil Reptiles of Great Britain* (Benton and Spencer, 1995); *Fossil Mammals and Birds of Great Britain* (Benton *et al.,* in prep)).

Description

To the north of Alum Bay Chine, the Becton Sand crops out above the foreshore. In contrast with the older strata to the south, the formation has a gentle northerly dip. The junction with the Barton Clay is faulted-out.

Further northwards as far as Totland [SZ 320 866] and above in Headon Hill [SZ 310 862], the remainder of the sequence comprises the lower part of the Solent Group, exposed intermittently in a very shallow E–W trending syncline.

At Hatherwood Point [SZ 305 860], which provides the best section (Figure 5.27), the strata dip gently eastwards whilst appearing horizontal when viewed from the seaward side. Strata along the northern face of the hill dip southwards at a low angle.

Lithological succession

The succession in Headon Hill is almost 100 m thick, of which some 63 m comprise the Headon Hill Formation (Figure 5.28). Much of the succession comprises mainly green to grey silty to sandy muds and marls. Sands occur as thin partings within the muds but are better developed at some horizons, such as the Becton Sand at the base of the succession and in the Linstone Chine Member (Headon Hill Formation), particularly where the latter is thicker towards the northern part of Headon Hill. A feature of the section is the occurrence of a number of cream-coloured limestones (Figure 5.29). Some (like the How Ledge Limestone) are lithologically homogeneous. By contrast, the thicker Hatherwood Limestone Member is complex in nature, with irregular internal bedding surfaces, the occurrence of limestone boulders and evidence of pedogenic alteration. It also contains a laterally discontinuous lignite bed. At Hatherwood Point, the top of the section mainly comprises marls which are succeeded by the well-lithified Lacey's Farm Limestone. Younger grey-green laminated muds (Fishbourne Member) and red and green mottled muds (Osborne Marls Member) may be visible further to the north below a thin remnant of the Bembridge Limestone at [SZ 317 863].

Stratigraphy

Headon Hill has been an important site for stratigraphy and stratigraphical nomenclature since the middle of the 19th century. The Barton Sand was called the Headon Hill Sand by Forbes (1856) and Bristow *et al.* (1889). Below his overlying Osborne Series, Forbes recognized a Headon Series which he subdivided into Lower, Middle and Upper Headon Beds, terms which until recently were widely used.

With the recognition of the need to regulate and standardize stratigraphical terminology (cf. Hedburg, 1976), new terms were introduced to replace these earlier ones and Headon Hill, more than any other site, has encouraged new thought on the stratigraphical subdivisions and nomenclature of this part of the English Palaeogene succession.

Headon Hill was designated by Insole and Daley (1985) the type section (stratotype) for the Headon Hill Formation (see (Figure 5.28)), a unit encompassing the Headon Beds and Osborne Beds of earlier authors, whose identity as separate units was in doubt as early as the latter part of the 19th century (Bristow *et al.,* 1889, p. 157). Of the nine members into which the Headon Hill Formation is divided, three have Headon Hill as the type locality: the Totland Bay Member, the Hatherwood Limestone Member and the Lacey's Farm Limestone Member. Headon Hill was chosen for the last of these since the future of the small, now disused pit from which it gets its name, was considered uncertain.

Invertebrate macropalaeontology

Headon Hill is the best palaeontological site at this level in the Eocene succession in Britain. A wide variety of molluscan assemblages have been recognized. Marine influences are apparent in the exposed upper and lower parts of the Colwell Bay Member where assemblages are dominated numerically by cerithiids (*Batillaria* and *Potamides* spp.), oysters (*Ostrea velata*) and corbiculids (*Corbicula obovata*) (Daley and Edwards, 1974). These assemblages are characterized by low species diversity and represent estuarine or lagoonal rather than fully marine conditions. The assemblage of the rarely exposed middle part is more marine in character.

Elsewhere in the formation, a variety of molluscan assemblages reflect freshwater to brackish conditions. Amongst the freshwater assemblages are those characterized by the pulmonates *Galba* and *Planorbina* and which occur mainly in cream-coloured micritic limestones (see for example the paper by Paul (1989) on the molluscan fauna of the Hatherwood Limestone Member). Other freshwater assemblages contain the river snail *Viviparus,* whilst an example of a possibly more brackish water assemblage is the '*Corbicula pulchra* Bed' in the Totland Bay Member. Here the main fossils are *Potamomya, Melanopsis, Theodoxus* and *Corbicula.* In the Bembridge Limestone, which completes the succession here, species of land snail are associated with freshwater molluscs (Preece, 1976).

