

WESSEX AND THE ISLE OF WIGHT

Field Guide

Edited by
K. E. BARBER

Quaternary Research Association



1987

WESSEX AND THE ISLE OF WIGHT

Field Guide

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prepared to accompany the Annual Field Meeting held
at Southampton and Cowes
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Cover illustration: Cranes Moor, New Forest, from Burley Ridge (SU 198033). An analogue for the New Forest during the Boreal chronozone, c.9000 years ago, when pine was the dominant tree. (Original photography by K.E. Barber).

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WESSEX AND ISLE OF WIGHT
FIELD GUIDE

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PREFACE

The guide differs from previous Field Guides in that each site or locality is treated as a separate paper or chapter. It thus follows the 1986 QRA/BGRG Field Guide to Quaternary river landforms and sediments in the Northern Pennines, edited by Mark Macklin and Jim Rose. The main reason for adopting this format is that this 1987 guide contains a large number of diverse reports from very different sites scattered over a wide area. The previous format of a regional account with a series of linked site visits would clearly have been inappropriate in this case. The contributors were also allowed to develop their own accounts in depth, and some of these are the first reports of new sites, while others are rather longer major statements of a research project. The other advantage of this format is that it allows easier reprinting and referencing of individual contributions. As editor I have sought to respect the views of individual contributors regarding terminology. For example, the use of BP and bp for 'before present', and the terms Holocene, Flandrian and Post-Glacial for the last 10,000 years, have therefore been left as they were in the original manuscripts.

Keith Barber, March 1987

ORDNANCE SURVEY MAPS

The field area is covered at 1:50,000 scale by Landranger series maps 194, 195 and 196. The New Forest and the Isle of Wight are covered at 1:25,000 scale by Outdoor Leisure maps 22 and 29 respectively.

THE CONTEXT OF QUATERNARY EVENTS IN WESSEX AND THE ISLE OF WIGHT

By

K. E. Barber

'The history of the succeeding Pliocene and Pleistocene periods is largely a matter of conjecture'. So begins the final chapter of the latest edition of the British Regional Geology guide to the Hampshire Basin and adjoining areas (Melville and Freshney, 1982). The area was also dealt with rather briefly in Mitchell et al (1973). It is the aim of the present Field Guide to further our knowledge of the Quaternary history of this area, but nevertheless it is clear that there is still much research to be done.

Figure 1 shows the simplified solid geology of the area covered by the guide, and the sites described in the chapters which follow. The appositeness of the term 'basin' is immediately apparent from this map, even without contours and structural information. The rim of chalk forming the high downland to the west, north and east is a noticeable feature, and one which any map of the distribution of archaeological artefacts for the earlier prehistoric period (especially the Neolithic) shows to have been of importance in human affairs. It is also apparent from figure 1 that the southern rim of the chalk and Jurassic strata, the Purbeck-Wight monocline, has been breached in geologically recent times, leaving Ballard Down in Purbeck and the Needles on the Island as pointed reminders of a land mass which encompassed the so-called Solent River flowing from west to east. This and other rivers flowed into a shallow sea in Palaeogene times when a succession beginning with the Reading Beds records the post-Cretaceous marine incursion into the area. The Tertiary fill is a mixture of clays and sands such as the Barton Clay and Barton Sand which underlie much of the New Forest, but also includes sediments - particularly in the upper part of the succession such as the Headon Beds and the Bembridge Limestone and Marl - which reflect fresh and brackish water conditions (Melville and Freshney, 1982). The complexity of facies variation and of structure - particularly in Purbeck - is of course lost at the scale of figure 1, but at the risk of over simplification it is rather remarkable how much this map reflects agricultural and settlement history, especially in the area of the former heathland from Rims Moor across to Cranes Moor.

The geomorphological evolution of the map area is well dealt with by Small (1964, 1980) and Jones (1980, 1981), and there is an increasing number of detailed recent studies of geomorphological features such as the Ports Down raised beach (ApSimon et al, 1977), periglacial features near Highcliffe (Barton, 1984) and the valley-side hollows known as dells in the New Forest (Tuckfield, 1986), as well as work on the deposits themselves such as the Plateau Gravels (Keen, 1980), the brickearths (Reynolds, this volume), and the organic deposits (this volume).

The most acute problem is that of chronology, as will be evident from several contributions to this volume. Seen in the light of



Figure 1 Simplified Geology of the field area

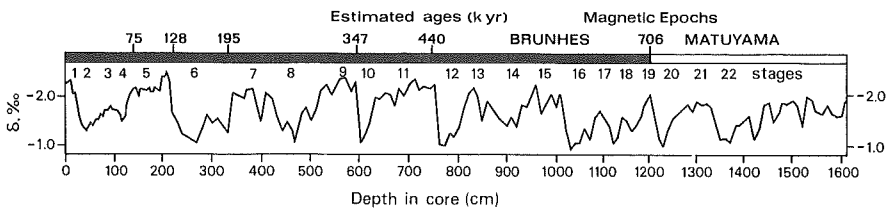


Figure 2 The global standard Oxygen isotope profile of core V28-238 (after Shackleton and Opdyke 1973)

the well-known oxygen isotope profile (figure 2) from core V23-238 (Shackleton and Opdyke 1973) the terrestrial record seems fragmentary indeed, but the terrace suite of the Avon stands out as a reasonable sequence, and with newer methods of dating such as amino-acid diagenesis (chapter 13, Bowen et al 1986), and the greater awareness of the need for secure regional stratigraphies, future research prospects are exciting. Above all there is a need for the discovery of further pre-Holocene organic deposits. The key position of the interglacial deposits at Stone (chapters 4, 5 & 6) is illustrated by the references to this Ipswichian stage datum line in other contributions and in previous publications. The reports in this volume of new discoveries at Ibsley (chapters 10 and 11) and at Bembridge (chapter 18) are hopefully pointers as to the possibility of finding new organic deposits within the gravel spreads of the major terraces and of applying modern techniques to deposits recorded by earlier workers. The re-interpretation of such diverse features as coastal landslips (chapter 17) and gravel terraces (chapter 9 and 10) as the products of widespread glaciation as propounded by Kellaway and his co-workers in the 1970's finds no support in this volume, following its dismissal by Jones (1981, 191-196). In the latest reviews of Quaternary glaciations in Britain (Shotton, 1986, and Bowen et al, 1986) there is no suggestion of glacial activity in central southern England.

The present landscape of the area is also of course a product of Late Devensian and Holocene processes, operating upon the legacy of geology which has not been enriched by a surface-dressing of till. Hence the soils of the New Forest for example are the product not just of 15,000 years of weathering, but of successive climatic stages during most of the Quaternary, (chapter 3), and the many valley mires and coastal peat beds developed in the area at least allow us to paint a coherent picture of Devensian Lateglacial and Holocene times (chapters 2,7,8,12,16,19 and 20). Finally, one is always aware of the presence of the sea in the area, whether as a result of its ancient incursions (Everard, 1956, Jones 1981), its former level relative to the land (chapters 13 and 16), or its relationship to the well-known Chesil Beach (chapter 14) and Solent River system (chapter 15). The present coastline is one of the most varied in Britain in such a small compass, but whether one studies the spectacular cliffs around St. Catherine's Point (chapter 17), or the quiet backwaters of Poole Harbour, one is acutely aware of the influence of earlier Quaternary events.

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LONG SLADE BOTTOM, NEW FOREST: PREHISTORIC FARMING AND COLLUVIAL HISTORY

by

J.A. Catt, K.S. Reynolds and P.J. Reynolds

The major NW-SE dry valley of Long Slade Bottom (SU266009) dissects the large flat area of Plateau Gravel at 60-63 m O.D. known as Wilverley Plain. On either side of the valley the Plateau Gravel rests on outliers of basal Osborne and Headon Beds (Oligocene), but the sides and floor of the valley are cut into Barton Sands (Eocene). A narrow strip of peat occurs on the valley floor to the south-east, but higher up the valley the floor is covered by silty colluvium. Upper parts of the valley side are covered by a periglacial slope deposit derived from Oligocene beds and Plateau Gravel. Long Slade Bottom is one of the New Forest 'lawns' created by cultivation of the better quality soils in World War 2, and maintained since by grazing.

THE PREHISTORIC EMBANKED ENCLOSURE

On the north-eastern side of the valley at 49-53 m O.D. a low earth bank 599 m long marks the complete SW margin and portions of the SE and NW margins of an ancient rectangular or possibly triangular field or enclosure (Fig. 1). The minimum area of land enclosed seems to have been approximately 5.65 ha, but could have been much more. The embankment is 2-3 m wide and about 0.5 m high, with a shallow ditch on the outer side. It has probably been degraded since construction, and erosion continues today along small rills probably initiated by the passage of stock to and from the re-seeded pasture lower in the valley. Approximately 80 similar embanked enclosures are known throughout the New Forest; from soil pollen evidence their ages range from Bronze Age to Mediaeval (Tubbs and Dimbleby 1965).

The exact age of the Long Slade Bottom enclosure is uncertain. An uncorrected radiocarbon date of 3265 ± 90 years BP (I-11,845) was obtained on humus from the buried soil beneath the bank at point A (Fig. 1), but this includes the mean residence time of the soil organic matter at the time of burial. This error could be as much as 1500 years or even more, suggesting that the soil was buried some time between the early Bronze Age and late Roman period. Pollen assemblages from the Ah horizon of the buried soil (Fig. 2) suggest that when the bank was built the vegetation nearby included birch-hazel woodland with some oak, lime and alder, also some open grassy areas with ferns and occasional heath species. The abundance of hazel pollen suggests that the soil was buried before a drastic decrease in hazel, which occurred in the New Forest soon after the Iron Age. The absence of pine pollen in the buried soil indicates burial before the late 18th Century A.D., when pine was reintroduced into the New Forest.

The purpose of the enclosure is also obscure. A few grains of cereal pollen were found near the top of the buried soil, but these do not necessarily indicate cereal-growing at the site. Other ancient New Forest enclosures, which were probably used for

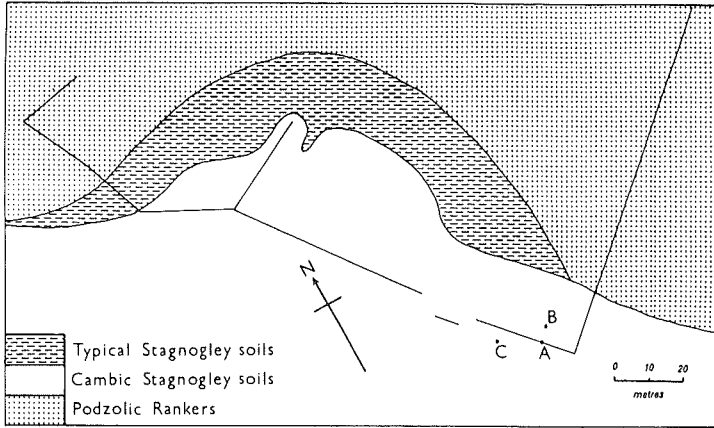


Figure 1 Soil map of Long Slade Bottom enclosure

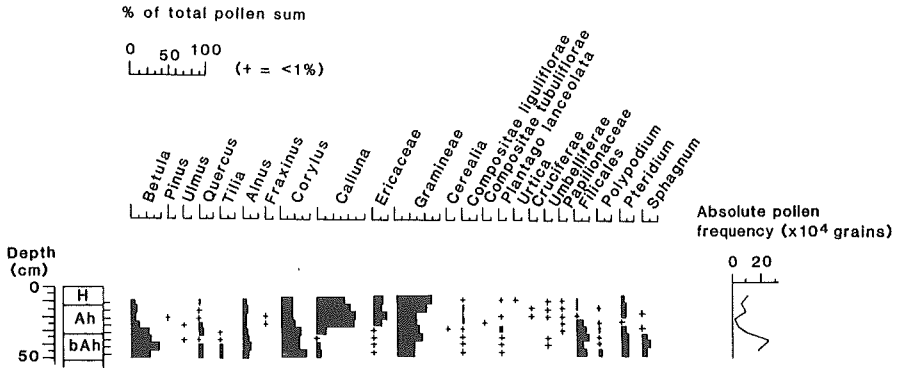


Figure 2 Pollen frequency through embankment and buried soil at Site A, Long Slade Bottom

stockading animals at night after grazing in the forest by day, show slightly increased soil phosphorus levels (Reynolds and Catt, in press), but the soil within the Long Slade Bottom enclosure has a similar range of phosphorus contents to the soil outside. Detailed particle size analyses of samples through a profile within the enclosure (site B of Fig. 1) suggested that the soil had been homogenized to about 20 cm depth, possibly by cultivation, because the same horizons of a profile outside the enclosure (site C of Fig.1) had more variable particle size distributions. But it would be wrong to base a theory of cultivation over the whole site on the evidence of two single profiles, and wrong to assume that soil cultivation was the only activity within the enclosure.

The main scientific value of enclosures such as the one at Long Slade Bottom is the evidence they provide for late Holocene soil and vegetation changes in the New Forest. At sites B and C (Fig.1) the unburied soils are cambic stagnogleys (Avery 1980) in thin loess over the solifluction deposit derived from Oligocene beds and Plateau Gravel. Similar soils occur beneath the embankment (site A) and over south-western parts of the enclosure, but are replaced northwards and eastwards by podzolic rankers on Plateau Gravel; a narrow zone of typical stagnogley soils lies between the two (Fig.1). Although all horizons down to about 50 cm depth in the profiles at sites B and C are very acidic (pH 3.4-4.2), the amounts of pyrophosphate-extractable Fe and Al are small (0.03-0.27%) and do not change regularly with depth, indicating that little or no podzolisation has occurred. The amounts in the embankment above the buried soil at site A are somewhat greater than this (0.35-0.98%), and some Al and a little Fe have moved downwards into the buried humic topsoil (bAh horizon), thus conferring some B horizon characteristics on the bAh horizon. Since it was built the bank has therefore been weakly podzolised, probably because it was raised above the level of the surrounding soil and better drained. But the profile does not yet have the field morphology of a podzol.

The podzolic rankers on Plateau Gravel are at present dominated by Calluna vulgaris, but on the cambic stagnogley soil this is accompanied by Erica tetralix and Agrostis setacea. The typical stagnogley soil also supports Eriophorum angustifolium, Narthecium ossifragum and Drosera rotundifolia. Although the present vegetation shows that all three soil types in the area are now moderately or strongly acid, comparison of the pollen from horizons in the bank at site A (Fig.2) with that from the bAh horizon beneath the bank suggests that changes in vegetation resulting from increasing acidity have occurred since the bank was constructed. In particular, Calluna and Ericaceae pollen are both much more abundant in the bank than in the buried soil, and Tilia, which requires neutral conditions with a mull humus, has disappeared from the area since the bank was built. The spectra from the buried soil are clearly mixtures of pollen from vegetation on neutral, poorly drained and acidic soils. These mixtures suggest that some of the nearby soils (probably the stagnogleys) were much less acidic when the bank was constructed

than they are today. Similar evidence has been obtained from profiles through the embankments of other New Forest enclosures, and suggests that heathland vegetation accompanied by soil podzolisation has expanded gradually in the New Forest during the late Holocene, probably commencing much earlier on the Plateau Gravel soils than on other parent materials (brickearth, solifluction deposits and Palaeogene sediments). However, the amount of podzolisation since construction of the most recent embankments (probably dating from the time of the Napoleonic Wars, 1789-1815 A.D.) has been very small. This suggests that, unlike podzolisation in other areas, it is little influenced in the New Forest by recent human activities.

Where pollen has been studied in embankments and buried soils at Long Slade Bottom and other New Forest sites no evidence has emerged for major changes in land use since the Bronze Age. The overall patchy vegetation pattern of deciduous woodland interspersed with open areas of ferny grassland and heath, which is known from historical evidence to have persisted since appropriation by the Crown in 1079 A.D., can be traced back to at least 1500 B.C. The enclosures were established in clearings and other open areas mainly for protected grazing. Those dating from Mediaeval and Napoleonic times must have been primarily illegal extensions of existing farmsteads or other encroachments onto Crown property.

THE VALLEY FLOOR COLLUVIUM

Most of the valleys dissecting Wilverley Plain have weakly stratified colluvium mantling their footslopes. In Long Slade Bottom and on other valley floors this colluvium contains a buried Ah horizon that marks a former ground surface (Fig. 3). The colluvium is thickest (1.2 m) immediately downslope of the prehistoric embanked enclosure, where profile D may be examined. The sediments are mainly sandy loams or sandy silt loams, indicating derivation from the aeolian Late Devensian Brickearth which covers the Plateau Gravel. However, sharp textural discontinuities occur, and occasional loamy sand layers are derived from the Barton Sands.

The upper 56 cm of the profile D is stoneless and varies in colour from very dark greyish brown (10YR 3/2) in the Apg horizon, to yellowish brown (10YR 5/4-3) with strong brown (7.5YR 4/6) mottles in the Bw(g) horizon below. This overlies the buried soil in older colluvium at 56-73 cm; the bAhg horizon is very dark grey (10YR 3/1).

This sections of both the buried soil and the younger colluvium above show a texturally heterogeneous fabric caused by alternating 1-2 mm thick laminae of tightly packed, well sorted silt grains and less well sorted mixtures of sand and silt. The buried soil contains rare undisturbed yellowish brown argillans, indicating some illuviation of clay.

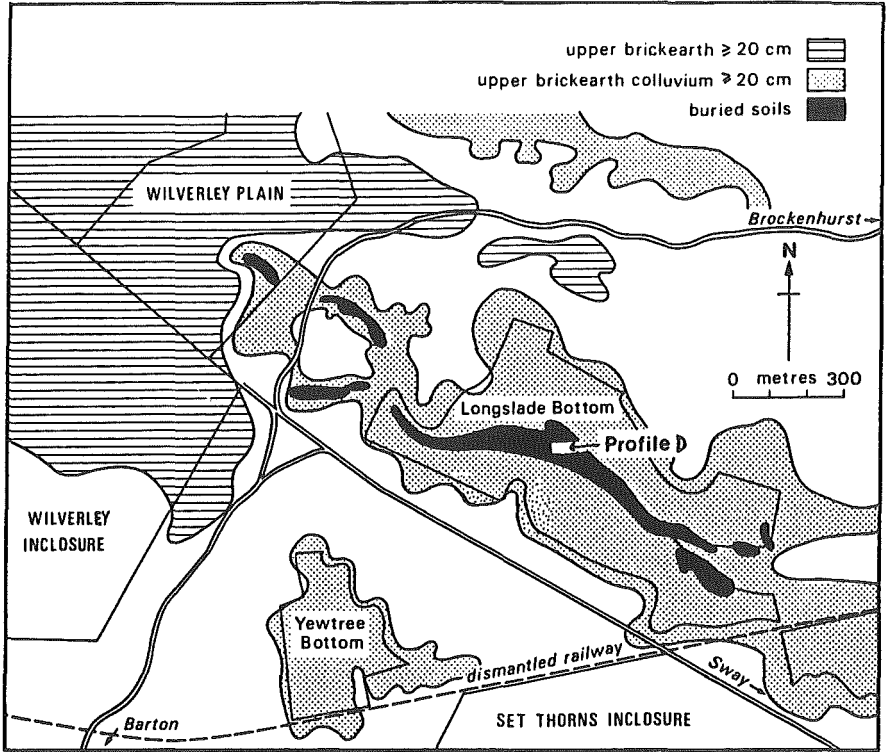


Figure 3 Map of Long Slade Bottom to show distribution of brickearth, buried soil in older colluvium, and younger colluvium

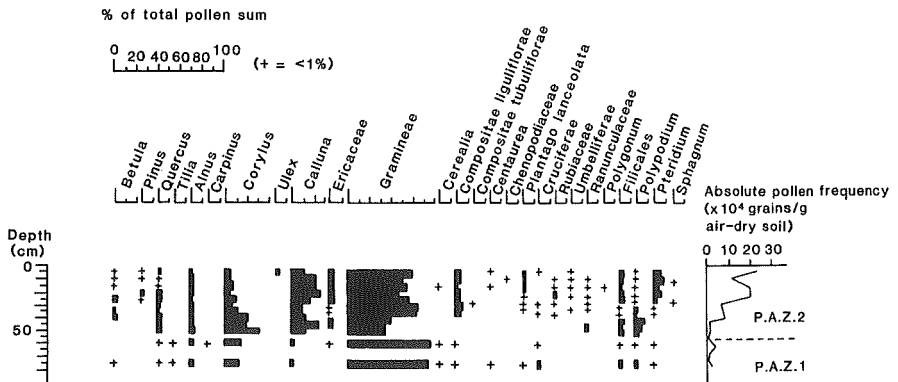


Figure 4 Pollen frequency through profile D, colluvium with buried soils at Long Slade Bottom

The profile is divisible into two Pollen Assemblage Zones (Fig.4): P.A.Z. 1 is dominated by Gramineae-Corylus and corresponds to the buried soil, and P.A.Z. 2 is dominated by Gramineae-Calluna and represents the upper part of the profile. In P.A.Z. 1 the pollen frequency peaks at 60 cm depth, just below the buried surface; the arboreal pollen content is only about 20%, and features Corylus with lesser amounts of Alnus, Carpinus, Tilia and Quercus. It also contains Cerealia type pollen and various arable and pastoral herbs, such as Cruciferae, Compositae liguliflorae, Plantago lanceolata and Centaurea. The pollen frequency in P.A.Z. 2 generally declines downwards from the ground surface, but a small peak at 15-20 cm probably results from inversion of the surface layer during cultivation. A smaller second peak at 35 cm may represent a former short-lived land surface. Below this depth arboreal pollen forms 23-41%, and is dominated by Corylus, Carpinus, Betula and Quercus, whereas above it is only 8-18% and also contains Pinus. Arable and pastoral herbs, such as Cruciferae, Rubiaceae, Ranunculaceae and Centaurea, are also more abundant above 35 cm.