A particularly interesting feature of the *Theodoxus* shells is that they retain much of their original pigmentation and portray a variety of colour patterns, the nature and significance of which have been investigated by Hill (1986) and, in a broader study of colour pattern preservation in the fossil record, by Hollingworth and Barker (1991).

Microfauna

Headon Hill is an important locality for microfaunal research. It was one of the two main sections studied by Keen (1977) in his work on the environmental significance of ostracods, which resulted in the recognition of salinity controlled, and hence salinity diagnostic, assemblages. The foraminiferal fauna was studied in some detail by Murray and Wright (1974). They considered that faunas from the Colwell Bay Member were indicative of salinities sometimes close to normal marine levels. Somewhat surprisingly, they found foraminifera in the Hatherwood Limestone, predominantly freshwater in origin but with hydrobiid-rich intervals indicating occa sional saline influence (see Paul, 1989). Derived Upper Cretaceous microfossils present in some of their samples confirm that the Chalk had been uplifted by this time and was being eroded.

Vertebrate remains

The importance of Headon Hill from the point of view of vertebrate remains cannot be in doubt. Amongst those found in the Totland Bay Member are freshwater turtles, the alligator *Diplocynodon,* fishes and various mammals. These include rodents described by Bosma (1974), six species from a green silty clay with shell fragments 2.5 m above the base of the member and seven from the grey-green marl immediately below the How Ledge Limestone (Figure 5.28). The latter is now known to be highly productive of vertebrate fossils and from it, Rage and Ford (1980) have described reptiles, including a salamander, lizards and snakes. Recently, a new genus of snake, *Headonophis,* has been described by Holman (1993) from the lignitic clay immediately below the How Ledge Limestone.

Higher up the sequence, at the junction of the Colwell Bay Member and the overlying Linstone Chine Member, is a thin, lenticular, argillaceous sand containing mammal remains which Cray (1973) called the 'Microchoerus Bed'. Amongst species he described from this bed were the primate *Microchoerus erinaceus* and the marsupial *Peratherium.* Other vertebrate material comes from the lignites of the Hatherwood Limestone Member, including turtle and mammal remains. Cray listed 14 mammalian species from the lignite at Hatherwood Point, including the primates *Adapis parisiensis* and *M. erinaceus,* three species of *Palaeotherium* and the creodont *Hyaenodon cf. minor* (Cray, 1973, Table 4, p. 27). A number of rodent species from just above and below the lignite have been described by Bosma (1974). Hooker (1987) has recognized three mammal zones at this locality (see (Figure 5.28)). More recently, Hooker *et al.* (1995) have described a mammalian fauna from the Bembridge Limestone.

Flora

Headon Hill is not particularly well-endowed with plant fossils, except for Charophytes. Six species were found in cream-coloured marls 1 m above the base of the Totland Bay Member (Feist-Castel, 1977), whilst three species were found in brackish clays and lignites which she referred to the Isleritina Beds' near the base of the Colwell Bay Member. The Totland Bay Member was sampled by Machin (1971) in her study of pollen and spores from the Palaeogene of the Isle of Wight.

Sedimentology

The section has considerable potential for sedimentological work on paralic brackish to freshwater environments, which mainly comprise those characterized by fine- to medium-grained elastics, but also include freshwater, limestone-producing lakes. Despite the study by Edwards (1967), virtually no modern work on the sedimentology or its environmental implications has been published.

The section contains some of the best repre sentatives of freshwater limestones in the British stratigraphical column. These include the How Ledge Limestone and the Warden Ledge Limestone from the Totland Bay Member. The former is prominent in the cliff face at Hatherwood Point, although at this locality, the Warden Ledge Limestone is thin and poorly exposed.

The best example is the 7–8 m thick Hatherwood Limestone Member that forms a prominent scar towards the upper part of the seaward face of Headon Hill ((Figure 5.27) and 5.29). It comprises pale, soft to well-lithified, more or less fossiliferous limestones with subordinate lignites, a facies only developed in Headon Hill. Soft limestones with vertical tubular hollows attributable to the former presence of roots are interbedded with well-lithified hard pans and 'banded' limestones (?pedogenic crusts) with irregular upper surfaces, first described by Jackson (1925).

The near-horizontal nature of this member provides a rare opportunity to study lateral changes in a freshwater limestone. A significant feature is the development of a destructive lateral surface within the member. At Hatherwood Point, where it descends well below the centre of the member, lignites fill the hollows in its very irregular profile (Figure 5.30). Surfaces such as this probably reflect exposure and the existence of solution or karst-type processes.

Fossil soils are well-developed in parts of the Headon Hill section. Halfway up the Cliff End Member at Hatherwood Point, a hard marl (<0.5 m thick) containing knobbly and cylindrical concretions and with a sharp irregular top, passes down into marls with vertical red stripes. Such features are pedogenic in origin and indicative of exposure.

The highest limestone scar above Hatherwood Point is formed by the Lacey's Farm Limestone Member (the Osborne (Beds) Limestone of Edwards (1967) or 'thick concretionary limestone' of White (1921, p. 111)). It comprises hard or soft limestones or calcareous sandstones passing down into very calcareous marls. The limestones are often nodular or rubbly; marked internal surfaces occur, whilst some levels comprise banded limestones or 'crusts'. The top of the member comprises a distinct surface, overlain in places by pebbles or concretions of limestone. The unit as a whole appears to provide a classic example of calcrete profile development.

Clay mineralogy

Little mineralogical work has been undertaken on the section. It was, however, sampled by Gilkes (1968, 1978) who recorded that, as in all the post-'Bracklesham Beds' sediments on the Island, illite dominates the clay mineralogy suite. He attributed this to either the reworking of older Palaeogene sediments adjacent to the basin of deposition and/or derivation from illites neoformed in the widespread calcareous lakes which existed at this time (cf. Porrenga, 1968; Millot, 1970).

Interpretation and evaluation

The unique sequence exposed in Headon Hill differs in certain respects from other contemporary successions in the Isle of Wight and on the mainland. All the stratigraphical units present occur at other localities, but some are particularly well-exposed here, sometimes with facies significantly different from their occurrences elsewhere. The site, therefore, has a critical contribution to make to our understanding of the depositional environments and Palaeogene palaeogeography.

Comparison with other localities

At the base of the succession, the Becton Sand is 27 m in thickness, compared with about 55 m at Whitecliff Bay and 22 m at the type locality (Barton Cliffs). The Totland Bay Member (27 m) is similar in thickness to the succession at Hordle Cliff (28.3 m), but distinctly thicker than the 8.3 m in Whitecliff Bay, where there are no freshwater limestones such as those present at Headon Hill.

By contrast, the Colwell Bay Member, at something over 9 m, is far thinner than at Whitecliff Bay (30 m). The member is also less marine in Headon Hill, the Brockenhurst Bed being absent. Excellent exposures of the Linstone Chine Member at the Totland end of Headon Hill (around [SZ 318 865]) thin to nothing near Hatherwood Point, whilst its presence is questionable in Whitecliff Bay, from which the overlying Hatherwood Limestone is missing. This member, which shows considerable variation along the length of Headon Hill, reaches some 9 m in thickness but appears to have been eroded further northwards except for a thin (0.5 m) representative at the northern end of Colwell Bay.

The Cliff End Member is thinner than at Whitecliff Bay (13 m), whilst the succeeding Lacy's Farm Limestone Member, although of approximately similar thickness there, lacks the thick limestone development found in Headon Hill. This unit is absent from the Colwell Bay succession. The Fishbourne Member above (3.9 m) is much thinner than at Whitecliff Bay (11 m), whilst the 6.8 m of the Osborne Marls Member is around half its thickness at Cliff End (13.5 m) and King's Quay (approximately 12.2 m), and two-thirds of that in Whitecliff Bay (10.7 m).

The Bembridge Limestone Formation (up to 7.5 m), exposed around grid reference [SZ 317 863], is slightly thinner than in Whitecliff Bay and a little thicker than at Gurnard Ledge. The presence of lignitic mud in palaeochannels is unique to this locality, but analogous to that in the Hatherwood Limestone Member. The limestone lithologies present resemble those of the other south-western sections such as Prospect Quarry and the now vegetation-concealed exposure at Cliff End.

Stratigraphical significance

Stratigraphically, the Headon Hill section has been important since the 19th century, although some early workers, such as Webster (1814, 1816), failed to fully understand its relationship to other localities. For Forbes (1853, 1856), it was the type section for his Headon Series and, later, Lower, Middle and Upper Headon Beds. Since it is now the type section for the Headon Hill Formation and three constituent members, its significance has been maintained to the present day.

Dating the succession

It has not proved an easy section to date since the predominantly non-marine or marginally marine facies markedly limit the availability of zone fossils. Costa and Downie (1976) do not refer to *Wetzeliella* being identified specifically from Headon Hill, but by analogy with localities such as Whitecliff Bay, the lower part of the succession may be assigned to the *W. perforata* zone. It may include strata of *W. gochtii* age, but since the environments represented above the Colwell Bay Member are incompatible with the occurrence of this fossil, confirmation of this seems unlikely. No calcareous nannofossil zone has been established from Headon Hill material, although the basal part of the Colwell Bay Member at Whitecliff Bay has been assigned to NP Zone 19–20 (Aubry, 1986).