The dark colour, laminations, stonelessness and Bw horizon are typical features of colluvial soils. The pollen analysis indicates at least two separate stillstands in colluviation, one represented by the buried soil and the other during deposition of the overburden. The earlier of these must have occurred between 2900 years B.C. and the 18th Century, given the absence of elm, which disappeared around 2900 B.C. on the Isle of Wight (Tomalin and Scaife 1980), and the absence of pine which was first planted in the New Forest two hundred years ago. The presence of lime (Tilia) suggests an early Sub-Atlantic date for the buried soil, and this is supported by the presence of hornbeam, which first became common in southern England around the Late Bronze Age/early Iron Age transition at 550 B.C. (Pennington, 1974; Tomalin and Scaife, 1980). However, the lower colluvium itself may have been deposited earlier, as it contains argillans and most Flandrian clay illuviation is thought to have occurred before or during the Atlantic period (Weir et al, 1981). The low content of tree pollen dominated by hazel indicates that the site was not wooded and subject to human interference. The cereal pollen and arable and pastoral herbs suggests that agriculture was practised nearby.

The increase in tree pollen during the later stillstand in P.A.Z. 2 could mean either that woodland regenerated at this time, or that this phase of colluviation was initiated by the expansion of agriculture onto wooded land upslope. The second stillstand occurred between the Late Bronze Age/early Iron Age and the 18th century.

The link between prehistoric agriculture, soil erosion and the formation of colluvium has been well documented. Here, as elsewhere in southern England, clearance of vegetation on slopes for cultivation left the unprotected soil surface open to erosion. The laminae in the colluvium are comparable to those in loess-derived slope deposits in the Low Countries (Mucher and De Ploey 1977; Mucher and Vreeken 1981), and indicate fluvial deposition by flow without splash and by rainwash. The palynological evidence for several episodes of deposition demonstrates repeated instability of the Long Slade Bottom slopes during the later Flandrian.

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HOLBURY GRAVEL PIT: DEPOSITION AND WEATHERING FEATURES OF PRE-DEVENSIAN BRICKEARTHS

by

P.J. Reynolds

The Quaternary brickearths of the New Forest have been subdivided broadly into Late Devensian aeolian deposits and various pre-Devensian 'paleoargillic' soil horizons (Reynolds, 1985). Holbury Gravel Pit is the only known site in the area where two layers of pre-Devensian brickearths can be seen. It lies on the edge of Beaulieu Heath East at 37m O.D. and is part of the 46m terrace of Everard (1954). The brickearths overlie stratified Plateau Gravel of unknown thickness which in turn overlies Eocene Barton Sands.

DESCRIPTION

The upper of the two older brickearths is a light grey (5Y 7/1) silty clay with common strong brown (7.5YR 5/8) to red (10R 4/6) mottles. Included within it are large (up to 1m³) pockets of flinty gravel with a silty clay matrix. In thin section, the fine particles have been well organised by soil formation to show an omnisepic fabric (Brewer, 1964), 27% of which is composed of silty periglacial fossil aggregates measuring up to 3.5 mm in diameter. These are often surrounded, but never penetrated, by sand grains. The horizon contains egg-yellow illuvial clay which is far more disturbed than the more abundant yellowish-brown illuvial clay. Red (rubified) segregations cover 5% of the section, and these sometimes enclose fossil aggregates containing egg-yellow papules. There is a contorted boundary with the lower deposit.

The lower deposit is a strong brown (7.5YR 5/8) to light yellowish-brown (2.5Y 6/4) clay loam. Thin sections revealed less well organised insepic to masepic plasmic fabric and only 0.5% fossil aggregates. The illuvial clay is equally egg-yellow and yellowish brown and is scarcely disturbed. Red segregations are rare.

INTERPRETATION

The original mode of deposition of the brickearths cannot be determined because they contain no sedimentary structures and their particle size distributions have been considerably modified by clay illuviation and incorporation of fine sand. The micromorphological evidence shows that the upper deposit is pedologically the more complex. Its red mottling and greater content of illuvial clay (43%) suggest that it has undergone more soil development than the lower deposit. The red segregations surrounding periglacial fossil aggregates which contain egg-yellow clay papules indicate weathering during at least two interglacial periods prior to the Devensian. Sand has been mixed into the horizon, probably by periglacial processes, at some time after the formation of fossil aggregates. Horizons with similar pedological features occur locally on terraces in the New Forest, particularly on Beaulieu Heath.

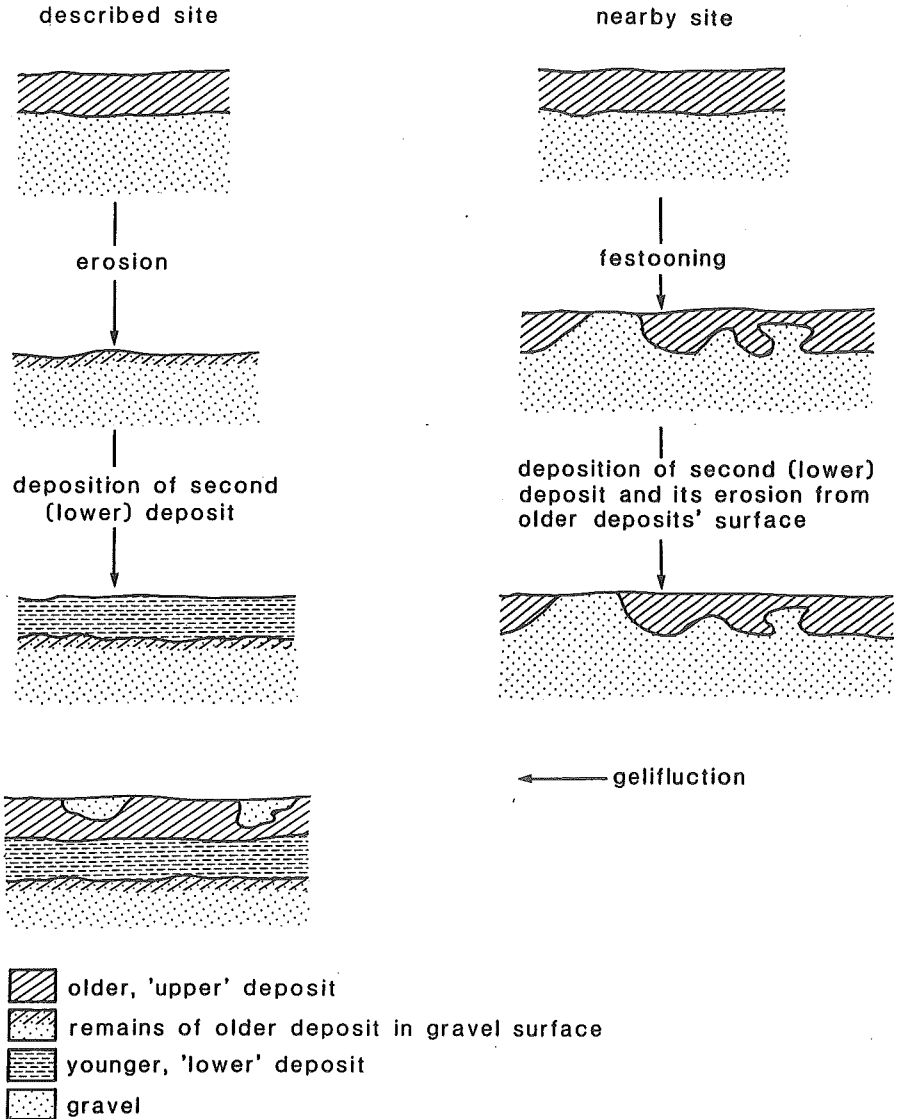


Figure 1 Sequence of events producing two pre-Devensian brickearths at Holbury Gravel Pit

The lower deposit has micromorphological evidence for pedogenesis in only one pre-Devensian warm period, which was characterised by illuviation of egg-yellow clay. This was followed by formation of periglacial fossil aggregates. Similar horizons are widespread on all the New Forest terraces; they are seen for example at Lepe Cliff (Reynolds, this volume). At many other sites these brickearths have not been so strongly affected by sand mixing, and their particle size distributions suggest they were originally deposited as loess. The pedological evidence suggests that normal stratigraphic relationships at the site are reversed, and that the upper brickearth is the older. A similar red-mottled horizon to the upper brickearth could once be seen resting directly on the gravel in other parts of the pit, and in places the colour and texture of the uppermost 10 cm of gravel suggest that a red-mottled brickearth once occurred directly above. This deposit was almost completely eroded, and the lower brickearth deposited on the erosion surface. Subsequent gelifluction probably then moved the older brickearth material from a nearby part of the terrace onto the weathered surface of the lower deposit. This sequence of events is illustrated in Figure 1.

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INTERGLACIAL DEPOSITS AT STONE POINT: THE 1960 INVESTIGATION

by

R.G. West

Pleistocene estuarine sediments on the foreshore at Stone were described by Clement Reid in 1893. In 1957 the same sediments were investigated by West and Sparks (1960), and this investigation was extended to demonstrate the local stratigraphy by Brown et al in 1975. Figure 1 shows the location of the site and of the pollen diagram of Figure 2. A lower gravel, of pre-Ipswichian age, rests on Tertiary sediments, and is overlain by estuarine clayey sediments which include horizons of more organic sediment representing less estuarine conditions. The pollen diagram indicates an Ipswichian (IpIIb) age for these sediments, with Quercus, Pinus, Acer and Corylus important taxa in the local forest vegetation at the time. The stratigraphy, macroscopic plant remains (including Aster tripolium, Beta maritima) and molluscs (including Hydrobia) indicate the sequence was formed under conditions within a tidal regime, and so are informative on IpIIb sea level. Succeeding the temperate stage deposits is a gravel considered by Brown et al (1975) to be part of a later wider fluvial aggradation.

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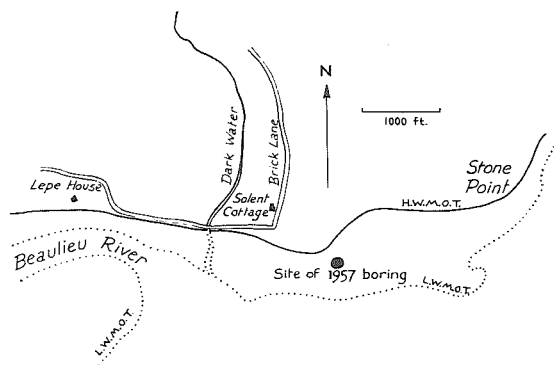
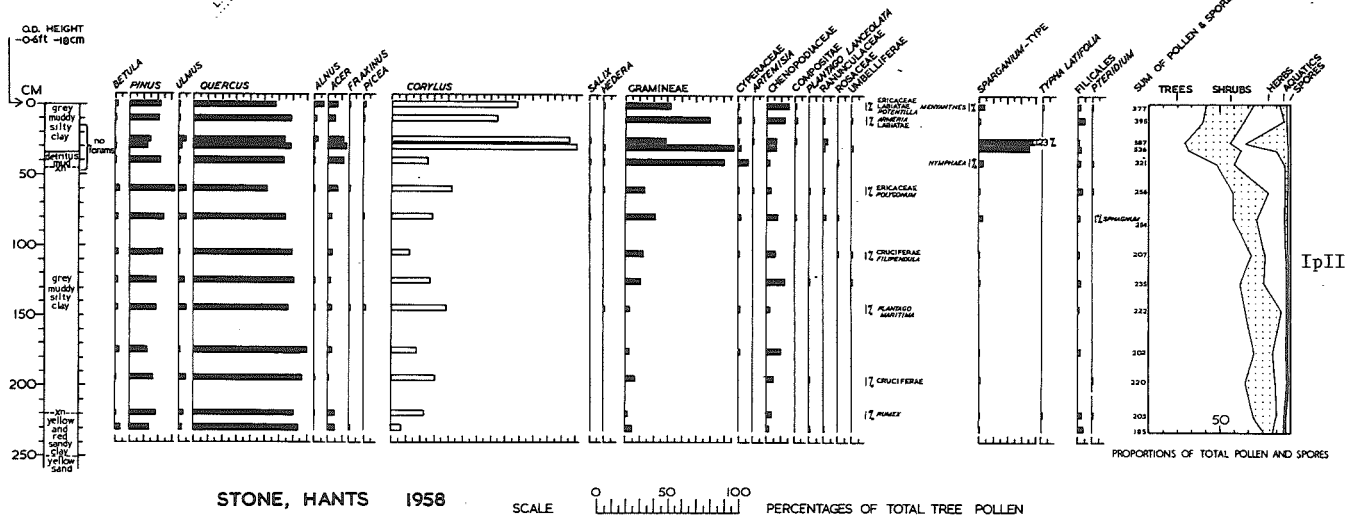


Figure 1 The area of Stone Point, Hants (West and Sparks 1960)

Figure 2 Pollen diagram from Stone Point (West and Sparks 1960)



STRATIGRAPHY AND PALAEOENVIRONMENTS OF THE STONE POINT DEPOSITS:
THE 1975 INVESTIGATION

by

C.P. Green and D.H. Keen

The Pleistocene deposits at Stone (SZ457984) were first described by Reid (1893) and subsequently by Palmer & Cooke (1923), West & Sparks (1960) and Brown et al (1975). Figures 1 and 2 indicate the arrangement of the deposits investigated by Brown et al (1975). On the foreshore, organic clays including several beds of *Phragmites* peat occupy depressions in the surface of an underlying Lower Gravel. In the cliff, the relationship of these deposits to an overlying Upper Gravel can be traced.

The full extent of the organic deposits and the Lower Gravel is unknown, but they are not present at Lepe Coastguard House, 0.6km west of Stone, or at Cadland, 2.0km north-east of Stone. At both these places a low terrace gravel of the River Solent rests directly on Tertiary bedrock, and has a base at approximately the same level as the base of the Upper Gravel at Stone. The Lower Gravel at Stone, and the organic deposits appear therefore to occupy a depression cut in the Tertiaries to below present sea level.

STRATIGRAPHY

Lower Gravel

This is the lowest member of the Pleistocene succession at Stone. In composition (Table 1) it resembles terrace gravels of the former River Solent. A maximum thickness of 2.6 m of gravel was seen in excavations beneath the modern beach without reaching a base. In some places the upper part of the Lower Gravel, a bleached horizon and iron pan resembling parts of a podzolic soil were seen.

TABLE 1 Solent gravels (3.3-6.3mm)

Site	Flint and Upper Greensand	Quartz	Other far- travelled rocks	Sample size
7.6 terrace				
Cadland (2)	77.3	22.2	0.9	514
Sowley	72.8	25.1	2.0	542
Milford	76.0	24.0	0.0	129
18.2 terrace				
Blackfield	77.0	21.1	1.9	270
Hordle	72.6	24.9	2.5	321
Upper Gravel				
Stone	75.3	23.2	1.5	1258
Lower Gravel				
Stone	77.2	21.0	1.8	3935

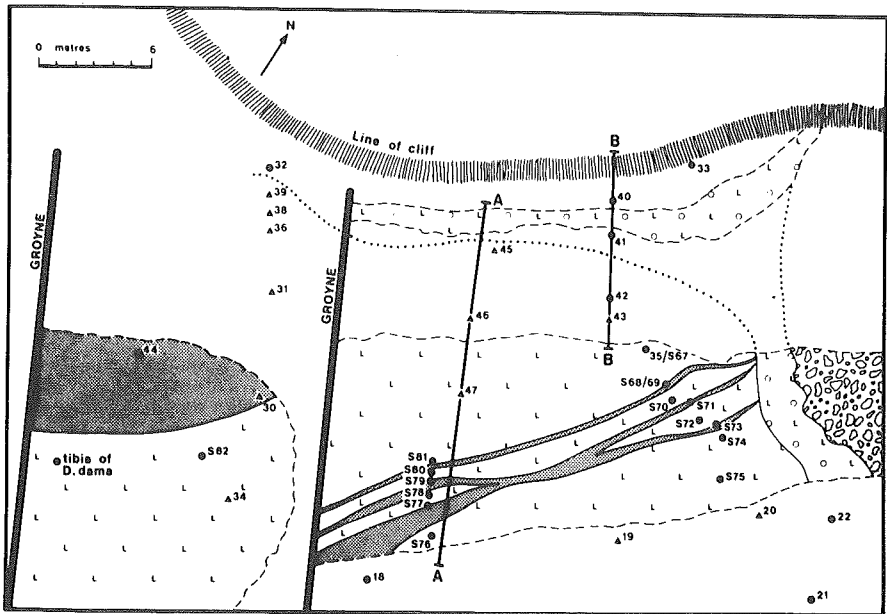


Figure 1 The area of detailed investigation, showing pit numbers and the location of bulk samples (S). Triangles indicate that the full depth of the organic beds was measured; AA and BB mark sections illustrated in Fig. 2 (for key to ornament, see Fig. 2)

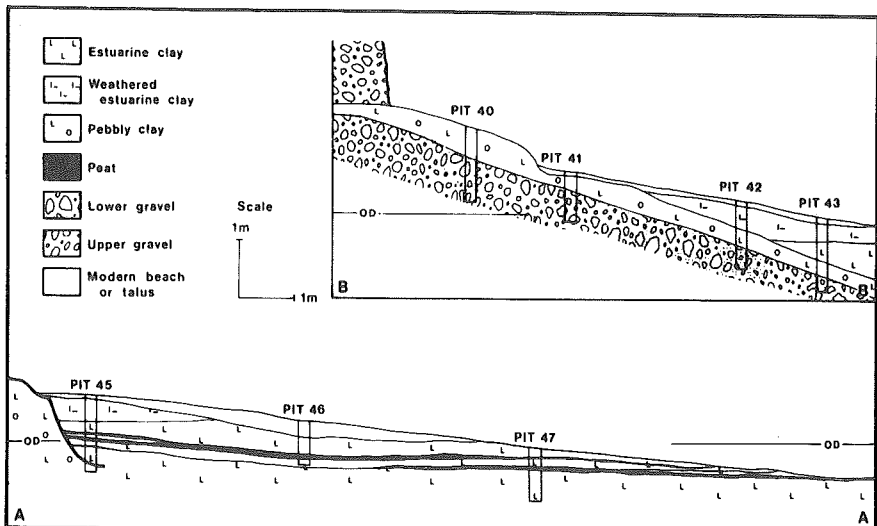


Figure 2 Sections through the Pleistocene deposits

Pebbly Clay

In most places the Lower Gravel is immediately overlain by a thin (0.25m) bed of inorganic pebbly clay.

Organic Deposits

These consist of well-defined peat horizons and lenses between 2 and 24 cm thick with abundant remains of Phragmites, alternating with beds of dark gray estuarine clay. The organic sediments described by West & Sparks (1960) came from a site low down on the foreshore and probably represent a level lower in the succession than those described by Brown et al (1975). The dip of the beds is generally inward at low angles from the edge of the organic deposit. The estuarine clays have yielded molluscan remains, abundant plant macrofossils and a tibia of Dana dana Linnaeus. A maximum thickness of 2.2 m of organic sediment is recorded. The uppermost clays show signs of weathering. Both Reid (1893) and West & Sparks (1960) suggest that the organic deposits pass beneath the gravels exposed in the cliff. This is not now the case in the area investigated by Brown et al (1975), but it is likely to have been when the cliff which has been subject to erosion stood further to seaward. Figure 2 (section AA) shows that the steep landward margin of the depression in which the organic deposits occur outcrops high up on the foreshore. Section BB shows that the Lower Gravel can be traced into the cliff up to a level of about 2.0m OD where it is overlain by the Upper Gravel, without an intervening organic horizon.

Upper Gravel

Composition (Table 1) suggests that this, like the Lower Gravel, is a gravel of the former River Solent. In addition, its surface forms part of a terrace extensively preserved at about 7-8m OD between Calshot and Lymington. Orientation of foreset beds in sand lenses at Stone indicates a current direction from c.280 N. Involutions and stone erection are weakly developed in the upper part of the gravel.

Brickearths

A thin layer (up to 1.0m) of brickearth occurs at the top of the cliff section.

FLORA

The pollen spectra described by West & Sparks (1960) and by Brown et al (1975) suggest that the organic deposits at Stone accumulated in zone IIb of the Ipswichian Interglacial. The presence of Carpinus may indicate a position towards the top of that zone. Quercus forms a large proportion of the tree pollen (47-79%), pointing to the importance of oak woodland in the regional vegetation. Acer is also consistently represented. Plant macrofossils support the pollen evidence, including wood, buds, cupules and fruit of Quercus robur, and fruit of Acer. Remains of saltmarsh species are common in the estuarine clays. In the peats saltmarsh and freshwater species are usually equally represented, suggesting periodic flooding of reed communities, which is also indicated by clay laminae and intertidal Mollusca in the peats.