Both in terms of dinoflagellates and nannoplankton, the assignment of late Eocene age to the section seems appropriate. Some have dissented from this view. Bosma (1974) suggested that, on the basis of mammalian studies, much of the succession should be assigned to a new 'Headonian Stage', straddling the Eocene/Oligocene boundary and for which Headon Hill would be the type site. Feist-Castel (1977) also considered that both the Eocene and Oligocene are represented here, the Lower Headon Beds (the Totland Bay Member as used here) being assigned to the Verzenay Charophyte Zone (Eocene) and the younger strata to the Bembridge Charophyte Zone (Oligocene).

Palaeontology

Despite the lack of zone fossils and a scarcity of plant macrofossils, the site is richly endowed palaeontologically. Together, a variety of low-diversity assemblages of molluscs, ostracods and sometimes forams indicate environments of varying salinity from freshwater to almost fully marine conditions. The generally very good molluscan preservation provides excellent opportunities for detailed research, both taxonomic and palaeoecological. An investigation of the freshwater molluscs has now been published (Paul, 1989), but considerable opportunity exists for research on such brackish water fossils as the Cerithiidae (*Potamides, Batillaria,* etc.), which occur in profusion at certain levels.

The presence of coloured *Theodoxus* shells has led to research into a relatively unusual aspect of palaeontology. Colour preservation is rare in the fossil record. What makes this site unique is that such large numbers of variably pigmented shells occur, thereby facilitating a detailed study of both the organic chemistry of pigment preservation and the palaeoecological significance of the colour patterns.

Palaeosalinity

In the Headon Hill section, Keen (1977) was able to recognize five of his six, predominantly salinity-related, ostracod assemblages. Only his fully marine *Hazelina* Assemblage (found elsewhere in the Brockenhurst Bed) is missing. His recognition that even in the Colwell Bay Member, salinities did not exceed upper brackish water conditions (*Haplocytheridea* Assemblage; 16.5 to 35%) is compatible with the low-diversity molluscan assemblages present. Murray and Wright's (1974) conclusions are not markedly different. They suggested that the salinities for the Colwell Bay Member were sometimes close to normal marine, whilst conceding that the low-diversity foraminiferal assemblages suggested an abnormal environment.

Keen (1977) and Murray and Wright (1974) were apparently at variance over the interpretation of the Hatherwood Limestone. Keen's work indicated a freshwater derivation whilst the latter authors (p. 36, fig. 15), having identified forams of marine aspect, suggested a lagoonal, intertidal origin. The molluscan faunas can be used to explain this apparent discrepancy, in that whilst such genera as *Galba* indicate freshwater, *Melanoides* and *Theodoxus* are more ambiguous salinity-wise and the hydrobiids represent saline influences. What needs to be remembered is that the carbonate lakes such as that producing the Hatherwood Limestone occurred in a paralic context, where separation from marine or semi-marine influences was from time to time incomplete, allowing the introduction of more saline elements by posthumous transportation or the periodic establishment of more salinity-tolerant communities when suitable conditions were maintained over a longer period. It is worth noting that a similar assemblage of forams to those in the Hatherwood Limestone was found in the predominantly freshwater Bembridge Limestone of Whitecliff Bay.

Palaeogeography and depositional environments

Whilst much palaeoenvironmental analysis of the site has been based on its fossils, the sedimentary features are also valuable for interpretation. It is unfortunate that little of a sedimentological nature has been published, although con siderable data may be found in the unpublished thesis of Edwards (1967). Essentially, deposition took place in a predominantly low-energy paralic embayment in which salinity fluctuated, perhaps in part as a result of eustatic changes. The Colwell Bay Member represents the major transgressive event but the evidence suggests that fully marine salinities were not developed here. Faunal evidence clearly shows that freshwater conditions occurred from time to time but the mixing or close juxtaposition of fresh and brackish water assemblages indicates that such freshwater conditions developed within the paralic aqueous complex rather than in separate, isolated lakes.

Some of the most revealing (and sometimes perplexing) palaeogeographical research arises from multidisciplinary studies and for the Headon Hill section this is well exemplified by the work of Hooker *et al.* (1995). In a study of the Bembridge Limestone, they found that such an approach can leave unresolved contradictions. In this case, whilst clear mammalian and land snail evidence suggests the proximity of open woodland to forested areas at the time when the Bembridge Limestone was being deposited, there is no other indication of the presence of trees, including a lack of any pollen evidence for woodland or forest, or indeed any flowering plant pollen.

Palaeopedology

By far the most interesting unit sedimentologically, and particularly so from a palaeopedological point of view, is the Hatherwood Limestone. Within it, Edwards (pers. comm., 1990) recognized features comparable with Quaternary–Recent calcretes from the north-western Mediterranean region but also identified a number of palaeokarst surfaces and the sapping of hardpans which had produced potholes and collapse breccias. Such features may be interpreted to suggest an alternation of drier and wetter climatic conditions, a possibility supported by recently published research on the mammalian fauna (Hooker, 1992).

Considerable scope exists for palaeopedological research on the sequence succeeding the Hatherwood Limestone. The Lacey's Farm Limestone appears to have been affected by calcretization, but has not yet been the subject of detailed study. Gley soil development may be reflected in the colour-mottled, variegated muds elsewhere in the succession and these also require investigation.

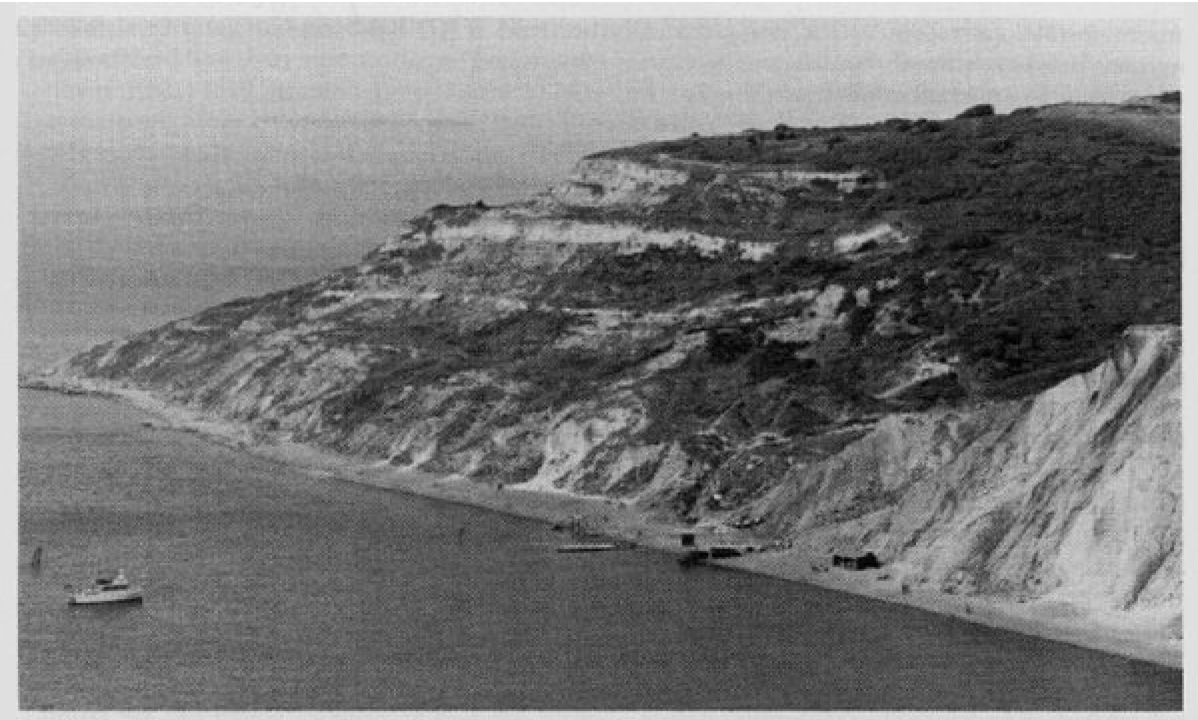
Conclusions

Headon Hill is a classic site, studied by geologists since early in the 19th century, and was a key locality where early workers such as Forbes first interpreted the local stratigraphy. Nowadays, it is the type section for the Headon Hill Formation and three of its members, whilst its stratigraphical importance is further enhanced by some aspects of the section which contrast markedly with successions of similar age elsewhere.