MOLLUSCA

Brown et al (1975) record four species, all of which are diagnostic of brackish water

Hydrobia ventrosa (Montagu)
Hydrobia ulvae (Pennant)
Phytia myosotis (Draparnaud)
Scrobicularis plana (Da Costa)

The dominant species, *H. ventrosa*, is more frequent today in the upper part of the intertidal zone. The total absence of freshwater and terrestrial species is unusual and indicates that the site was not influenced by freshwater streams while the sediments were accumulating.

DISCUSSION

The earliest Pleistocene deposit at Stone, the Lower Gravel, represents evidence of an aggradation from below present sea level to at least 2.0m above it. The Lower Gravel had accumulated and had already been dissected before the deposition of organic sediments in zone IIb of the Ipswichian Interglacial, but it seems unlikely to relate to the earlier part of the Ipswichian on account of its elevation up to at least 4.0m above the base of the Ipswichian deposits. Accumulation during a 'Wolstonian' interstadial is tentatively proposed by Brown et al (1975).

Early in the Ipswichian the Stone site seems to have been a gently sloping valley side, developed in part on Tertiary bedrock and in part on Pleistocene river gravels. Accumulation of intertidal muds and the development of salt marsh occurred in zone IIb of the Ipswichian as rising sea level caused marine conditions to encroach across this low-lying terrain.

Overlying, and probably truncating, the Lower Gravel and the Ipswichian organic deposits is, or formerly was, the Upper Gravel. This is a typical braided river deposit indicative of rigorous climatic conditions, and presumably of Early Devensian age. Periglacial disturbance of the Upper Gravel, and subsequent brickearth (loess) accumulation can probably be related to Late Devensian climatic rigour.

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LEPE CLIFF: THE EVIDENCE FOR A PRE-DEVENSIAN BRICKEARTH

by

P.J. Reynolds

The low (8m) cliff at Lepe (SZ457984) provides a section through the 5m terrace of Everard (1954). Stratified Plateau Gravel forms the cliff and is underlain by interglacial (Ipswichian?) deposits. Above the gravels lies a 40cm thick layer of brickearth with palaeoargillic features (Avery, 1980), which is in turn covered by 80cm of a younger brickearth displaying a normal argillic soil profile.

DESCRIPTION

The upper brickearth varies from a dark greyish brown (10YR 4/2) sandy silt loam in the Ah horizon to a strong brown (7.5YR 4/6) clay loam in the Bt horizon. It is very slightly flinty throughout, and the sand content (expressed on a clay free basis to eliminate the effects of clay illuviation) increases from 33% in the Ah horizon to 45% in the Bt. Thin sections show a weakly oriented insepic plasmic fabric in the Bt horizon; all the illuvial clay is yellowish-brown, and about 75% of it is in undisturbed argillans.

The lower brickearth is discontinuous and is separated from the upper by a line of flints; it is a silty clay containing 37% clay and only 10% sand (on a clay-free basis). It is strong brown (7.5YR 5/8) and yellowish brown (10YR 5/6), and contains rare, extremely fine, dark red (2.5YR 5/6) mottles. In thin section it has a moderately reorganised masepic plasmic fabric with both yellowish brown and egg-yellow illuvial clay. About 10% of the yellowish brown illuvial clay is undisturbed compared to 43% of the egg-yellow. The soil is very densely packed and made up largely of fossil aggregates or patches of soil with circular (orbiclic) oriented sand and silt grains. The fine sand and coarse silt fractions of this brickearth contain the same minerals as the same size fractions of the upper brickearth, but the amounts of weatherable species (feldspar, muscovite, glauconite, hornblende, chlorite) are much less.

INTERPRETATION

The upper brickearth is a typical example of the aeolian silty sands which mantle the Plateau Gravel throughout south Hampshire (Reynolds, 1985). These are Late Devensian (Wintle, 1981) and part of a sheet of Late Devensian loess extending across southern Britain (Catt, 1978). The south Hampshire deposits are sandier than other loess because the loess-carrying winds deflated sand from locally exposed Tertiary deposits and mixed it with the far-travelled silt. The upward decrease of sand content in the Lepe Cliff brickearth is typical of the New Forest area, and probably reflects diminishing supplies of local sand as the loess covered the Tertiary deposits.

The lower brickearth is clearly distinguishable from the upper on colour, particle size, mineralogy and micromorphology. The micromorphology provides clear evidence that it is pre-Devensian: the egg-yellow clay is typical of pre-Devensian soils, and the fact that it is more disrupted than the (Flandrian) yellowish brown clay points to a period of cryoturbation between the two episodes of clay illuviation. Cryoturbation is also indicated by the fossil aggregates, though as the aggregates contain no papules of egg yellow clay this episode could have occurred prior to the earlier episode of clay illuviation. The smaller amounts of weatherable minerals in the lower brickearth suggest they were removed by a longer period of weathering. If the higher clay content of the lower brickearth can be attributed to weathering and/or illuviation, its particle size distribution suggests it was derived from loess. Several deposits with similar texture and soil characteristics occur on various terrace levels in the New Forest, and this distribution is best explained by aeolian deposition.

The late Ipswichian or early Devensian age suggested for the gravels at Lepe (Brown et al 1975) does not fit the evidence for a pre-Devensian interglacial soil lying above. The various soils at the site suggest instead that the deposits with typical Ipswichian pollen date from a warm period which was separated from the Devensian by a climatic cycle involving periglacial loess deposition followed by interglacial pedogenesis.

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MIRE DEVELOPMENT FROM THE DEVENSIAN LATEGLACIAL TO PRESENT AT CHURCH MOOR, HAMPSHIRE

By

M.J. Clarke and K.E. Barber

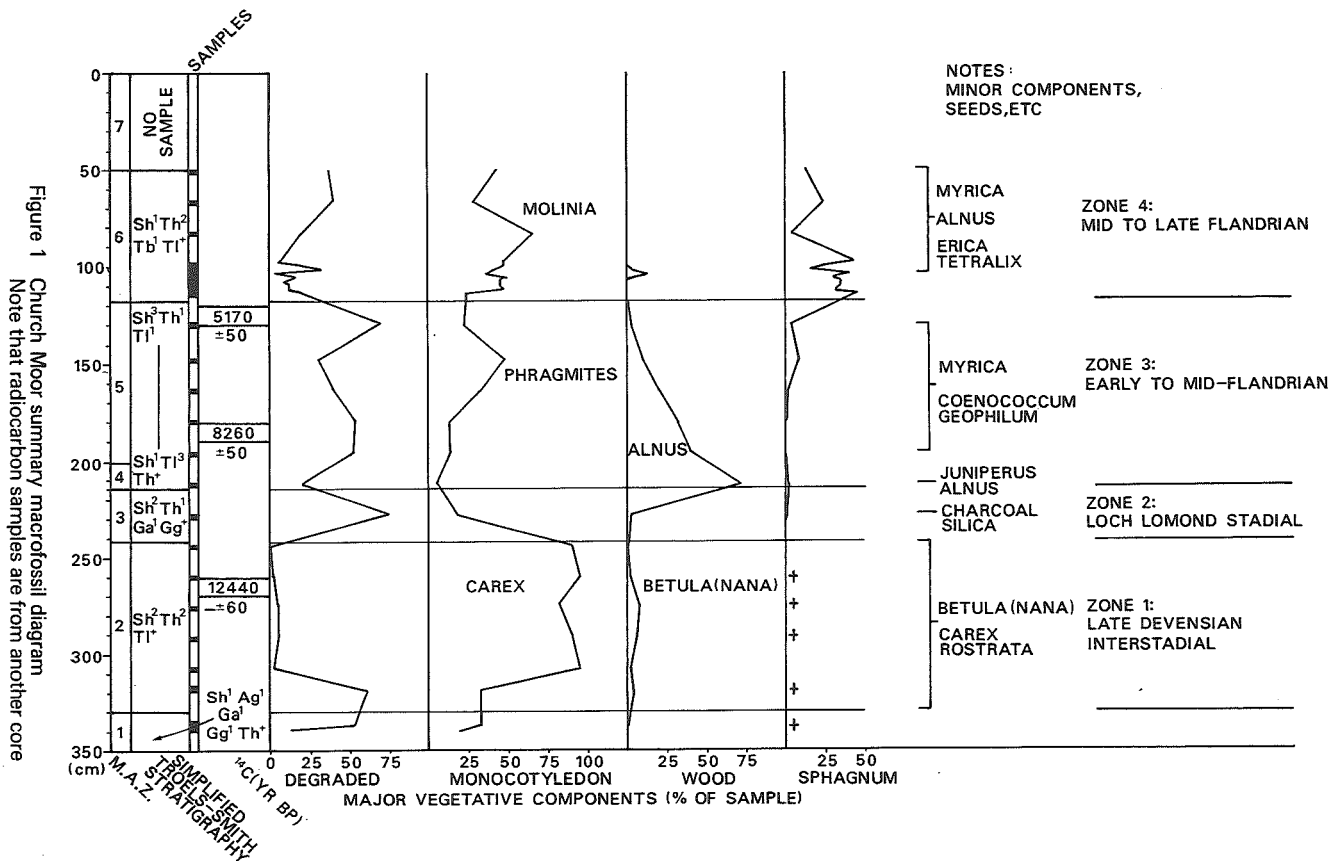
Peat development is a natural interglacial process in the Hampshire Basin. The proximate cause of valley mire formation in the New Forest is the collection of groundwater and throughflow in breaks of slope, hollows and valley bottoms. Bisequal soil profiles are widespread and the generation of lateral waterflow - in relatively permeable horizons over slowly permeable subsoils - is an important factor in determining the development and present distribution of mire vegetation (Clarke and Allen, 1986). Radiocarbon dating and pollen analysis of New Forest mires show that the process of peat inception has operated since the Late Devensian. Peat inception is not synchronous with primary deforestation in any of the sites investigated, and peat formation has commenced at several sites in later prehistory without forest clearance occurring in the catchment. These data falsify the hypothesis that mire formation is due to a direct change in the water budget caused by anthropogenic deforestation. There is a broad temporal correlation between climate change and a regional acceleration in peat inception from about 3600 to 2200 BP. This hypothesis of climatic control can only be tested with independent evidence of local change in effective precipitation.

Church Moor (SU 248068) is a small mire (2.7 ha) in a shallow, woodland valley which forms the headwaters of a tributary to the Dark Water. Today, the main structural feature of the mire is an alder carr, occupying about 25% of the surface, which is displaced to the south-western edge of the mire along the axis of water flow. The peat deposits are mainly 1-2m or less in depth, but accumulations of 2.5 - 3.4m occur locally. The site was first studied by Barber (1975), who described a core taken from within the carr which extended back to the late Boreal chronozone (c.8000 bp). Subsequent investigations located deeper peat, including 1.2m of Late Devensian sediments. Separate cores were taken for pollen and macrofossil analysis.

MACROFOSSIL ANALYSIS

Compared to several other sites in the New Forest, the peat at Church Moor contains a species-rich macrofossil assemblage, particularly of bryophytes. A simplified diagram (figure 1) shows the vegetative macrofossil components together with a summary of other features. The core is divided into four zones for descriptive purposes.

The basal sediment is a strongly-gleyed silty clay with some fine-medium gravel. The sparse macrofossil assemblage is dominated by monocotyledon rootlets, including Carex, which may post-date sedimentation. However, it also includes relatively



well-preserved Sphagnum leaves which must be contemporaneous with sediment deposition. The Sphagna (S. recurvum-type, S. papillosum and S. palustre) are temperate species and are some of the most frequent in the New Forest today.

Most of the Lateglacial peat at Church Moor is characterised by abundant, well-preserved monocotyledon remains, derived mainly from Carex, (zone 1). Associated nuts and utricles suggest that the main species present were C. rostrata and C. paniculata-type. Fruits and cone-scales from Betula pendula and B. nana occur in this zone, corresponding to the Betula pollen phase (figure 2). Numerous leaves of B. nana and rootlets resembling this species indicate that B. nana was growing on the mire between 293 and 243 cm. Size-frequency analysis of Betula pollen, using a Bhattacharya plot (Prentice, 1981), shows a high, but declining, proportion of B. nana pollen in the assemblage during this period, from an earlier peak at 312 cm (not shown in figure 2). The bryophyte assemblage of this zone is also noteworthy, comprising Calliergon cuspidata, Campylium stellatum and Hemalothecium nitens, in addition to sparse Sphagnum remains (species as above). The first two species are common in Late Devensian assemblages (including Colney Heath, Godwin, 1964), and Campylium stellatum is thought have survived in Britain as a periglacial species throughout the Devensian (Dickson, 1973). The third, H. nitens is now restricted to basic flushes and fens in East Anglia, North Wales, Shropshire and scattered localities northwards (Smith, 1978). This species exhibits a wider ecological distribution elsewhere in its range, however, and is one of the commonest mosses of arctic and sub-arctic regions (Dickson, 1973). In summary, the macrofossils show the mire to have been dominated by a tall sedge-dwarf birch community, with a moss groundlayer, throughout much of the Lateglacial period.

A marked change occurs in the macrofossil assemblage at the beginning of zone 2. This corresponds with the relatively abrupt decline of Betula pollen, shortly after 12,440 bp, and the following horizon in which pollen was absent between 236 and 204 cm. Peat humification increases and the amount of degraded material rises rapidly from previously very low levels in the macrofossil assemblage. A number of species disappear from the stratigraphy, denoting their extinction at Church Moor, including Betula nana, Carex rostrata, Scirpus tabernaemontani, Hemalothecium nitens and Campylium stellatum. Inorganic deposition occurred within this zone, forming a silty peat with some fine sand. This contained abundant charcoal fragments, which formed c 1-2% of the sample by volume at 228 cm. The horizon can be traced across the entire area of Devensian peat at Church Moor. The mire probably continued to be dominated by Carex; both Carex utricles and epidermal material are found in this zone. The high proportion of Cyperaceae pollen in the transition to this period also indicate that Carex species were prominent in the local flora. The poor preservation of macrofossils, the absence of pollen and the presence of fire within the catchment all suggest a seasonally dry climate.

Several taxa are recorded for the first time in the beginning of the next zone, and the assemblage most notably includes single macrofossils of Alnus glutinosa (fruit) and Juniperus communis (needle) at 212 cm. The latter may correlate with the Juniperus expansion noted by Scaife (1982) at about 9,900 bp. The presence of Alnus provides macrofossil evidence in support of a local origin for early Flandrian Alnus pollen in the Isle of Wight (Scaife, 1982), Dorset (Haskins, 1978) and the Thames estuary (Devoy, 1979). The high levels of decomposition continue throughout this zone. The peat is initially dominated by Alnus wood from zone 4. As the amount of root penetration by Alnus declines, there is a proportionate increase in monocotyledon rootlets. The latter are poorly preserved but Phragmites australis epidermal tissue was identified in several samples. Myrica gale rootlets also occur frequently. The macrofossil assemblage from this zone is remarkably poor in recognisable remains. The poor degree of preservation is a major factor, but it may also reflect the extremely closed plant community indicated by the low values for non-aboreal pollen at similar depths. The mire surface was probably heavily shaded most of the time, with Phragmites and Myrica as the most probable dominants. The poor preservation shows that the local environment, at least, favoured decomposition processes. Drier conditions are indicated by the abundance of fungal sclerotia from Coenococcum geophilum between 197 and 129 cm, which van Geel (1978) associates only with relatively dry mire surfaces.

Zone 4 is marked by the expansion of two species which are dominant of the present vegetation at Church Moor; Alnus and Molinia. The frequent occurrence of Alnus fruits from 113 cm upwards correlates with a sharp increase in Alnus pollen at 118 cm (dated to 5170 \pm 50 bp). This zone denotes the beginning of a mire community which has persisted in a similar form to the present-day. The community was probably dominated by Molinia tussocks with Erica tetralix, Myrica and Sphagna (principally S. palustre) as important components. The macrofossil assemblage includes Eriophorum angustifolium, Rhynchospora alba, Eleocharis multicaulis, Carex echinata, C. demissa, Juncus acutiflorus-type, Potamogeton polygonifolius, Drosera Rotundifolia, and Calluna vulgaris. The assemblage suggests a relatively open environment in the immediate vicinity of the core. However, the carr margin must have been close since wood and bark of Alnus and Betula occur frequently in this zone, with relatively abundant fern sporangia and frond fragments.

An increase in surface wetness around 5200 bp may account for the local expansion of Alnus, the change in mire vegetation composition, and the reduction in decomposition between zones 3 and 4. Local environmental change is also indicated by a temporary increase in herb pollen and a disproportionate decrease in Corylus pollen just before the increase in Alnus. The macrofossil analysis shows that the local mire community and the carr margin have remained stable for the last 5000 years. The persistence of the vegetation pattern may be due to environmental

stability, particularly in the valley mire drainage network, since the stratigraphy of Church Moor shows the stream to have occupied its lateral position along the edge of the mire for much of the Flandrian.

POLLEN ANALYSIS AND CHRONOLOGY

The pollen samples were prepared by the standard method used at the Palaeoecology Laboratory at Southampton (Barber, 1976) and the results are shown in Figure 2, which is a summary diagram only and does not show the full range of herb types. It was prepared by A.R. Tilley during the tenure of a NERC studentship, work which was unfortunately not finished. The present account is therefore provisional and a full recounted diagram is in preparation.

The pollen record begins with zone CHMI, dominated by pollen of birch, grasses and sedges. A radiocarbon date of $12,440 \pm 60$ bp (SRR-1921) places this assemblage firmly in the Devensian Lateglacial Interstadial (Lowe and Gray 1980, Lowe and Walker 1984), and dates a peak in birch pollen of 76% total dry land pollen. This is far in excess of the 10-25% level for the area at 12000 bp according to the isopoll map of Huntley and Birks (1983). However this estimate was based on sites in Devon and Kent and there is no other evidence of vegetational history from so early a date elsewhere in south-central England - the Isle of Wight record, for example, begins during the Younger Dryas/Loch Lomond Stadial, Zone III (Scaife, this volume). Church Moor therefore stands alone in its evidence of Lateglacial Interstadial conditions. From both the macrofossil and pollen-size evidence quoted above it is clear that both dwarf birch and tree birch contributed to the pollen rain. With only 4% Salix and 18% grasses and dryland herbs recorded at the peak of the birch pollen curve it seems likely that quite a dense birch forest existed at Church Moor 12,500 years ago.

This woodland declined, to be replaced by a grass-sedge-herb community and shortly thereafter the pollen record is terminated by the layer of silty-sandy peat with charcoal remains and in this core pollen is not again preserved until after the regional pine pollen zone (Barber and Clarke, this volume) at around 8,300 bp.

Pollen zone CHMII records the decline of this pine forest and the rise of a mixed oak-elm-hazel woodland, with a radiocarbon date of $8,260 \pm 50$ bp (SRR-1920). As noted above Alnus macrofossil material appears for the first time at 212 cm (a single fruit) and the woody component of the peat is dominated by alder roots, which are almost certainly intrusive. Pollen evidence for the local presence of willow, with c.10% DLP, is not matched by macrofossil remains, nor is there any grass pollen peak to match that of Phragmites macrofossils. The presence of Myrica macrofossils cautions against acceptance of a purely Corylus origin for the Coryloid pollen.