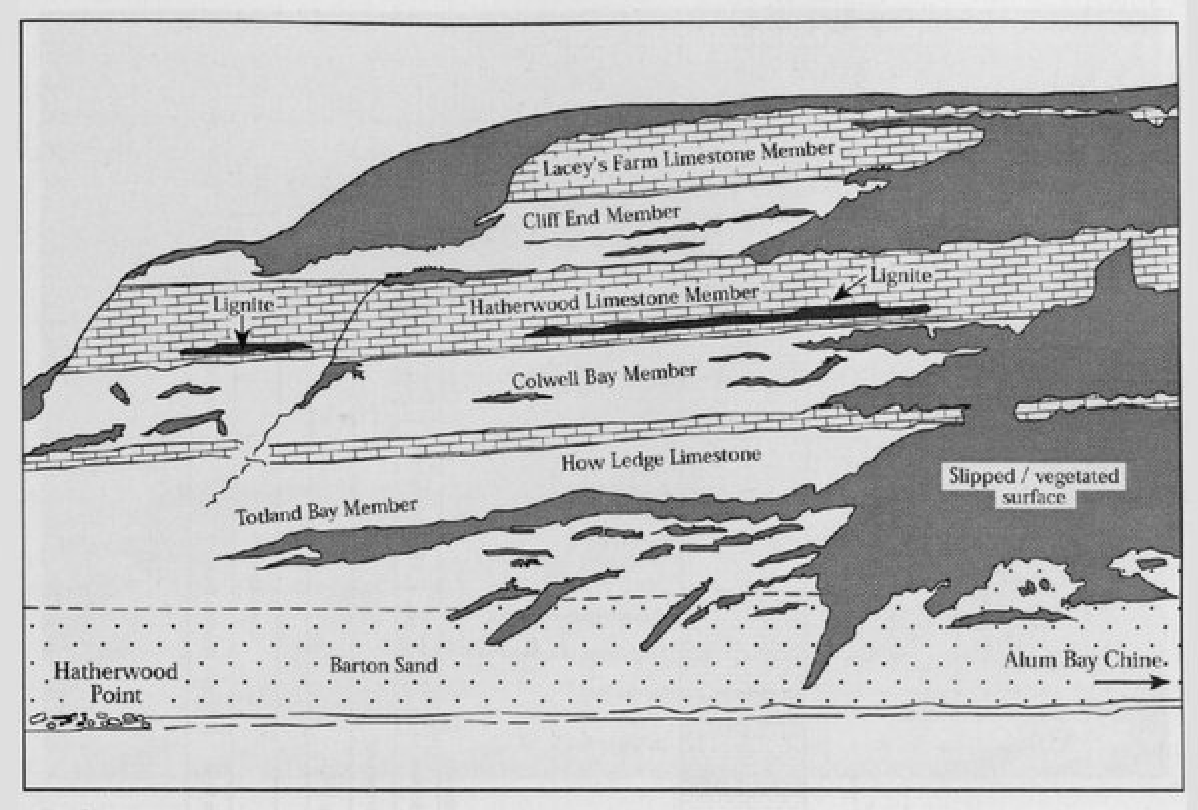
Palaeontologically, it is no less significant. Although not important biostratigraphically, it contains a wide variety of macrofossil and microfossil assemblages of palaeoenvironmental significance. Molluscs, foraminifera and ostracods have indicated the former presence of a wide variety of freshwater to nearly fully marine environments in a low-energy paralic (coastal) embayment. Amongst the vertebrate fossils found are primates and other mammals.

The section offers excellent opportunities for the study of a wide variety of freshwater and brackish water sediments. The freshwater limestones have attracted particular attention, and of these, the Hatherwood Limestone is the thickest and most interesting. Fossil soils (palaeosols), indicating emergent episodes, are well developed at a number of horizons. From the presence of calcretes, the former periodic existence of climatic drier conditions can be inferred, rather than the continual humid tropical or subtropical climates previously considered characteristic of the local Palaeogene from palaeontological (mainly palaeobotanical) evidence.

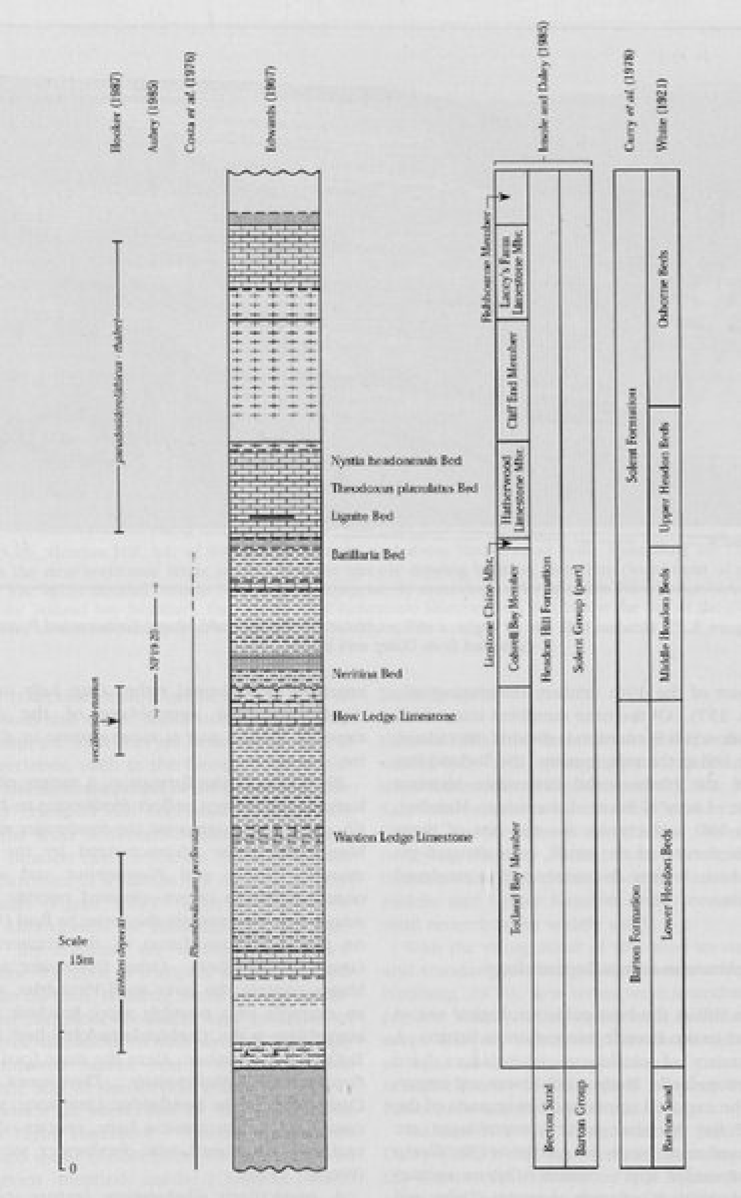
References



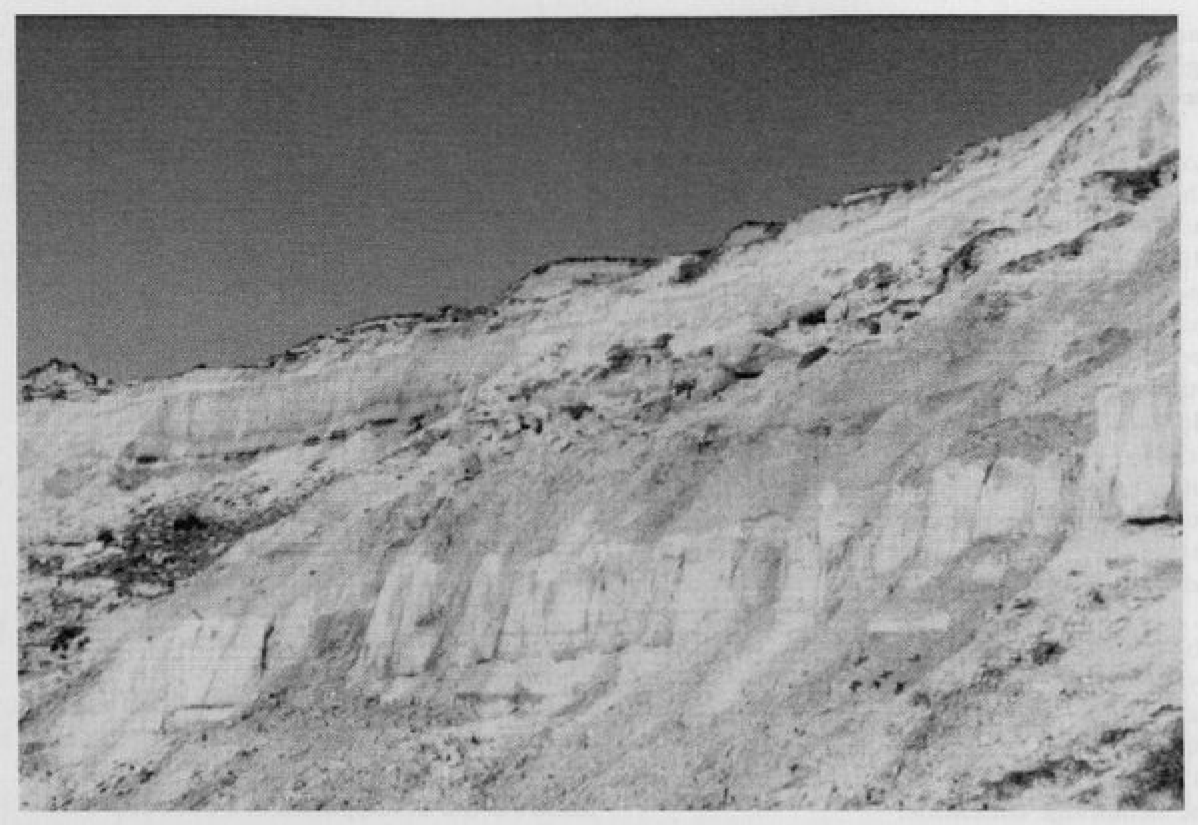
(Figure 5.26) Headon Hill, Isle of Wight. The western end above Hatherwood Point, illustrating the contrast between the near-horizontal strata present and the steeply dipping beds in Alum Bay (front right of photograph). The light-coloured units in Headon Hill comprise, in ascending order, the thin How Ledge Limestone (within the Totland Bay Member), the Hatherwood Limestone Member and, just below the top of the cliff, the Lacy's Farm Limestone Member. (Photograph: B. Daley.)