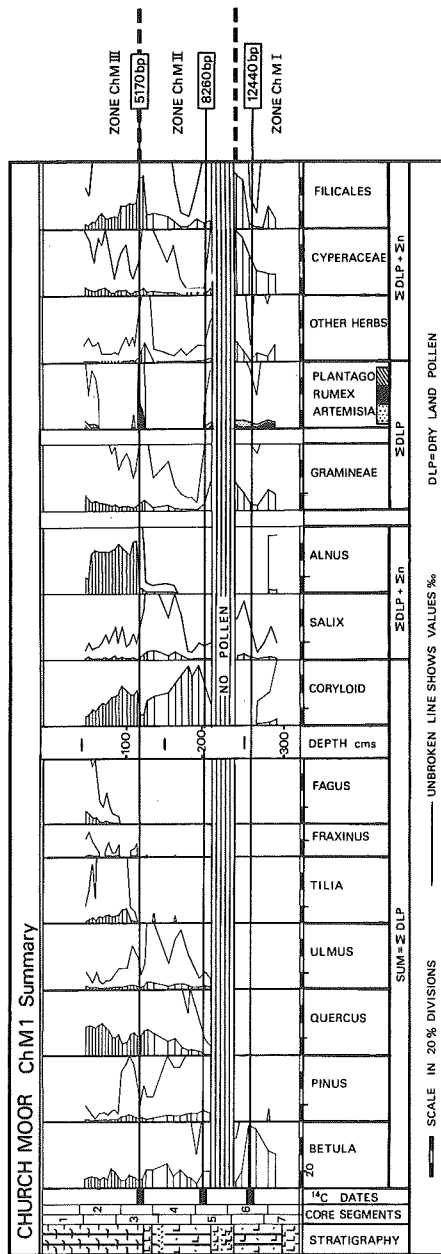


Figure 2 Summary Pollen diagram from Church Moor, New Forest

The opening of pollen zone ChMIII is radiocarbon-dated to 5,170±50 bp (SRR-1919) is associated with a clay-inwash stratum with charcoal and dramatic increases in Rumex pollen, (from 0.5% at 126 cm to 22% at 122 cm peaking at 32% DLP at 118 cm) in other herb pollens and in fern spores. There are falls in elm and other tree pollen values and shortly thereafter lime trees (Tilia) appear to have penetrated the drier woodland while the fall in Salix and the dramatic rise of Alnus point to a change in the dominant trees of the carr woodland. This late rational limit, in the sense of Smith and Pilcher (1973), of alder at Church Moor, compared to Cranes Moor (Barber and Clarke, this volume) and to other sites in Britain (Smith 1984, Chambers and Price 1985) is intriguing. Local site factors - the dryness of the mire noted from the macrofossil evidence above, and the possible occupation of the niche by willow - offer some explanation, and point to rather more localisation of alder pollen in sheltered wooded valleys than has hitherto been allowed for by palynologists. This is reinforced by the radiocarbon dates for the alder rises at Cranes Moor, 7 km to the west of Church Moor, and at Warwick Slade, 2.75 km to the east. The former date, 7000±80 bp (SRR-1916) may perhaps be taken to be the date for widespread regional representation of the species since Cranes Moor (Sphagnum Bog) has no macrofossil evidence of alder growth and is a much larger site with proportionately more extra-local pollen. At Warwick Slade the alder rise is as abrupt as at Church Moor but more than 2600 years earlier at 7,830±100 bp (SRR-2250) - see figure 2 in Barber and Clarke (this volume). Whilst such diachroneity has been established on a regional basis for some time (Smith and Pilcher 1973), these dates infer that some variation, amounting to several centuries, is to be expected over small distances, and especially when small sites are analysed. That the alder rise at Church Moor occurs after a long period of low pollen values (figure 2), the 'empirical limit' of Smith and Pilcher (1973), and especially after the signs of disturbance noted above, adds weight to Smith's (1984) arguments regarding man's influence on the spread of alder in Britain.

Following the alder rise the diagram charts the continued fall of pine pollen to levels indicative of long-distance transport only; low levels of elm pollen compared to that of lime, and the early stages of the expansion of beech (Fagus) into Mark Ash Wood, which surrounds Church Moor and is predominantly composed of beech at present (Barber 1975). Closely-counted pollen diagrams which detail the history of Mark Ash Wood over the past five millennia are in preparation (Barber, unpublished).

CONCLUSIONS

Church Moor is notable for the depth of well-preserved Lateglacial Interstadial peat deposits. This site is particularly significant in the context of the extra-glacial region of southern England, where such sediments are rare. Pollen and macrofossil analyses suggest the co-existence during this period of plant species with contrasting present-day ecological distributions, such as Saxifraga

nivalis and Betula nana (cold), Chrysosplenium and Filipendula (temperate), Ericaceae and Sphagna ("calcifuge") Helianthemum and Hippocrepis ("calcicole"). The end of the Devensian is marked by high biological turnover, with many population extinctions. Church Moor provides evidence for the development of present relict species distributions (eg Homalothecium nitens), and for a different set of ecological interactions governing community composition during the Late Devensian compared with today.

In comparison with raised bogs, valley mires provide only limited evidence of climatic change because of the indirect coupling between mire development and effective precipitation, due to intermediate catchment effects. However, in addition to the Lateglacial, Church Moor does provide some evidence for climatic change which can also be correlated with Cranes Moor (see Barber and Clarke, this volume) during the first part of the Flandrian. Decomposition processes were favoured up to 8260 bp at Church Moor, indicating dry (possibly seasonal) conditions continuing from the Loch Lomond Stadial. The Sphagnum subnitens - dominated mire was dry enough to permit the growth of Calluna on Cranes Moor, later (c 9000 bp) a fluctuating water regime is indicated, similar to that recorded from the Netherlands by van Geel *et al* (1981). A relatively short-lived dry phase is also reported by Scaife (1980) from the Isle of Wight during the first part of the Boreal chronozone. The return of pollen preservation at Church Moor, indicating wetter conditions, is dated to 8260±50 bp. The pool sequence wet phase at Cranes Moor is also estimated as beginning at about 8250 bp. A further increase in wetness appears to have occurred at Church Moor at 5170±50 bp, and this is possibly correlated to a wet shift at Cranes Moor between about 6100 and 5300 bp. Since that time, the peat composition at Church Moor indicates little change in surface wetness of the mire up to the present, just as the pollen evidence indicates more or less continuous woodland cover, despite species changes - eg from oak to beech.

Macrofossil and pollen analyses from the same area of Church Moor can be seen to give interesting complementary information on the development of the mire and its surrounding plant communities. The approach outlined here is especially valuable in valley mires where, unlike the situation on large ombrotrophic mires (Barber 1981), the mire forming vegetation itself can have considerable impact on the pollen record.

ACKNOWLEDGEMENTS

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CRANES MOOR, NEW FOREST: PALYNOLOGY AND MACROFOSSIL STRATIGRAPHY

By

K. E. Barber and M. J. Clarke

This site was the subject of extensive investigations during the 1950's by Newbould (1960) and by Seagrief (1960) who respectively described its present vegetation and water chemistry, and its palaeoecology. It was reinvestigated using modern techniques as part of a programme on New Forest palaeoecology involving A.R. Tilley, whose work was unfortunately left unfinished, and M.J. Clarke, both funded by NERC studentships. Since this work is being written up for publication elsewhere this account presents only summary pollen diagrams which include the salient points and nine new radiocarbon dates.

Cranes Moor is by far the largest mire complex in the New Forest and is rather untypical. It is situated in the far west of the New Forest (grid reference SU 193028) below Burley Ridge which is capped by Headon Beds. The mire is surrounded by, and underlain by, Barton Sand which is heavily podsolised over most of the area and supports heathland with stands of pine woodland. Unlike most Forest mire systems there are no alder carrs and from the top of Burley Ridge the view over Cranest Moor is an excellent analogue for the Boreal period of the early Holocene.

Following earlier workers we refer to the central area, shielded from water flow by two ridges of Barton Sand, as Sphagnum Bog (Figure 1); the large flushed area on the south side of this carries the rather unfortunate appellation Flush Bog, and the smaller flushed area to the north of Sphagnum Bog is called Little Bog. It appears that Sphagnum Bog has remained as an oligotrophic, and at least partially ombrotrophic, Sphagnum - dominated mire throughout the Holocene or Flandrian. Little Bog accumulated monocotyledonous peat at a very rapid rate throughout the Boreal (Seagrief 1960) before developing into a Sphagnum mire in late Boreal - early Atlantic times, while Flush Bog dates back further than either of the other two parts of the site and shows an accumulation of clayey monocotyledonous peats with frequent wood remains before it also develops some Sphagnum cover in late Boreal-early Atlantic times. The very rapid accumulation rates during the early Holocene - up to 4 years/cm between 9,600 and 9,100 bp for example (figure 3) - give an almost unique opportunity of studying the detail of this under-researched period which is often represented elsewhere by a few centimetres of lake mud.

CHRONOLOGY AND POLLEN ANALYSIS

A suite of nine radiocarbon dates were kindly provided by the NERC and are shown in Figure 2 and tabulated below:

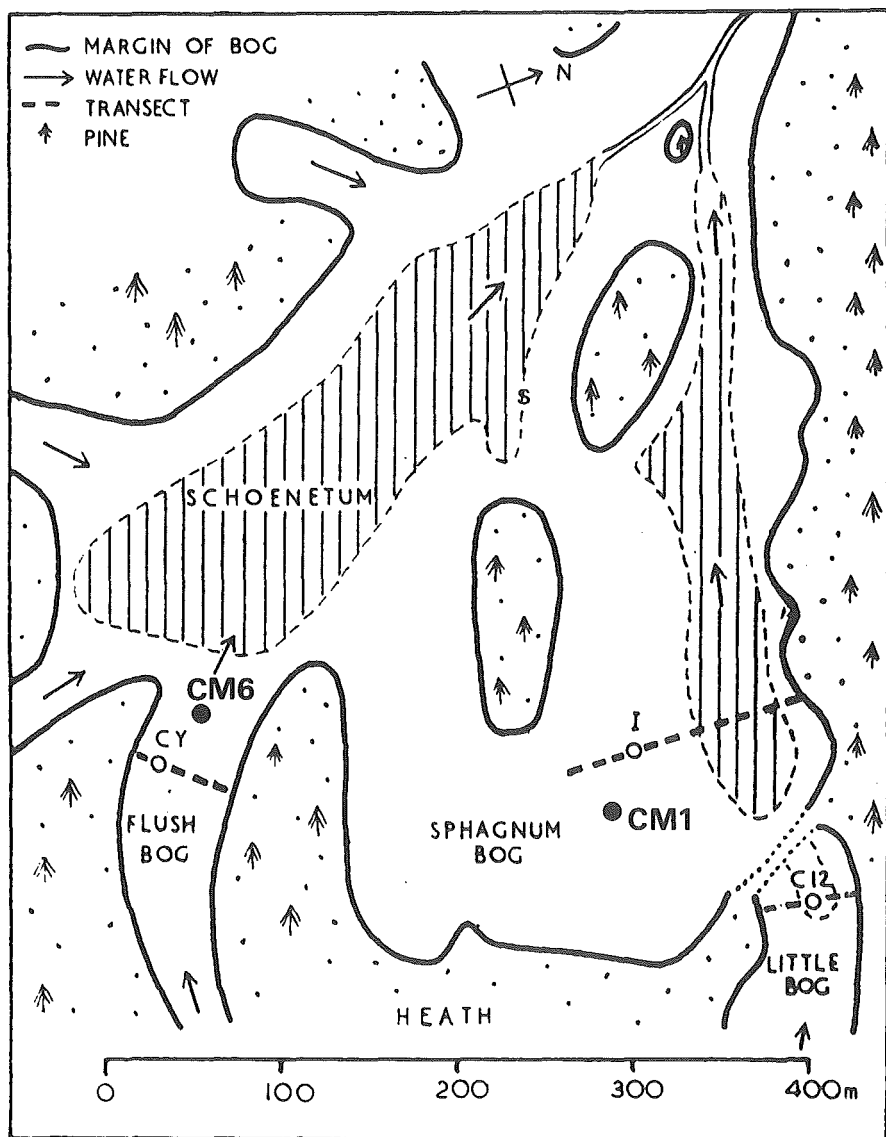


Figure 1 Sketch map showing Cranes Moor Bog

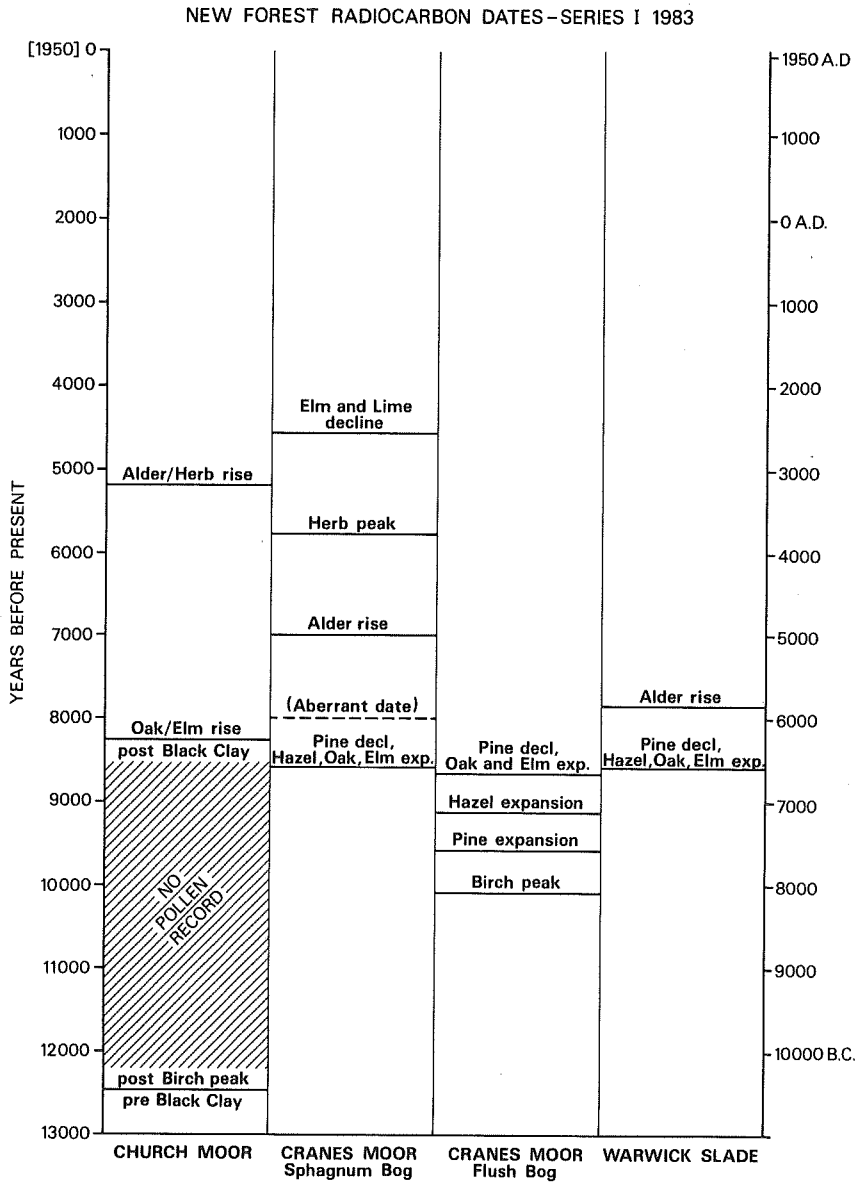
Lab No.	Site & Depth in cm	Age in radiocarbon years	Event
SRR-1914	SB 60-70	4550 \pm 60	Elm decline
SRR-1915	SB 148-158	5750 \pm 60	Herb peak
SRR-1916	SB 238-248	7000 \pm 80	Alder rise
SRR-1917	SB 362-372	8590 \pm 90	Oak/elm/hazel rise; pine fall)
SRR-1918	SB 435-445	8000 \pm 110	(Aberrant)
SRR-2126	FB 100-104	8630 \pm 60	Oak/elm rise, pine fall
SRR-2127	FB 160-164	9110 \pm 60	Hazel rise
SRR-2128	FB 275-279	9570 \pm 60	Pine rise
SRR-2129	FB 316-320	10070 \pm 60	Birch peak

SB = Sphagnum Bog; FB = Flush Bog

The samples were taken with a 10cm diameter Russian corer (Barber 1984) and the larger samples from Sphagnum Bog reflect the unhumified nature of the almost pure Sphagnum peat. Apart from SRR-1918 these dates form a coherent series and together with those reported by Haskins (1978) from the Poole Basin, Scaife (1980 and this volume) from the Isle of Wight, and Waton (1982a, b, and this volume) from various sites bordering the Chalklands, will allow a coherent regional vegetational history to be erected. The two pollen diagrams presented here (figures 3 and 4) show selected pollen curves only for clarity and agree well in their main features with Seagrief's (1960) findings.

Both diagrams open with peaks of birch pollen at or shortly after the Devensian/Holocene border, the date from Flush Bog being 10,070 bp. Grasses are also high at this level as are a number of weeds and ruderals indicating an incomplete forest cover - eg *Artemisia*, *Rumex*, *Plantago* and *Ericales*. The date from Sphagnum Bog of 8000 \pm 110 bp (SRR-1918) is clearly aberrant in dating this early Holocene period - it is considerably younger than SRR-1917 which is from peat 73 cm above, and extrapolation of the age/depth curve from dates SRR-1914 to 1917 would suggest an age of about 9,800 bp, whilst correlation of pine and birch pollen curves would suggest a slightly younger age. There are also small amounts of lime and elm pollen in the deposit which gave this aberrant date, suggesting contamination with younger material and/or reworking.

Pine pollen rises strongly in both pollen diagrams around 9600 bp and is dominant for about 1000 years, during which time *Salix* carr developed over Flush Bog, and herbs of open ground diminished markedly. This is in accord with the data presented by Bennett (1984). The decline of pine c.8600 bp appears to be a synchronous event throughout the New Forest - besides the two dates from Cranes Moor, there is a date of 8590 \pm 120 bp (SRR-2251) from Warwick Slade Bog, and this time zone also sees the expansion of oak, elm and hazel. The latter taxon expands first at Flush Bog, at 9110 bp and with the higher rate of peat accumulation and thinner radiocarbon samples from this site it is probably correct



All dates courtesy of NERC Radiocarbon Laboratory

Figure 2 New Forest radiocarbon dates, Series I

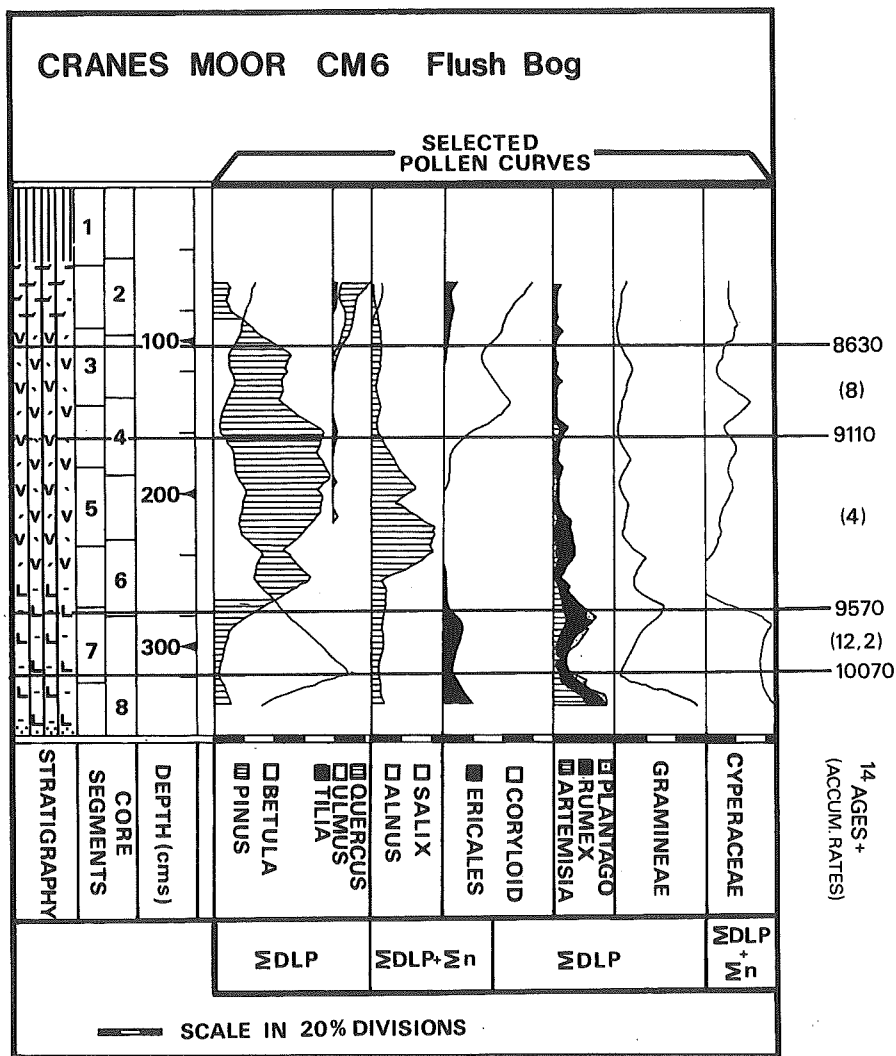


Figure 3 Pollen diagram from Cranes Moor, Flush Bog

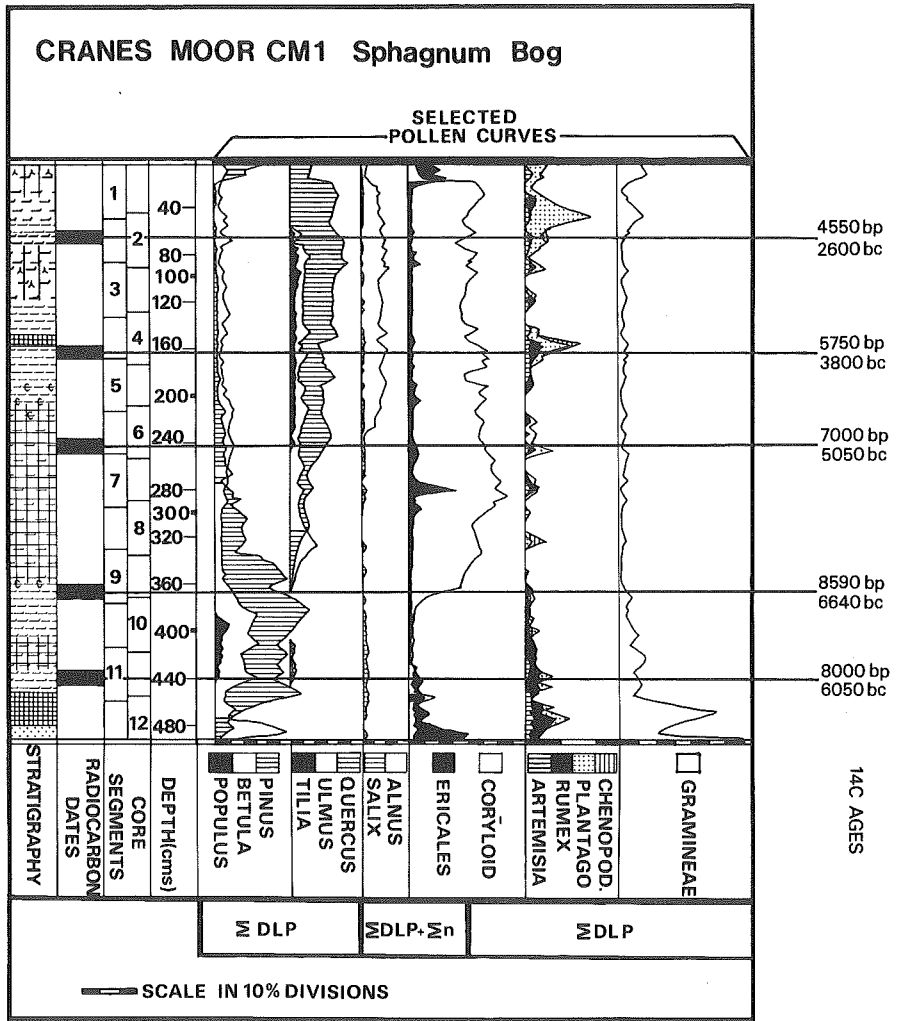


Figure 4 Pollen diagram from Cranes Moor, Sphagnum Bog

to see the date of 9110 bp as the true rational limit of Corylus, a date which puts it in the early part of the range of dates plotted by Smith and Pilcher (1973) and by Deacon (1974). With the expansion of these thermophilous trees, the decline of pine to levels below 20% and the beginning of the alder curve shortly thereafter, the record at Flush Bog is truncated by signs of peat-cutting and disturbance in the form of black oxidised surface peat.

The whole of the Cranes Moor mire complex shows signs of extensive peat cutting (Barber 1981). The pools on the surface of Sphagnum Bog are superficially natural and were taken to be so by Ratcliffe (1977), but closer examination and the use of coring equipment shows them to be steep-sided and with a number of rectilinear facets, whilst aerial photographs clearly show their artificial arrangement. Further field evidence lies in layers of sand underlying two causeways of drier peat which extend out onto the bog towards the main pool area. On the landward side the causeway which extends westwards over Sphagnum Bog links to an eroded trackway up onto the heathland. Clearly the sand was laid over the peat to give a drier footing and, although as Tubbs (1986) notes, there is little documentary evidence of deep peat diggings, as opposed to stripping off the turf of the heathland for fuel, there can be no doubt that Cranes Moor has been heavily cut, back to the Subboreal and Atlantic levels in the peat.

The record of Sphagnum Bog continues undisturbed to about 20 cm below the present surface. The next major event is the rise of alder and the empirical limit of lime at about 7000 bp. This date is very similar to the same events at Red Moss, Lancashire (Hibbert, Switsur and West 1971), and in accord with data from elsewhere in Britain (Smith and Pilcher 1973, Huntley and Birks 1983). There are a number of small peaks of herbaceous and ericaceous pollen types during mid-Holocene times. Whilst an anthropogenic interpretation of these is possible, in view of the possible predeliction of Mesolithic peoples for sandy areas such as Cranes Moor (Jacobi, 1981), they could also be due to local changes on the mire surface and margins.

By around 6000 bp the pollen curves of the major tree taxa have reached steady values indicating a mixed oak forest, with substantial amounts of hazel and with pine pollen reduced to long-distance travel proportions. It seems extraordinary in view of the success of pine today in the New Forest, and on the Barton Sand around Cranes Moor itself (see front cover photograph), that it should become extinct in the area, and not have persisted around bog margins, even if in a depauperate state. However, the historical records are clear - until its reintroduction in 1776 AD pine was not part of the Forest flora in historical times, and the sharp increase in its pollen at about 20 cm in most uncut Forest mires serves as a useful datum in studies of later Holocene palaeoecology (Barber 1975, 1981).

The two youngest radiocarbon dates on the Sphagnum Bog profile are probably connected with man's activity. The first, at 5750 bp, dates a sharp peak of herb pollens associated with a fall in oak

values, and is referable to either late Mesolithic activity or earliest Neolithic clearances. The second, dating a pronounced elm and lime decline at 4550 bp (2600 bc) is rather later than the elm decline elsewhere (Smith and Pilcher 1973) but similar late dates have been reported from Dorset (Haskins 1978) and the Isle of Wight (Scaife 1980 and this volume). The increases in herbs and grasses at this time point clearly to an anthropogenic explanation, though an element of elm disease cannot be excluded (see review and maps in Huntley and Birks, 1983).

MACROFOSSILS

Macrofossil analysis has divided the core into seven zones:

- M z.1 : 500-484 cm: the sub-peat sediment
- M z.2 : 484-456 cm: the "Nivea" layer
- M z.3 : 456-406 cm: Sphagnum phase
- M z.4 : 406-340 cm: Molinia phase
- M z.5 : 340-116 cm: pool sequence
- M z.6 : 116-15 cm: Molinia - Sphagnum - Erica tetralix phase
- M z.7 : 15-0 cm: recent peat accumulation

At least 16 cm of fine sand accumulated before peat preservation. A wide range of macrofossils are incorporated within this unit (M z.1), including Calluna, Juniperus, Juncus acutiflorus - type and several species of Sphagna. The base of this zone is thought to date to 10100 bp from the pollen spectra, correlation with Flush Bog and the radiocarbon age-depth profile of the core.

Following Seagrief's (1960) description of white basal muds resembling face-cream, the deposit within M z.2 has become known as the "Nivea" layer. The sediment matrix was found to be an amorphous aluminosilicate, subsequently identified as proto-imoglite allophane (J.A. Catt, pers.com). The macrofossils of this zone are transitional between the Calluna dominated community of M z.1 and the subsequent Sphagnum - dominated mire, and appear to be partially mineralised; the boundaries of this zone are defined mainly by inorganic features. The deposition of the Nivea layer is diachronous across the peat base, and it therefore post-dates peat deposition. In this core, it occurs between pollen peaks of Betula followed by Pinus, with high frequencies of grasses and herbs. Correlation with Flush Bog indicates a date of c.9600 bp for the lower part of this zone. In Seagrief's (1960) core, this deposit occurs after the expansion of Pinus with rising Corylus - the same event has been dated here to 8590 \pm 90 bp. The proto-imoglite allophane is possibly derived from acidic weathering of muscovite which is a component of the underlying Barton Sand (including M z.1) in the Cranes Moor area. The deposits are suggestive of a process involving the movement of groundwater containing proto-imoglite allophane along the basal peat-sand interface, some time after peat formation had begun, rather than in situ weathering. This may be of significance to the recent debate on podzol formation (Buurman & van Reeuwijk, 1984; Farmer, 1984 and references therein), particularly the

origin of allophane is Bs horizons of podzols (see also Farmer *et al.*, 1985).

The Nivea layer grades into Sphagnum subnitens - dominated peat (M z.3) which is initially granular in texture, similar to that described by Seagrief (1955). This zone spans the first half of the Pinus pollen phase, between about 9500 and 9000 bp. Towards the middle of M z.3, at 422 cm, the peat is more humified. Calluna returns to the macrofossil assemblage, followed by Polytrichum sp. and Sphagnum subnitens, indicating a shift to drier conditions on the mire surface. There is increasing rootlet penetration by Molinia towards the top of the zone. Subsequently Molinia and Sphagnum tenellum invade the mire (M z.4) and, although Molinia is not abundant in absolute terms, the amount of above-ground remains suggests that it was an important component of the community. Both these species may have been favoured by a more fluctuating water regime. This zone spans an estimated period from 9000 to 8250 bp, based on the radiocarbon sample from 362-372 cm.

Between 340 and 116 cm (M z.5) a series of sediments occur which are dominated by Sphagnum subnitens, Sphagnum of section Subsecunda (cf S. auriculatum var auriculatum) and algal muds. These were formed in bog pool, and later in wet lawn environments which were interspersed by two, shorter dry shifts between 256 and 240 cm (7000 \pm 80 bp) and 200 and 180 cm (c 6100 bp). This pool sequence is correlated with changes elsewhere on the mire (Seagrief, 1955). Together, these indicate a greater differentiation of the mire surface into hummock and hollow communities due to increased wetness following c 8250 bp, coupled with a diversification of the Sphagnum assemblage.

The wet lawn phase is terminated by the accumulation of more decomposed peat (M z.5). The macrofossil assemblage in this zone suggests a drier community dominated by Molinia, Sphagnum and Erica tetralix. This is also indicated by the associated high levels of fungal hyphae present (Middeldorp, 1984). Traces of sub-angular sand occur at 69-71 cm, coincident with the Ulmus decline which is dated to 4,550 \pm 50 bp. The peat column is truncated by peat cutting at c 4000 bp and a secondarily-humified horizon occurs across the mire beneath the junction with recent peat.

The centre of Sphagnum Bog is some 40-100 cm higher than its margin on three sides, so that the mire forms a gently sloping ridge. The possibility that raised mire development may have taken place at this site is partially confounded by extensive peat cutting, and by the fact that floristics are a poor discriminant of meteoric and telluric water supply in an area of base-poor lithology. However, estimation of the parameters determining the height of a groundwater mound (Ingram, 1982) suggest that ombrotrophic peat development is possible at Sphagnum Bog. Both the gross peat stratigraphy and detailed macrofossil composition are consistent with this interpretation.

CONCLUSIONS

The Cranes Moor mire complex is the largest and arguably the most scientifically valuable site in the New Forest and indeed in south-central England. The rapidity of accumulation of great depths of early Holocene peats (pre-Boreal to Atlantic, Godwin zones IV to VIIa) give us a detailed picture of the vegetational history of this period. On Sphagnum Bog the lack of local tree growth and the large size of the site provides us with a regional standard pollen diagram, with which more locally-influenced pollen sequences from smaller New Forest mires may be compared. The stratigraphy and macrofossils from the site are similarly valuable, with the contrasts between the different areas of the mire, the extraordinary allophane layer, and the probability of past ombrotrophic conditions being particularly noteworthy. The palaeoecological research started by Stanley Seagrief over thirty years ago, and added to by his daughter Rose more recently, (Seagrief, R.J., 1980), now has the benefit of a radiocarbon chronology and closely-counted pollen diagrams. The potential for further detailed studies of peat chemistry and palaeohydrology is great. Meanwhile the site itself stands as an evocative analogue of the Boreal landscape of 9000 years ago.

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PALAEOLITHIC SITES IN TRIBUTARY VALLEYS OF THE SOLENT RIVER

by

D R Bridgland and P Harding

Large numbers of Palaeolithic artefacts have been recorded from the gravels of the former Solent River and its tributaries. As with collections from the better known Thames terrace gravels, most of this material came to light during the last century or the early part of this, when gravel pits were excavated manually. Even finds from the Solent cliffs were probably considerably more common before coastal defences and breakwaters were erected. The paucity of new discoveries is to an extent offset by the increased information now gained when sites are excavated under controlled archaeological conditions; important new sites such as Red Barns, Portchester (Gamble and Ap Simon, in press) and Boxgrove, near Chichester (Roberts et al, in press) have rekindled interest in the Palaeolithic record of the Hampshire Basin. Both these sites, however, are in raised-beach deposits. Although the overall numbers of palaeoliths from the terrace gravels in the area are large, reference to the gazeteer compiled by Roe (1968) shows that sites yielding more than a few tens of artefacts are very rare, and the majority of finds appear to involve a single hand axe, or perhaps one or two. The exceptions are some of the cliff sections, such as Barton and Hillhead (over 200 hand axes from each); Thistlebarrow Pit, Kings Park, Boscombe (SZ116927; listed under Boscombe and thistlebarrow by Roe and so perhaps yielding a similar number of hand axes), Dunbridge in the Test Valley (over 950 hand axes) and Wood Green in the valley of the Salisbury Avon (over 400 hand axes). Most of the area around the Thistlebarrow site at Boscombe is now covered by Bournemouth football ground and modern housing, but the two tributary sites are still available for study. Sections were therefore opened at these localities during April 1986 as part of the Nature Conservancy Council's 'Geological Conservation Review'. (Only one of these sites will be included in the excursion programme, but it is hoped that artefacts from both will be on display)

WOOD GREEN GRAVEL PIT

Wood Green lies on the eastern side of the Avon Valley, 3km NE of Fordingbridge and at the edge of the New Forest. The pit (SU172170) once worked Avon Terrace gravel aggraded to c.56m OD. The earliest reference to the site was by Westlake (1889), who recorded 10-14 ft (c.4m) of gravel which he referred to the '100 Foot Terrace' of the Avon (reflecting height above river-level, not OD). Accordingly to Westlake, the pit had then yielded about 24 hand axes and 4 flakes, found at depths between 0.3 and 3m from the surface. He realised that many of these artefacts had been weathered under sub-aerial conditions before being incorporated in the Avon gravel. Reid (1902) included the gravel at Wood Green in his 'Palaeolithic Terrace' and was the first to describe the

character of the gravel itself, noting the presence of Greensand chert, sarsen, quartz and schorl-rock as well as overwhelmingly abundant flint. A "Chellean chopper" from the pit was recorded by Crawford (1922) and the site was again mentioned by Bury (1923), who remarked on the unusual coarseness of the gravel. Artefacts from Wood Green were documented by Smith (1926, p.63).

More recent work on the Avon terraces has resulted in several different interpretations of the Wood Green gravel, so that a confusing range of classifications of the same deposit can be listed: '100 ft Terrace' (Westlake, 1889), '1st Terrace' or 'Palaeolithic Terrace' (Reid, 1902), 'Iver Terrace' (Green, 1950), Boyn Hill Terrace (Seally, 1955) and No. 7 Terrace (Kubala, 1980; Clarke and Green this volume). The term '100ft Terrace' is especially confusing, as various authors in various regions have used it either to describe height above river level or height above ordnance datum, without necessarily specifying which. Some early workers suggested correlation between the terrace 100ft above river level and the so-called '100ft Raised Beach', also associated with Acheulian artefacts (e.g. Burkitt, 1931). In the most modern study, an extensive investigation of the Avon gravels as part of BGS national resource surveys, Kubala (1980) and Clarke and Green (this volume) have established a numbered terrace system, recognising up to 15 subdivisions.

The 1986 section and finds

A single section cleared by the authors in April 1986 allowed the presence of in situ, bedded fluvial gravel to be recorded (Figs 1 and 2). Just over 4m of gravel was exposed, variously fine and coarse, horizontally and cross-stratified, matrix-supported and open framework (Fig. 2). Bagshot Beds sand (bedrock) was reached slightly above 51m OD. The small area of bedrock surface exposed showed considerable small-scale relief, in the form of apparent scour features with an amplitude of some 23cm (Fig. 2). These may be comparable to features in London Clay bedrock beneath fluvial gravel at Stoke Newington, described by Harding and Gibbard (1984), although the latter were uncovered over a much larger area.

A small handaxe was found in situ in the Wood Green section, in open framework crossbedded gravel 0.9m above the bedrock surface (Figs 2 and 3). This handaxe, of Wymer's (1968) Type E (i.e. crude pointed handaxes of less than 100mm in length), is in a rolled condition with heavily crushed edges and flake ridges. It measures 59mm long, 31mm wide and 22 mm thick. Its manufacture involved simple shaping of a thermally fractured fragment of flint by flaking one surface and leaving the opposite thermal surface, which has heavy iron staining, largely untouched. The flake scars, which are both deep and non-invasive, together with the thick profile probably indicate production by hard hammer percussion. The edges are crude and sinuous in profile and slightly convex in plan. The thin rounded butt is unworked and retains what may be part of a heavily weathered pebble surface. Two unstratified flakes were also found, both stained and in a rolled condition. One, a bulb removal (Janus) flake, demonstrates the production of flake tools or of handaxes made on flakes.

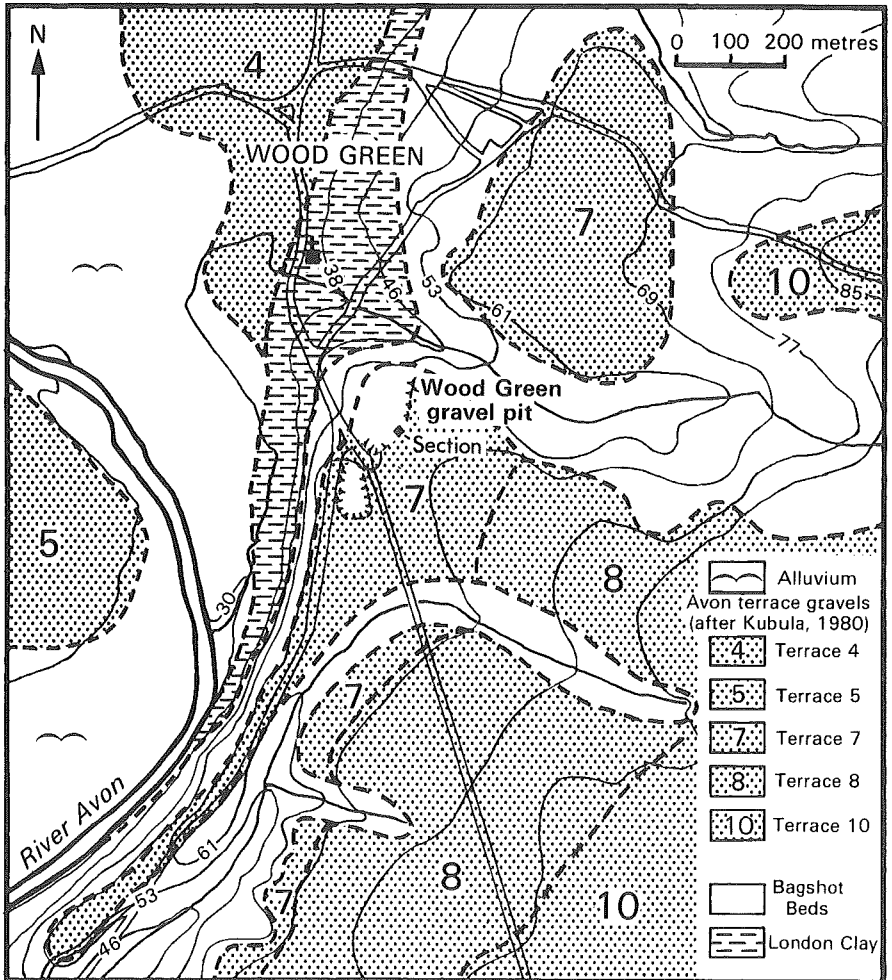


Figure 1 Location map of Wood Green gravel pit. Terrace and geological mapping from Kubala (1980)