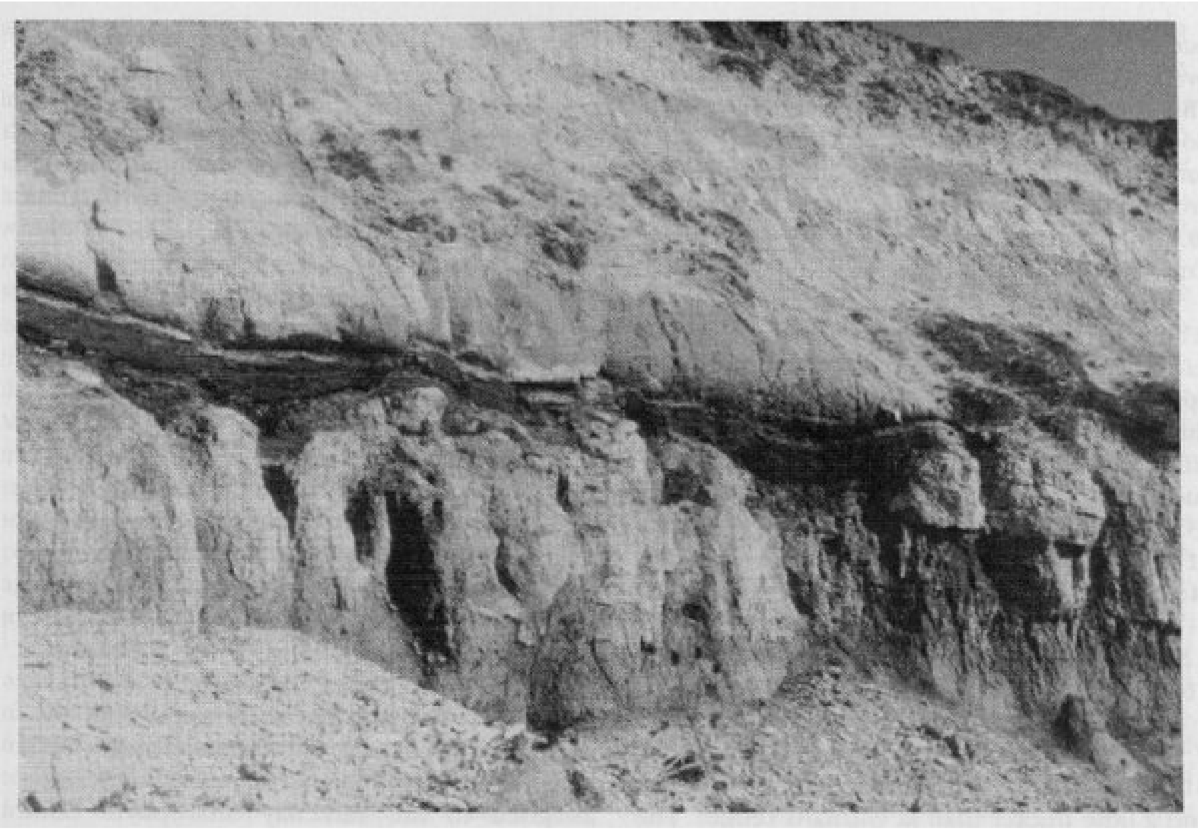
(Figure 5.27) Headon Hill, Isle of Wight: a cliff profile at the western end, above Hatherwood Point (adapted from Daley and Insole, 1984).



(Figure 5.28) Lithostratigraphical succession of the Headon Hill Formation at the western end of Headen Hill, Isle of Wight, above Hatherwood Point (after Edwards, 1967; Insole and Daley, 1985 and other authors) and biostratigraphy (mammal concurrent range zones after Hooker, 1987).



(Figure 5.29) Limestones in the Headon Hill Formation at Hatherwood Point, Headon Hill. The How Ledge Limestone (within the Totland Bay Member) occurs towards the middle of the succession illustrated, with the Hatherwood Limestone forming the top of the cliff, above which the Lacy's Farm Limestone is just visible towards the centre and on the extreme left. (Photograph: B. Daley.)



(Figure 5.30) The Hatherwood Limestone Member (Headon Hill Formation) above Hatherwood Point, where a laterally impersistent lignite rests on an irregular internal surface within the limestone. (Photograph: B. Daley.)