Section excavated at Wood Green, April 1986

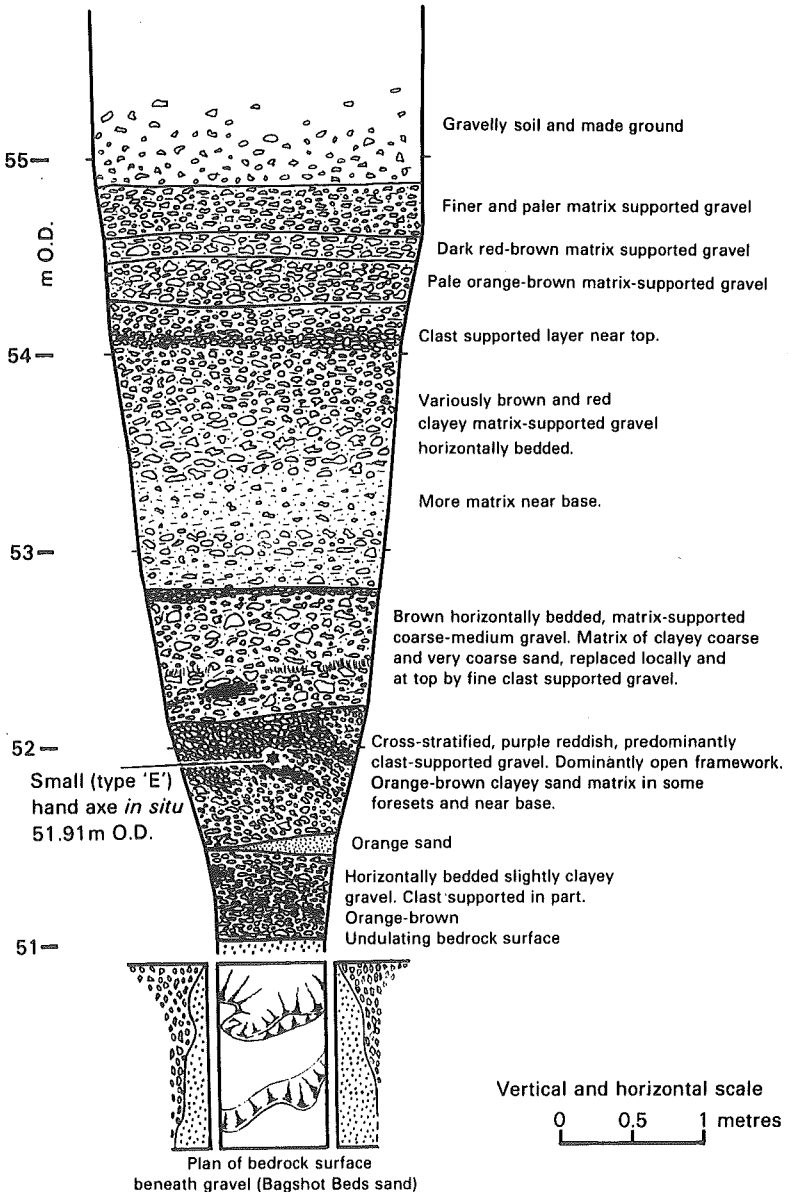


Figure 2 Section excavated at Wood Green, April 1986

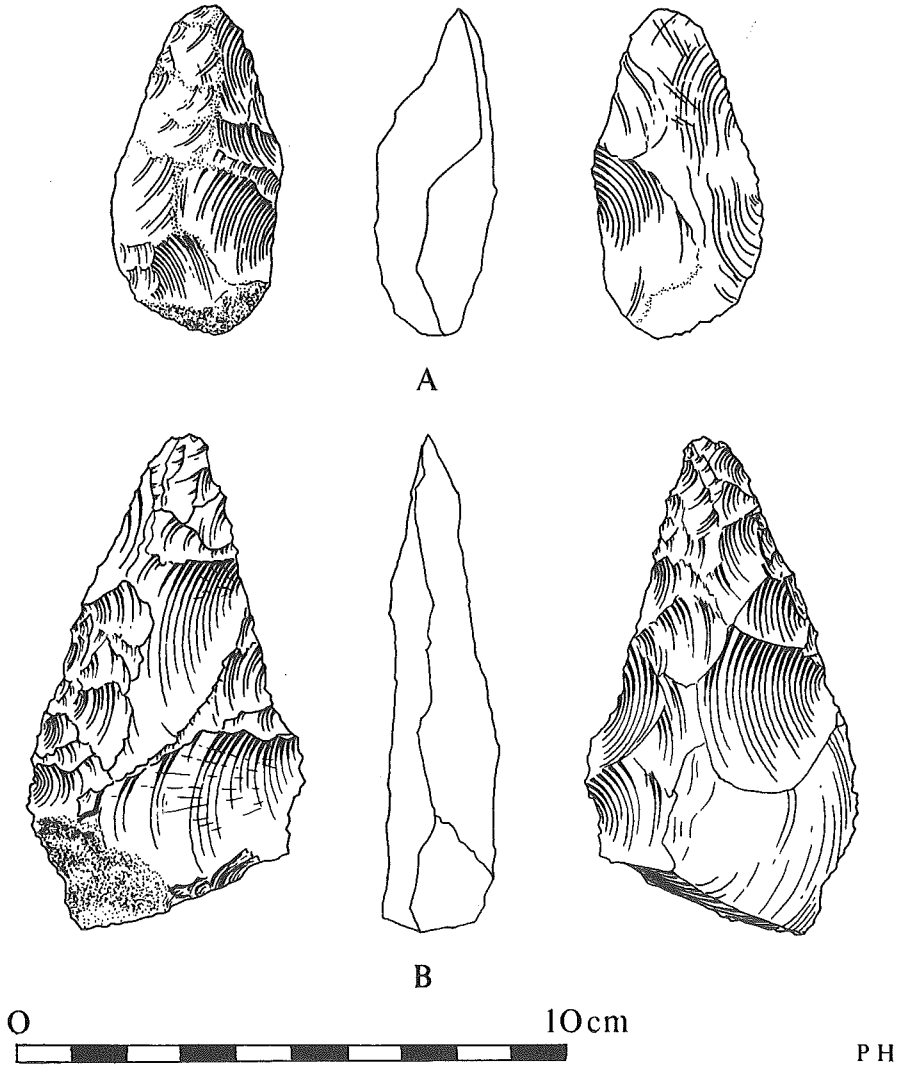


Figure 3 Hand-axes recovered in the 1986 excavations. A from Wood Green, B from Dunbridge

DUNBRIDGE PITS

Gravel pits at Dunbridge (SU317257), in the valley of the Test, have provided what appears to be the largest collection of Palaeolithic artefacts from a single locality in Hampshire. These pits (Fig 4) exploited a large patch of "Valley Gravel and Sand" (Geological Survey, New Series map, Sheet 299) on the west side of the Test, immediately downstream of the confluence between that river and the tributary River Dun. The highest part of the gravel remnant, furthest from the river, reaches over 40m OD, but the workings have predominantly exploited the lower river-ward edges. The pits at Dunbridge have eaten back into the northern edge of the gravel and face the tributary stream (although this is no reason to suspect that the gravel was not deposited by the Test itself), but at a still lower height pits were also excavated at Kimbridge (SU325255), on the eastern side of the remnant, facing the Test. These pits also yielded palaeoliths, at least 80 hand axes (Roe 1968), while the numbers from Dunbridge approach 1,000 (Roe 1968, 1981, Shackley, 1981), mainly collected in the early part of the century (Dale, 1912a, 1918; Sturge, 1912; Smith, 1926).

The Test Valley has received comparatively little attention from geologists or archaeologists, but happily the Dunbridge site was recorded in some detail by Dale (1912a). Dale described up to 7m of gravel overlying an irregular surface cut in clay and sand of the Woolwich and Reading Beds. He observed that palaeoliths with different types of preservation came from different stratigraphic levels in the gravel. Dale's subdivision of the gravel was based on colour: he recognised, at this and other pits in the Ramsey area, a lower dark red gravel, a middle yellow-brown gravel and an upper white gravel. These colour differences he attributed to the translocation of iron from the upper to the lower layers, a view supported by Whitaker (in discussion of Dale, 1912a). The upper (bleached) gravel yielded white artefacts, "delicately shaped, fine pointed ... absolutely un-waterworn" (Dale, 1912a, p.111); the middle yielded yellowish and brown implements, while those from the base have a 'double patina', one side (the lower) the colour of the bedrock on which they formerly rested and the other deeply stained by iron from the lower layers of gravel. Dale later (1918) claimed that "gravel of two periods" was represented, an upper paler deposit, separated from a lower darker aggradation by a "ferruginous band" extending widely around the pit (presumably the middle and lower units of the earlier tripartite subdivision were combined in the new lower, darker division). Dale considered the sharp white implements from the upper deposit to be "of a later character than those of the lower beds". This bipartite subdivision of the Dunbridge gravel was supported by Sturge (1912). Both Dale (1918) and Smith (1926) believed the white artefacts had been bleached before inclusion in the white gravel.

From his comparisons of their characteristics it appears that Dale considered the gravels at Dunbridge and Kimbridge to be closely related, although he also recognised separate "100ft" and "150ft" gravels (Dale 1912b). The geology map shows a single gravel spread covering the higher ground in the angle downstream of the Test-Dun

confluence (Fig 4), but it is apparent from the memoir that two levels were recognised (White, 1912). White described two 'groups' or 'stages' of terrace-gravels which yield Palaeolithic tools of various forms (1912, p.69), an upper 'Belbins Stage', c.70ft (21m) above river level, and a lower 'Mottisfont Stage', 40ft (12m) above the river. He ascribed the gravel at Dunbridge to the Belbins Stage and that at Kimbridge to the Mottisfont Stage, noting that these deposits were apparently connected by further gravel covering the intervening slope.

Dale (1912 a,b) suggested that the Dunbridge Deposits may be of subglacial origin. His grounds were that (1) a large lenticular mass of Reading Beds clay separating the underlying Reading Beds sand from the gravel over part of the site showed evidence that it may have been glacially transported and (2) the surface of the Reading Beds sand was so uneven as to suggest that it was frozen when the gravels were laid down on it. This view was not supported by White (1912).

Sites with different Lower Palaeolithic industries in stratigraphic superposition are extremely rare in Britain, so if Dale's observations are accurate the Dunbridge site could be of considerable significance. This led Roe (1981) to consider the site at some length. Roe noted that the Dunbridge material comprises a mixture of worn and fresh, pointed and non-pointed hand axes, the majority of which were deeply patinated and stained yellow, brown or deep red. About 100 hand axes can be separated from the rest, forming the 'white series' described by Dale. These are patinated pure white, less worn, and are dominated by well made pointed types, although white ovates and Levalloisian flakes are also present in the collections (Roe, 1968, 1981).

The 1986 Sections and finds

Three sections were excavated in various parts of the old Dunbridge workings (figs 4 and 5). These revealed fluvially bedded gravels comprising largely flint with subordinate sarsen. The deposits were generally of a brown, ferruginously stained appearance and no subdivision into upper white and lower darker units could be made, although white patinated flints were observed in the uppermost layers in sections 2 and 3 (fig 5). Patinated flints were also recorded, however, from lower down in section 3, well below any 'upper gravel'. Similarly the "ferruginous band" described by Dale could not be identified; iron (or possibly iron/manganese) panning was observed within the sequence, but at more than one level. One observation of Dale's that was confirmed, however, was the existence over part of the site of Reading Beds clay beneath the gravel. This was found in section 3 and presumably represents the 'lenticular mass' interpreted by Dale (1912 a,b) as glacially transported. The surface of the Reading Beds sand, exposed only in section 1 and admittedly over a very small area, showed little relief, in contrast to the Bagshot Beds surface beneath the gravel at Wood Green. It is possible that the bedrock surface undulations recorded by Dale at Dunbridge were of a similar nature to those at Wood Green.

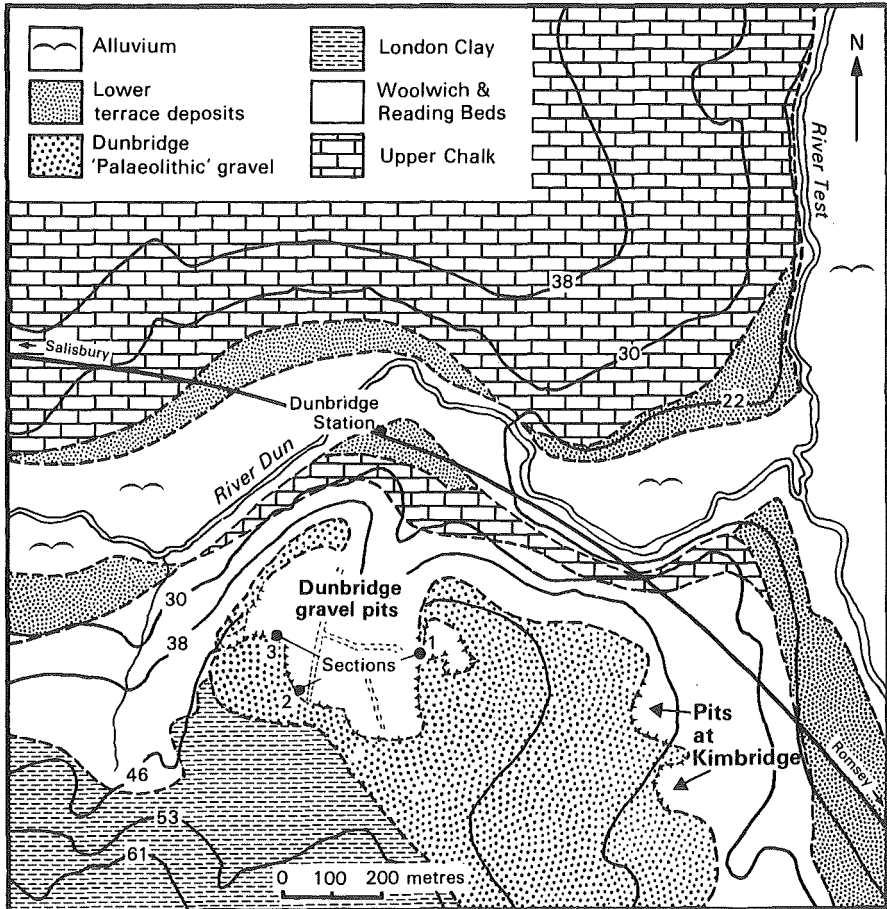
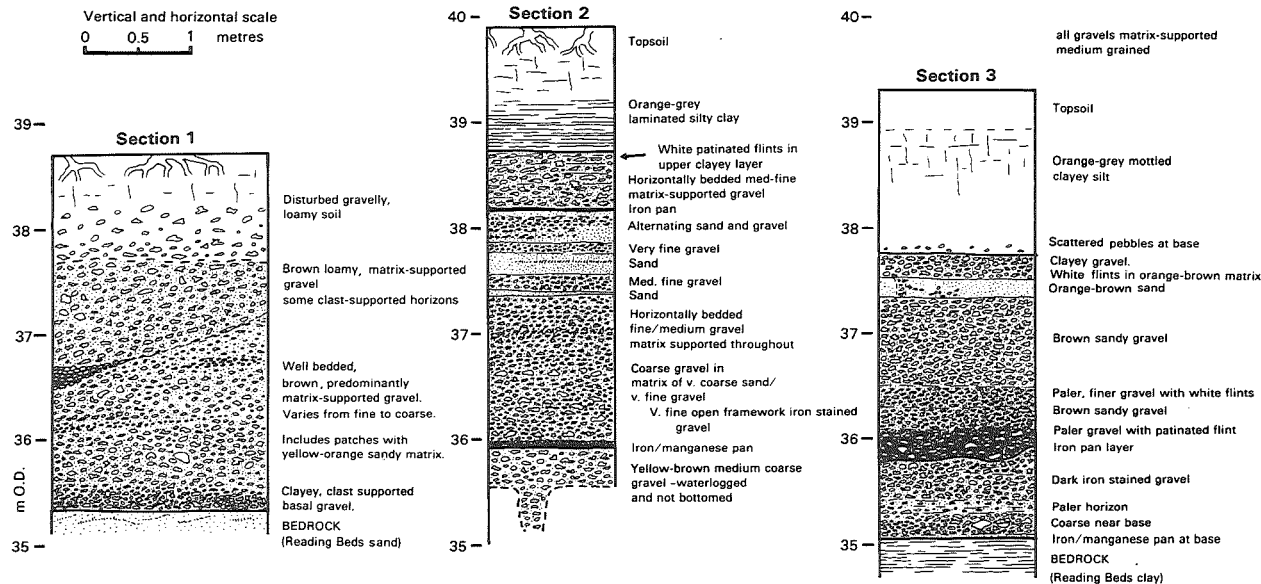


Figure 4 Location map for Dunbridge pits. Geological mapping from Geological Survey, New Series, Sheet 299

Sections excavated at Dunbridge, April 1986

Figure 5 Sections excavated at Dunbridge, April 1986



A handaxe was found in the talus when excavating section 2; its original position can be placed with some certainty in the upper half of the section although an origin from the land surface could not be ruled out. It is, like that from Wood Green, a pointed handaxe of Wymer's Type E, but in this case in mint condition and fresh brown in colour (Fig. 3). It measures 89mm long, 51mm wide and 19mm thick towards the butt, which terminates in a thermal snap. The surface which was flaked first has a small patch of weathered cortex, from a water worn nodule, on the butt. The flint is of good quality. The opposite surface, which appears to be stained with manganese, is of poorer quality flint and includes part of a thermal fracture and cherty inclusions.

These contrasting surfaces indicate that the nodule was probably broken and a fragment from its outside, where the best quality flint is often found, was selected for the handaxe. The manufacture, by hard hammer percussion, was relatively simple and similar to the Wood Green handaxe. This involved bifacial flaking sufficient to thin the tip to a functional point and refine the edges, which are straight in plan but sinuous in profile. Tools of this type can be produced quickly without involving the sequences proposed by Newcomer (1971) or Bradley (in Sampson, 1978); roughing out, thinning and shaping and finishing. They also produce very limited amounts of waste in their production. There were, in addition, two flakes and a core from Section 1. All were unstratified and undated. A previously unrecorded scatter of 17th and 18th century gunflint knapping waste, making gunflints by the 'wedge' technique (de Lotbiniere, 1977) was identified in the topsoil to the south of section 1. The material has been deposited with the Hampshire Museum Service at Andover Museum.

DISCUSSION

The scale of this report has neither justified nor permitted a thorough study of the extant collection of palaeoliths from either Wood Green or Dunbridge. A visual assessment of the artefacts in Salisbury Museum has, however, enabled these two handaxes to be placed in their respective contexts.

The Wood Green material consists mainly of ovate handaxes with some mixed pointed forms (Roe 1981). Crude and refined implements are present and the ovates include some with a twisted profile. The handaxe described here lies at the smallest end of the size range but is consistent with other Type E handaxes and small ovates from the site. Flakes, which include fragile thinning flakes, are also present in the collection, which suggests that the retrieval of artefacts by the gravel diggers was both unbiased and thorough. Most handaxes from Wood Green are rolled and the yellow surface colour with differential iron staining is also typical. This handaxe from Wood Green is therefore consistent with those already known from the site.

The Dunbridge handaxe displays both similarities and differences from the museum collection. Pointed handaxes, some with flat untrimmed butts, are predominant at the site although both ovates and cleavers are present (Roe 1981; Robinson, in press). Artefacts in mint condition are rare, the white patinated implements from the upper gravel representing the nearest parallel in condition but not in colour. Brown implements with a yellow cherty interior and weathered cortex are present at Salisbury Museum but are in a minority. The combined evidence of condition and colour suggests that this handaxe was originally located in the middle part of the section where brown implements, some of which were water worn, were recorded (Dale 1912a, p 112). This is consistent with the position of the artefact in the talus. It does nothing to clarify the context of the white patinated implements.

CONCLUSION

The sites described here stand virtually alone in the fluvial terrace deposits of the Hampshire Basin in that they have produced significantly large numbers of Palaeolithic artefacts. If the amounts of gravel likely to have been worked at each locality is taken into consideration, the Wood Green pit appears to have been the richest source, but only at Dunbridge is there any evidence, in the form of unabraded material, of the proximity of a working site. The absence in this area of rich working sites, such as occur relatively frequently in association with the Thames terraces (see Wymer, 1968), is a problem in the British Palaeolithic which has yet to be explained. The possibility that at Dunbridge different industries may occur in stratigraphic superposition, the younger of them manufactured nearby, suggests that further work at this site might be worthwhile.

ACKNOWLEDGEMENTS

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THE PLEISTOCENE TERRACES OF THE BOURNEMOUTH - FORDINGBRIDGE AREA

by

M.R. Clarke and C.P. Green

Generations of field workers have been able to enjoy the spectacular scenery of the Avon valley and the adjacent moorland of the New Forest. Few however, appear to have appreciated the complex Pleistocene history of the deposits which in many places cap the Tertiary bedrock strata to form this remarkable landscape.

That the high-level spreads of sand and gravel (Plateau Gravels) found in this area represent part of a succession of fluvial terraces was clearly recognised by Reid (1902) during the geological survey of the Ringwood and Bournemouth areas in the final years of the 19th century.

Further interest was shown in the relationship of the terraces in the Bournemouth area with local finds of Palaeolithic implements by Bury (1923) and was followed by a more detailed study of the terraces by Green (1945) who established a sequence of seven terraces lying below the level of the 300 ft 'Sicilian Terrace' thought at that time to represent the plane of deposition attributed to the Pliocene marine level.

This pioneering work was extended up the valley of the Avon by Sealy (1955) who was able to correlate the spreads of valley gravel as far as the Chalk downlands near Salisbury. Investigations of the terrace gravels themselves between Ringwood and Salisbury (Figure 1) were reported by Green (1973).

No other major study of the terraces of this area was made until the extensive borehole drilling surveys were carried out by staff of the British Geological Survey in 1976/77. These surveys (Clarke, 1980 and Kubala, 1980) were carried out as part of a national study of Sand and Gravel Resources, and involved the drilling of 212 six-inch diameter boreholes sited primarily in the mapped spreads of Terrace and Plateau Gravels.

TERRACE CORRELATION

As with many other deposits of Pleistocene age, the general lack of fossiliferous material or intraformational organic deposits, causes one to seek other means of correlation. The well-tried technique of construction of longitudinal profiles appears to help with the task, but one is ever mindful of the shortcomings of the method, and the various assumptions made about the sequence of events.

Nonetheless, with the benefit of the substantial amount of new borehole data available, the correlation of the terrace deposits has been able to use not just the surface morphology of the terraces, but also the basal plane of erosion. This method has proved to be particularly successful in other parts of Southern England.

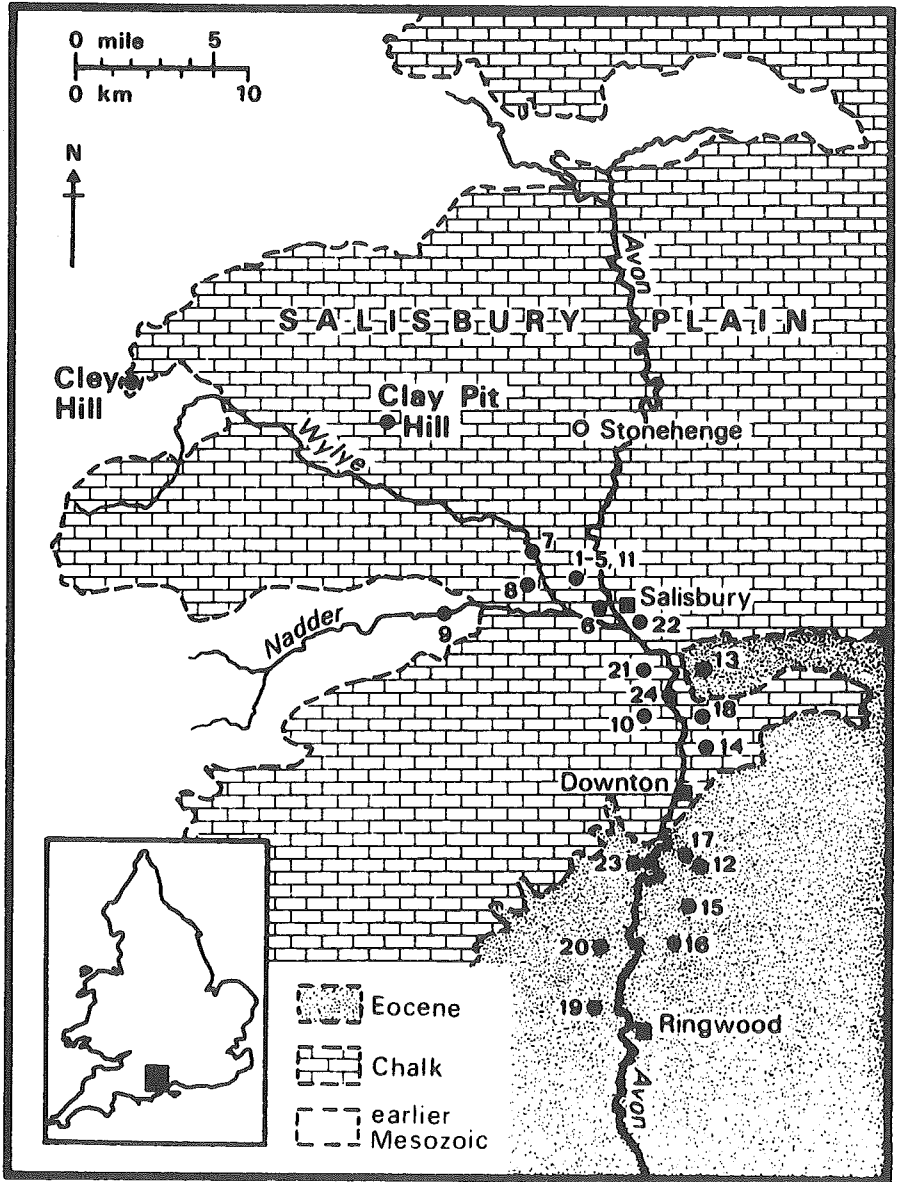
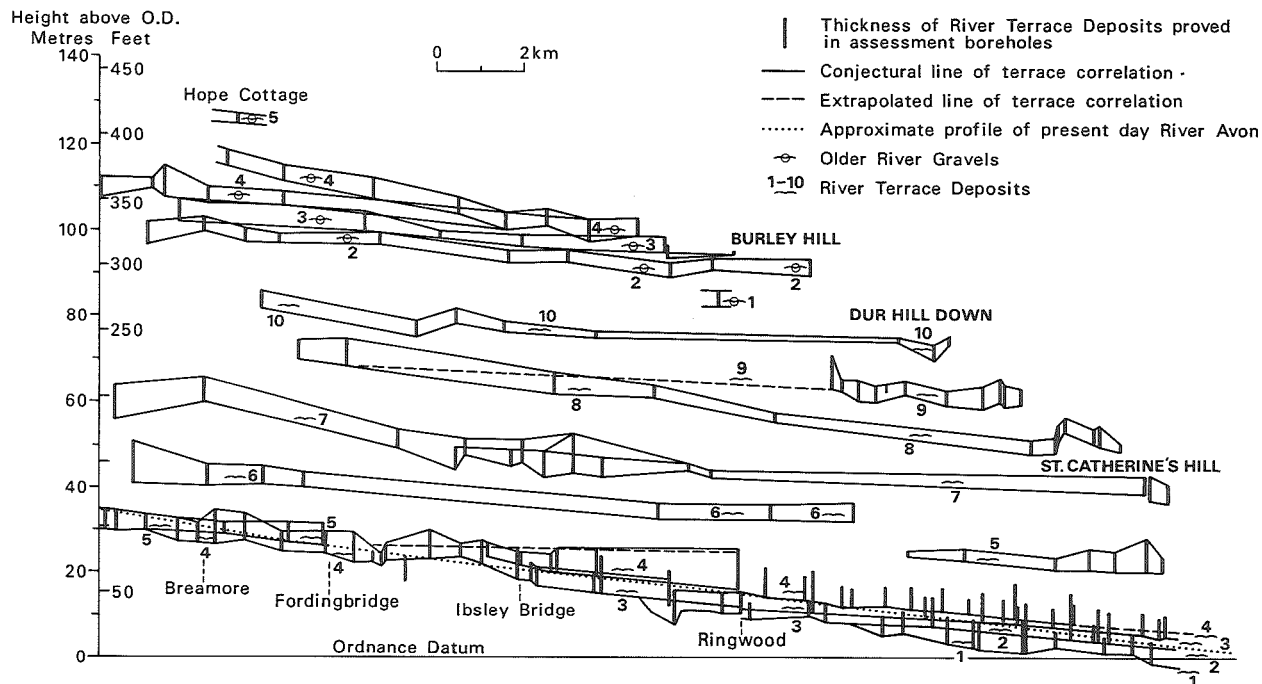


Figure 1 Sample sites (from Green, 1973). For details see Table 1 and Figure 3

Figure 2 Longitudinal profile of the Avon Terraces



In general, this new work verifies the earlier studies of Green (1945) and Sealy (1955) and Green (1973), although local differences are inevitable, and the presence of the sub-alluvial terraces could only be interpreted from the new data available. The longitudinal profile shown in Figure 2 represents a summary of this correlation, and indicates that the terraces can be subdivided into three broad categories.

THE LOWER TERRACES

The Lower Terraces (Terraces 1 to 4) form the extensive areas of terrace flats which lie within the main valley of the present-day river, and stretch from the outskirts of Bournemouth to Fordingbridge in the north. Together, they form a group separated by only a few metres in altitude, and all lying below 40m O.D.

The third and fourth terraces are the most prominent, and in places form features over 3km in width, such as in the Sopley (SZ 160 980) and Ringwood (SU 150 050) areas. In contrast, the first and second terraces are quite restricted, occurring close to the central part of the valley and largely concealed below the present-day floodplain Alluvium.

THE MIDDLE TERRACES

The steep bluff at the eastern edge of the Avon Valley serves to emphasise the significant break in altitude (although not necessarily in time) between the Middle Terraces, numbered 5-10 (previously classified as Plateau Gravels) and the Valley Gravels below.

The lowest terrace is formed by the fifth terrace which is a prominent feature at Burton Common (SZ 195 095) some 15 metres above the floodplain. The remaining terraces in this group are generally represented by remnant spreads capping the interfluvies on the western side of the New Forest. As such they are not always readily identified in the field, except where they form coherent features such as those at Ibsley Common (SU 165 095) and Rockford Common (SU 170 075), both formed by deposits of the 8th Terrace.

Together, these terraces span an altitudinal range of some 50 metres and are themselves each separated by a vertical interval of at least 10 metres. They all lie below 90m O.D. and appear to be equivalent to the Palaeolithic and Eolithic terraces of Reid (op cit). Palaeolithic material has been collected at several sites in the Avon Valley, from Salisbury (Blackmore 1864), downstream to Christchurch. The bulk of the material appears to be at and below terrace level 7 (figure 3).

THE HIGHER TERRACES

Above approximately +90m O.D. are a series of gravelly deposits which are assumed to represent the oldest Pleistocene deposits found in the area. They occur as thin and sinuous, dissected spreads which cap the highest parts of the New Forest.

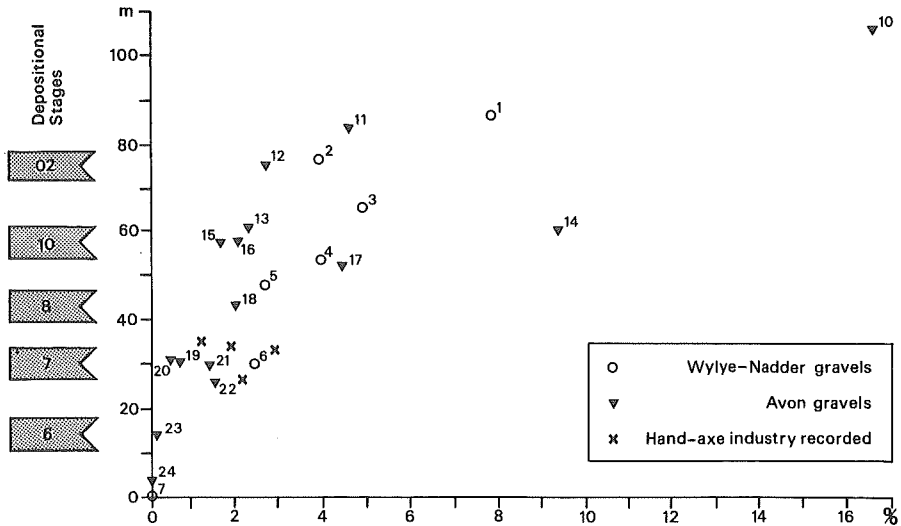


Figure 3 Frequency of far-travelled material (% vein quartz) related to elevation of gravel above present river (m). Numbers refer to Figure 1. Depositional stages indicated on the basis of borehole records between Ringwood and Downton (see Figure 2)

Site No.	Wylde-Nadder				5†	6*	7	Nadder		Avon				14	15	16	17	18	19	20	21	22	23	24
Height (m) above river	87	77	66	54	48	30	0	54	0	107	84	76	61	59	58	58	53	44	31	31	30	26	14	3
Flint and Greensand	91.7	96.2	94.8	95.7	96.1	96.1	99.9	98.6	99.9	83.6	95.5	97.2	97.8	90.6	98.2	97.9	95.6	98.0	99.3	99.4	98.6	98.5	99.8	100
Quartz	7.6	3.8	4.6	3.9	2.6	2.4	0.1	1.3	0.1	16.4	4.4	2.6	2.2	9.3	1.6	2.0	4.3	2.0	0.6	0.5	1.4	1.5	0.2	—
Other far travelled	0.7	—	0.6	0.4	1.3	1.5	—	0.1	—	—	0.1	0.2	—	0.1	0.2	0.1	0.1	—	0.1	0.1	—	—	—	—
Size range of sample	b	b	b	b	b	b	b	c	b	b	b	c	b	b	c	c	c	b	c	a	b	b	a	b

* Mean of two samples. † Mean of three samples.
Size range of samples: a, 6.3–25.4 mm; b, 4.0–12.7 mm; c, 3.3–6.3 mm.

Table 1 Composition (%) of Pleistocene River Gravels

In boreholes, these deposits have proved to be very clayey and appear to have locally been affected by solifluction and deep periglacial weathering. However their general similarity in nature and composition to the main terrace deposits suggests that they are more likely to be of fluvial rather than of any other origin.

The longitudinal profile for this group shows them to span an altitudinal range of 30 metres or so, and suggests that they appear to coalesce towards the south. In view of the general uncertainty of the origins of these deposits and their obvious antiquity, they have been classified as Older River Gravels 1-5. As such, they may not necessarily relate to the depositional events associated with the River Avon. However, their composition, displaying an upward continuation of trends apparent in the Lower and Middle gravels (figure 3), suggests that they are in fact deposits of the River Avon.

THE TERRACE DEPOSITS

Analysis of several hundred samples collected during the Resource Survey has shown that all of the terrace deposits are remarkably similar in texture and composition. These results are also broadly similar to those reported by Green (1973) and shown in Table 1.

Subangular Flint dominates the coarse aggregate material and frequently forms up to 85% by weight of the +4-16mm fraction counted. Well-rounded (Tertiary) Flint is also an important constituent and can normally be expected to form 10 to 12% of the gravel fraction. Thus, only trace amounts of other materials (such as Lower Cretaceous Sandstone and Purbeck Limestone) are found in these deposits.

Despite the large amount of data available, it is difficult to distinguish between terraces or groups of terraces on the basis of lithological characteristics. As Green (1973) has already observed, there is thus little evidence to suggest that glacial material was ever introduced into this ancient river system, or that there has ever been a significant change in provenance of the terrace deposits. Green (1973) has shown however that far-travelled material, derived from Tertiary pebble beds, is more common in the higher and older gravels and becomes progressively less common at lower levels. This trend is presumed to reflect the progressive denudation of the Tertiary outcrop.

Natural exposures of the terrace gravels are unfortunately not particularly numerous since many of the old workings that occur in the high-level deposits are badly overgrown and the workings seen in the lower level deposits are generally flooded on completion of the mineral operations. At the present time the active workings in the 4th Terrace at Ibsley Airfield (SU 150 085), have some free faces visible where sections in the deposits appear to demonstrate the sedimentary characteristics of the braided stream depositional environment.

CHRONOLOGY OF THE TERRACES

Until recently, the tools available for this task did not look particularly promising; the lack of organic material from within the terrace deposits meant that any attempt at dating these deposits was at least speculative!

The assumptions of earlier workers that height above present-day river or sea level was significant, is now generally regarded as optimistic, in that it assumes constant rates of erosion and deposition throughout space and time.

If one takes the simplistic view that these fluvial deposits are the remnants of a process of constant erosion (downcutting) and subsequent deposition, then it seems reasonable to assume that the highest terraces are indeed the oldest and vice versa.

The discovery of a buried interglacial deposit in one of the Resource boreholes (SU10 NW12) drilled at Ibsley (Barber and Brown, this volume) is very exciting and may enable a partial chronology for these deposits to be established. An Ipswichian date for this organic material would tend to confirm that the terrace deposits in the area studied do provide an almost complete record of Pleistocene cold events in Southern England.

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LATE PLEISTOCENE ORGANIC DEPOSITS BENEATH THE FLOODPLAIN OF THE RIVER AVON AT IBSLEY, HAMPSHIRE

By

K.E. Barber and A.G. Brown

The discovery of any pre-Holocene organic formations outside the well-endowed East Anglian region is always a matter of some importance, and this is particularly so in south central England where only two coastal interglacial sites are recorded at Stone and at Selsey (West and Sparks 1960, West, this volume, Green and Keen, this volume). The organic material at Ibsley is even more remarkable in possessing a most unusual pollen flora, rich in herbaceous pollen types, with very few tree pollens but with large quantities of the pollen of holly, Ilex aquifolium. A cursory examination of the pollen slides might lead one to assign the material to the Upton Warren Interstadial Complex of Middle Devensian times, but the presence of Ilex and of the ivy, Hedera, both limited in their present-day ranges by cold winters and unknown from any Devensian deposits, points to an interglacial age.

LOCATION AND LITHOSTRATIGRAPHY

The site was discovered during the Sand and Gravel Resources Survey of the Avon Valley, from Salisbury to Bournemouth, by the Institute of Geological Sciences in 1977. M.R. Clarke, then of IGS, M. Kubala and K.E. Barber recored the site with a powered rig fitted with baler and clay-cutter heads. The site location is shown on Figure 1 (National Grid Reference SU147098) with four of the ten river terraces recognised by Kubala (1980) and Clarke (1980, this volume). Terraces 1-4 were assigned to the Devensian Stage and the organic deposit underlies gravels of Terrace 3, (Figure 2) into which the present river is cutting (Kubala, 1980). Figure 3 shows a cross-section of the valley angared and levelled by KEB and AGB, from which it can be seen that the present channel lies directly on these gravels and could not have traversed the floodplain without disturbing them. The organics under the gravels rest unconformably on Bagshot Beds, probably in a hollow formed by fluvial erosion since no other boreholes located similar deposits. The stratigraphy is as follows:

0-278 cm Floodplain alluvium over fine and coarse gravel, of angular to subangular flint with some sand.

278-297 cm Dark-grey clay with seams of black organic material. Prismatic-flaky structure.

297-298 cm Seam of sand and gravel.

298-325 cm Dark-grey clay with black seams.

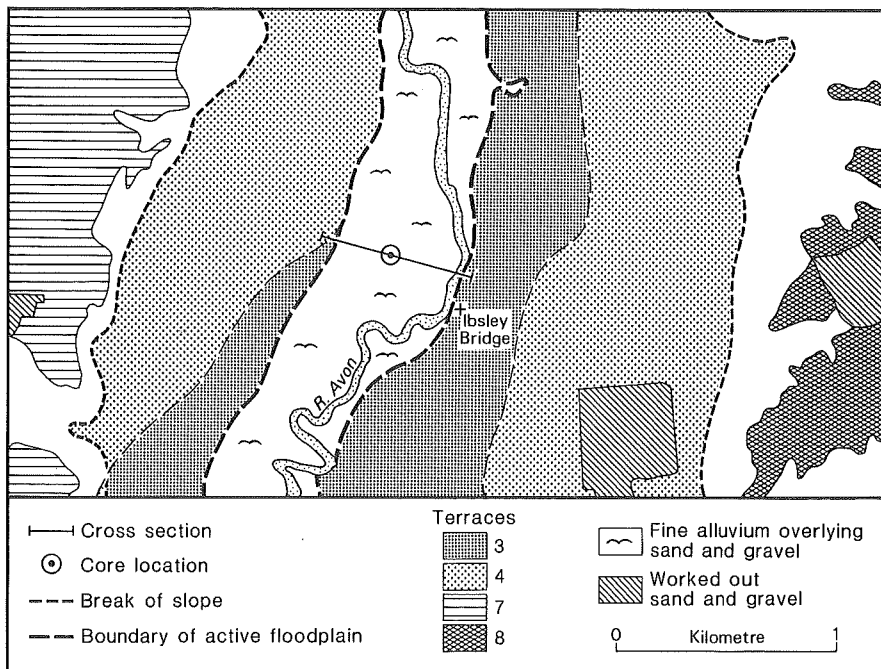


Figure 1 Map of the terraces around Ibsley and the location of the surveyed cross-section and core

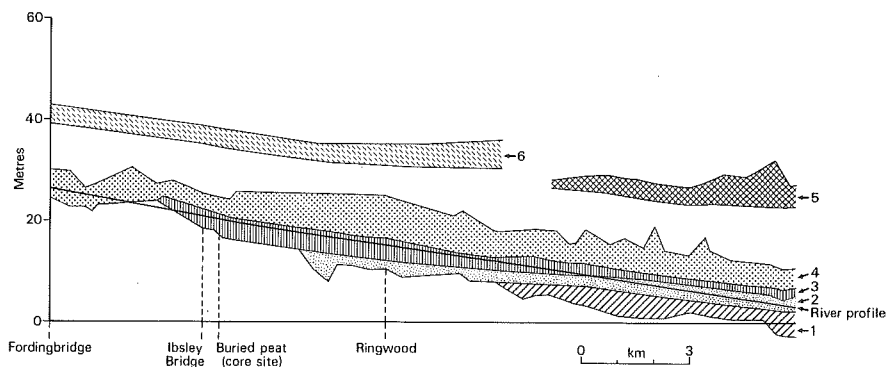


Figure 2 Longitudinal section of terraces 1-6 south of Fordingbridge

The above stratigraphy is from a core extracted as one piece using the baler. The stratigraphy below is from three clay-cutter samples:

- a) 320-340 cm Black amorphous peat with coarse sand.
- b) 352-365 cm Black clayey peat with coarse sand.
- c) 385-400 cm Black amorphous peat with coarse sand.

Below 400 cms sampling was very difficult due to water ingress and only three samples, each a lump of black peat of about 500gm, were secured from depths of 420, 440 and 500 cm. These are not included in the pollen diagram but show the same general spectrum as the samples higher up.

The peat is compacted and contains only a few very poorly preserved fibrous plant remains which have not as yet been identified. Together with its high inorganic content (loss on ignition 29-44%) and the presence of sand and grit, these characteristics are typical of floodplain organic accumulations associated with meandering or anastomosing channels (Brown, in press).

POLLEN ANALYSIS

Samples for analysis were cut out of the centre of the core and clay-cutter samples and prepared according to Barber (1976). The pollen diagram (Figure 4) is most unusual and intriguing. It contains a great variety of herb pollen types, dominated by those from the families Rosaceae, Umbelliferae and Rubiaceae, but more remarkable still is the large percentage of pollen from Ilex aquifolium, the common holly, associated with larger than usual quantities of Hedera helix pollen, the common ivy. Coryloid pollen (Corylus + Myrica) and other shrub types take the percentage of shrubs from around 20% in the lower part of the diagram to a peak of 50% near the top. Tree pollen is very low throughout, usually only single grains, but does include Acer, Carpinus, and Picea as well as Fraxinus, Pinus, Quercus and Fagus. Alnus is virtually absent. Gramineae and Cyperaceae are unusually low in such a herb-dominated diagram, as are Rumex types, and Plantago is absent from these counts.

The diagram has been divided into two local assemblage zones, IBS a and IBS b, on the basis of the shrub percentages. In the lower zone, a, Coryloid percentages are relatively high while Ilex is relatively low and these relationships are reversed in zone b.

The local environment inferred from these data is of a tall-herb rich fen in the lower zone, with very little in the way of sedges or reeds such as Phragmites, changing to a rather drier fen on which holly bushes or even trees were able to grow. Even allowing for massive local pollen production from such communities (and

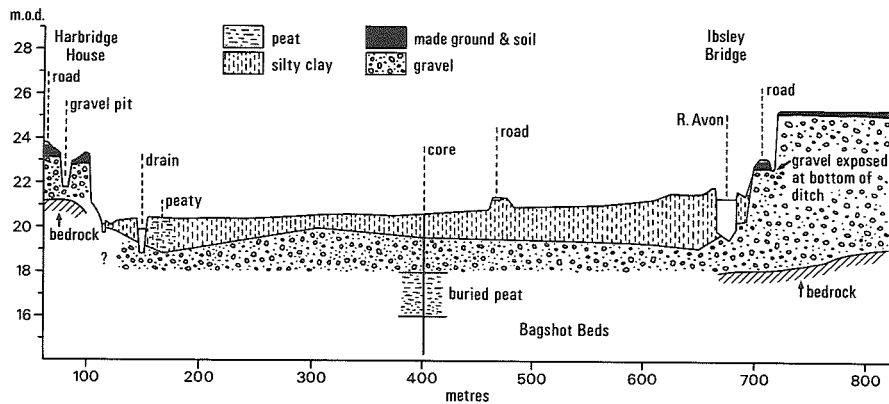


Figure 3 Surveyed cross-section of the floodplain and terraces at Ibsley

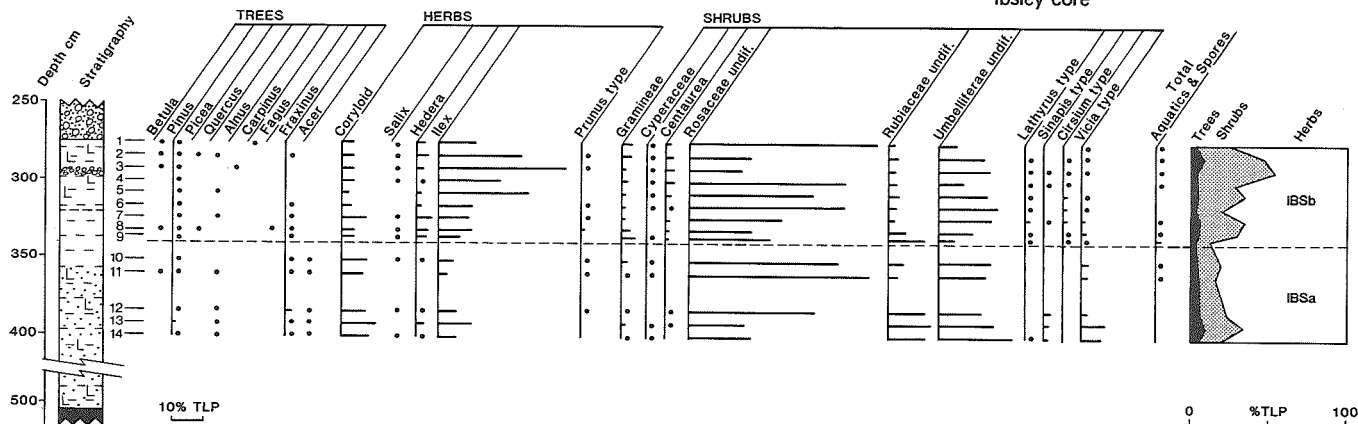


Figure 4 Pollen diagram of major taxa from the Ibsley core

comparative modern pollen data are lacking at present), the evidence here also points to regional deforestation, affecting an area larger than the floodplain.

The presence and quantities of Ilex and Hedera are of great importance in deciding upon both the local and the regional environment. Both are limited in their range and fertility by cold winters. Iversen (1944), in a classic study, showed that Ilex was strictly limited by frosts and did not generally occur where the mean temperature of the coldest month fell below -0.5°C , and that Hedera was only slightly more tolerant, only showing normal development of fruit within the area encompassed by the -1.5°C isotherm. There are some indications from Iversen's thermal limit curves that a reasonable degree of summer warmth is also demanded (Godwin 1975). The ecology of Ilex is thoroughly reviewed by Peterken and Lloyd (1967) and there is useful extra information in Peterken (1969), Peterken and Hubbard (1972) and Tubbs (1986). As they point out holly is tolerant of both a widespread range of soil conditions from calcareous rendzinas to acid podsoles (eg pH values from 3.5 to 7.2 - Peterken and Lloyd 1967) and whereas it is often considered to be a dry land species it can be found as locally abundant in New Forest alder carrs and on soils which are permanently waterlogged except for the surface few centimetres in summer. It is also capable of repeatedly regenerating new shoots under heavy browsing pressure, '.... even small seedlings show remarkable tenacity in the face of repeated nibbling'. (Peterken and Lloyd, 1967, p.849). Though male holly plants flower freely in open conditions, as do ivy plants, both are entomophilous low pollen producers and poor dispersers (Huntley and Birks 1983). Ivy may also be found in fen woods (Godwin 1975).

From this data it is clear that both species must have been growing on the site in the floodplain, together with a rich variety of herbaceous species, including probably prickly members of the Rosaceae, forming a wet, locally dense and impenetrable scrubby fen. Present day examples of such vegetation may be seen in the Test and Itchen floodplains such as the North Walls area of Winchester.

CHRONOLOGY AND AFFINITIES

There is no other site in the British Pleistocene quite like Ibsley. Values of high non-arboreal pollen reported by Pike and Godwin (1953) and by Gibbard and Stuart (1975) both come from rather special contexts - the first from scrapings from a Hoxnian rhinoceros tooth which also yielded 37% ivy pollen; the second from hippo teeth, and a rhinoceros mandible, gave NAP values of around 90% of total pollen. These finds were attributable to the Hoxnian and Ipswichian interglacials respectively and in both temperate periods there are phases of high NAP values (West 1980; Philips 1974, 1976) and a great variety of weeds and ruderals are recorded from interglacials (Godwin, 1975, pp 498-499). These phases occur during the early temperate zone II, Hoxnian IIc and Ipswichian IIb, and both West (1980) and Philips (1974, 1976) discuss the role of large herbivores creating and/or maintaining

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such open non-forested areas, as does Stuart (1982) who includes a useful pie-diagram summarizing the variations in land pollen percentages from zone IpIb.

Grazing and browsing are not the only impacts of large herbivores on vegetation. Dung may be deposited and/or transported to sites such as Ibsley, and the impact of African elephants as 'bulldozer' herbivores has recently been stressed by Kortlandt (1984) - the extinct straight-tusked elephant *Palaeoloxodon antiquus* is part of the classic Ipswichian zone Iib fauna (Stuart 1982). Most of the UK Ipswichian sites are from river valley locations, often associated with gravel deposits and with a rich vertebrate fauna. Examples include Histon Road (Sparks and West, 1959), Trafalgar Square (Franks, 1960), Wortwell (Sparks and West 1968), Barrington (Gibbard and Stuart 1975), Beetley (Philips 1976). High NAP values from in situ organic sediments (as distinct from tooth and bone scrapings) range from 5-49% at Wortwell and from 75-90% at Beetley. Other Ipswichian sites such as the lacustrine deposits at Bobbitshole, Ipswich (the type site, West, 1957) and at Wing (Hall, 1980) show more orthodox forested environments, between them covering the whole interglacial as defined by West (1980) though the former record ends in zone IpII while the latter begins suddenly within zone IpII with no trace in the sediments of Zone I deposits. Clearly, as discussed at the QRA meeting at Leicester in January 1987 (Quaternary Newsletter No 50) there are still some uncertainties connected with the record of post-Hoxnian temperate interludes in the British Pleistocene, although on the basis of biostratigraphic correlation 'a convincing composite picture of the interglacial cycle can be built up ... which tallies closely with pollen diagrams from the whole temperate period recorded in the Netherlands, north-west Germany and Denmark' (West, 1980, p.590).

On the basis of its stratigraphic position underneath gravels of Devensian attribution (Clarke and Green, this volume), and the pollen assemblages which lack taxa of Hoxnian affinity (Type x, Tilia, Alnus and Taxus), as well as Tertiary types, but include those of Ipswichian affinities (Carpinus and Acer), it seems reasonable to place Ibsley within the Ipswichian, and with the evidence of climate provided by the Ilex and Hedera records, to place it within zone Ip Iib, as a southern correlative of Beetley.

At a much nearer site of Stone considerably more woodland is indicated (West and Sparks 1960, Brown et al, 1975, this volume) with the bulk of the NAP (12-36% in Brown et al 1975) coming from Gramineae and Chenopodiaceae as one would expect in a coastal situation with reed beds and salt marsh, so the comparison is of little correlative value.

There remains another possibility - that the deposit dates from the Mid-Devensian Upton Warren Interstadial Complex of around 43,000 years ago (Coope 1975, Coope and Angus 1975). The evidence for this interstadial being warm enough to support tree species, with summer temperatures of 18°C and average January/February temperature near 0°C, (Coope and Angus 1975) is based on

coleopteran remains, with the absence of trees being explained by three main hypotheses, which are not of course mutually exclusive:

- 1) Antecedent conditions - the previous 15000 or more years of very cold climate since the Chelford Interstadial wiped out tree growth in northern Europe.
- 2) Migration rates - a very rapid and short-lived climatic amelioration would allow beetles time to migrate to England, but not trees.
- 3) Browsing animals - large herds of bison, mammoth, horse etc would check the northward spread of trees.

These arguments, and others, have been rehearsed many times (see review in Lowe and Walker, 1984) but if we accept that the climatic conditions at the time of the interstadial were suitable for tree growth then the problem resolves itself into getting the trees into southern England. It may therefore be significant that both Ilex and Hedera bear berries which are avidly sought out by birds, particularly members of the thrush family, and as noted by Huntley and Birks (1983, p.230) ... 'since many are migratory they may be important in the migration and rapid spread of these plants (Iversen 1944)'. This intriguing possibility does not of course explain the presence of other arboreal taxa, though Corylus is also known to spread rapidly and Quercus is thought to have had a western 'primary refugial area ... in northern Spain or around the Bay of Biscay' (Huntley and Birks 1983, p.354) and to have spread rapidly in early Holocene times - eg from 5% pollen values in Brittany at 10,000 bp to 5% values in South Wales by 9,500 bp.

A further line of evidence is provided by radiocarbon-dating. A sample collected by M. Kubala was submitted by M.R. Clarke to D.D. Harkness for dating at East Kilbride. The initial determination (SRR-1190a) gave an age of 31,385±700-600 years before present, having been digested in 2 M HCl at 80°C for 24 hours and washed acid free. However, SRR-1190(b) digested in 2M HCl at 80°C for 72 hours and SRR-11909c) similarly treated but also pre-digested in 0.5M KOH at 80°C for 6 hours gave ages of 43,285±1250 and 41,027±1065

-1070

- 940

respectively. While these dates show an acceptable statistical agreement it does not necessarily confirm the complete removal of contamination in either case. It may therefore be safer to interpret the age of the peat as being beyond the practical capability of radiocarbon evaluation, ie over 43,000 years in this instance (D.D. Harkness, personal communication). More recently Worsley (1980, 1986) has reviewed the problems of radiocarbon dating the Chelford and Upton Warren Interstadials and concluded that the Chelford material was effectively beyond the range of conventional dating techniques and it is clear that caution must also be employed in evaluating dates of Upton Warren age. However Coope and Angus (1975), in their report of the Isleworth deposits,

are confident that their date of 43,140 \pm 1520 (Birm 319) after similar pretreatment to SRR-1190, - 1280 gives the true age of the deposit. One important difference between the Ibsley and Isleworth samples is that the latter consisted mainly of pieces of Umbelliferae stalks, whereas the Ibsley material is compacted peat of relatively fine particles.

CONCLUSIONS

The evidence available points to a probable Ipswichian interglacial age for the Ibsley organic deposit, with a high level of deforestation induced by large herbivores. This is compatible with evidence from other Ipswichian sites with high NAP counts. The high levels of *Ilex* pollen and the association of Rosaceae and Umbellifera types points to a local environment of a tall-herb fen with thickets of holly scrub. The increasing levels of holly pollen in the later stages of the accumulation of the deposit point to the encroachment of holly scrub over the site itself. It is possible that pollen of dry land trees has been swamped to some degree by local pollen production. The alternative view of a Mid-Devensian interstadial age is crucially dependent upon radiometric dating - the biological arguments for an Upton Warren age require a combination of rather special circumstances. Nevertheless such a possibility cannot be ignored, and it is clear that the site is worth re-coring and further more detailed biological analyses and radiometric dating.

ACKNOWLEDGEMENTS

We are grateful to Martin Clarke then of the IGS, for drawing our attention to this site and to Douglas Harkness and the NERC for the radiocarbon dating. Some of the pollen analysis was done while AGB held a NERC Research Fellowship at Southampton.

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RIMSMOOR, DORSET: BIOSTRATIGRAPHY AND CHRONOLOGY OF AN INFILLED DOLINE

By

P.V. Waton and K.E. Barber

The deep peat bog of Rimsmoor is situated on the edge of the Tertiary sands and gravels of the Poole Basin, 4 km south-west of Bere Regis (grid reference SY 814922). The chalk of the Dorset Downs outcrops within a kilometre to the north and the bog itself has formed in a depression in the Reading Beds. The depression is a doline, a form of solution hollow, which reach a maximum density of 157 per square kilometre within this marginal zone of the Tertiary beds (Sperling *et al* 1977). The majority of the dolines are relatively dry with minimal, if any, organic accumulation. The size varies from the largest, Culpepper's Dish, some 80m in diameter and 20m deep, to small features less than a metre deep and a few metres in diameter. The site was investigated and is fully described by Waton (1982) as part of a palynological study of man's impact on the landscape of south-central England.

LITHOSTRATIGRAPHY AND CHRONOLOGY

Rimsmoor has formed within a doline which consists of a northern part some 35m in diameter and 20m deep, with a shallower extension to the south 4-5m deep and 20-30m in diameter. It is infilled to a maximum depth with nearly eighteen metres of peat (figure 1). Clay inwashes are very rare, occurring only intermittently below 15.5m and between 1.0 and 1.5m and together with the absence of limnic deposits attest to the continuous slow solution of the doline rather than to a sudden collapse of the feature, which Sperling *et al* (1977) envisaged as the usual mode of formation. Radiocarbon dating (Figure 2) of peat samples in the upper eleven metres of the peat together with palynological dating of sediments at about 16.5m show that most of the accumulation has occurred in the last 8,000 years. Rates of peat accumulation are exceptionally high, averaging about 4 years per cm. Since the peat is telmatic, with abundant Sphagnum and monocotyledonous remains and a humification of 2 on the Troels-Smith scale, the water level can never have been very different from today - that is more or less at, or a few centimetres below, the Sphagnum surface. The rate of solutational subsidence of the doline may therefore be taken to be equivalent to the rate of peat accumulation and in this possibly unique case we can state that this rate, of 3.84 yrs/cm or 2.6 mm/yr, is maintained between five radiocarbon dates (HAR 3919-3923), covering 3070 radiocarbon years from 5150 bp until 2080 bp (figure 2). The present surface vegetation of Rimsmoor is a rich Sphagnum-dominated mat with a central pool, and the surrounding vegetation is coniferous forest which was planted on heathland during the 1950s. The pH of the surface water is around 3.5-4.5.

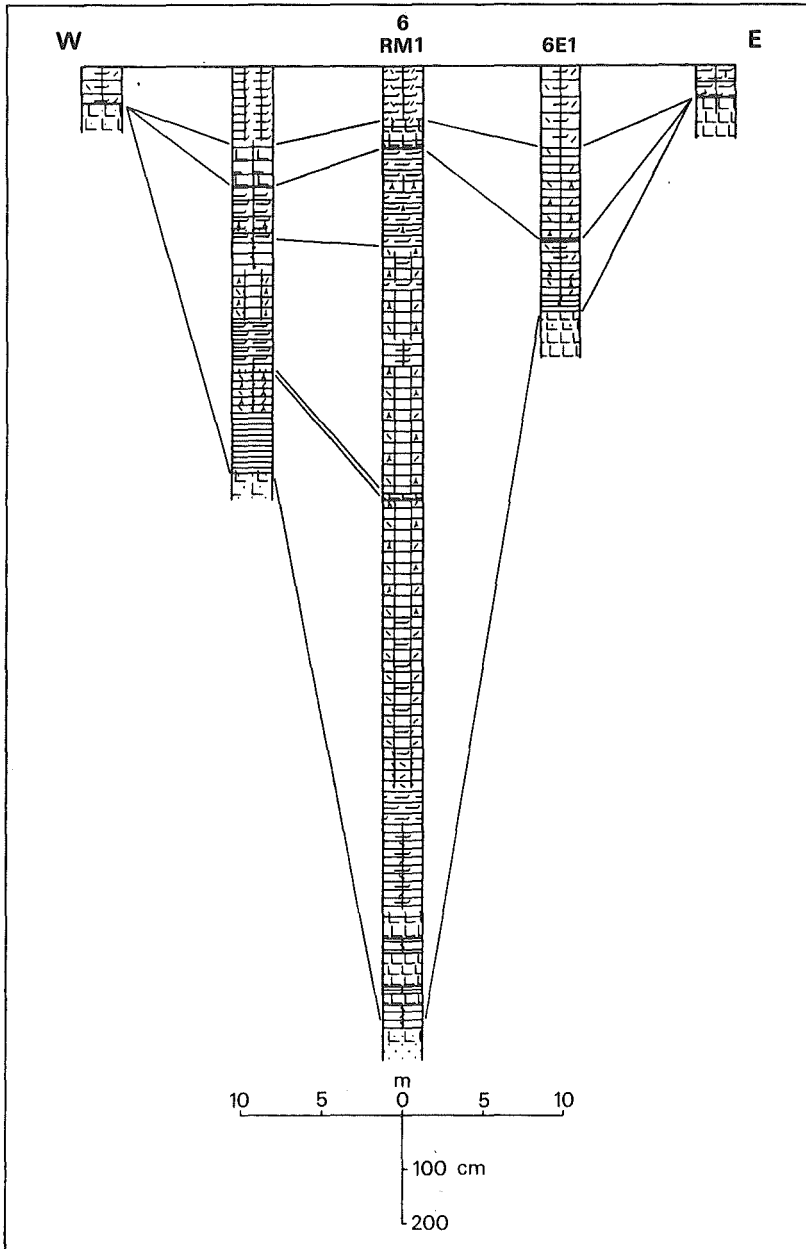


Figure 1 Stratigraphic cross-section of Rims Moor. Symbols follow Troels-Smith (1955)

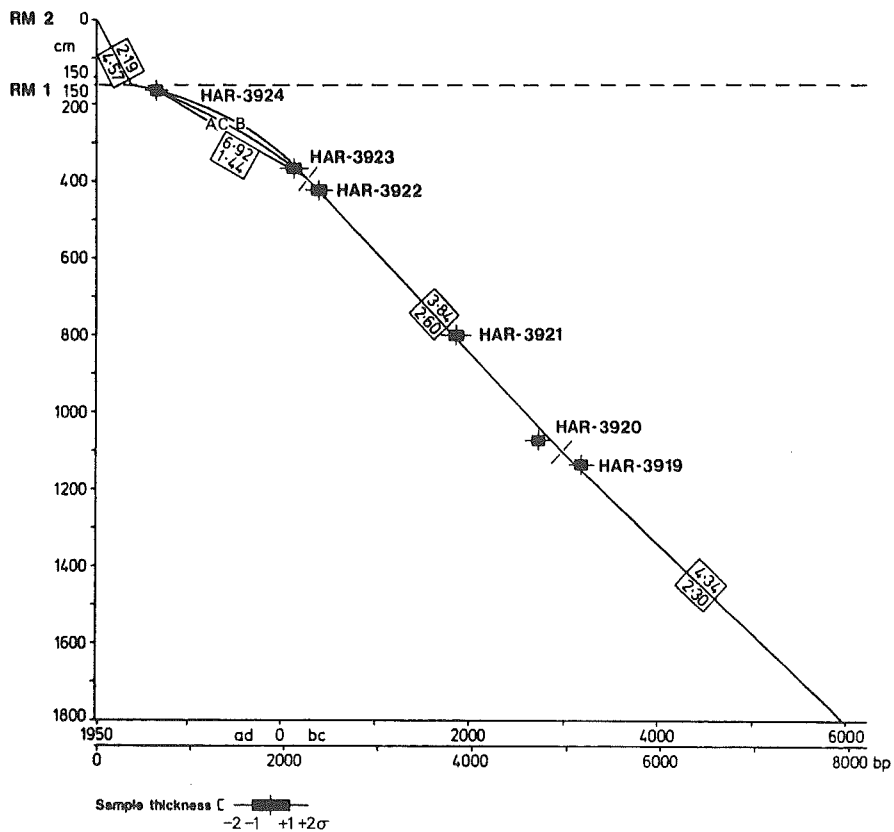


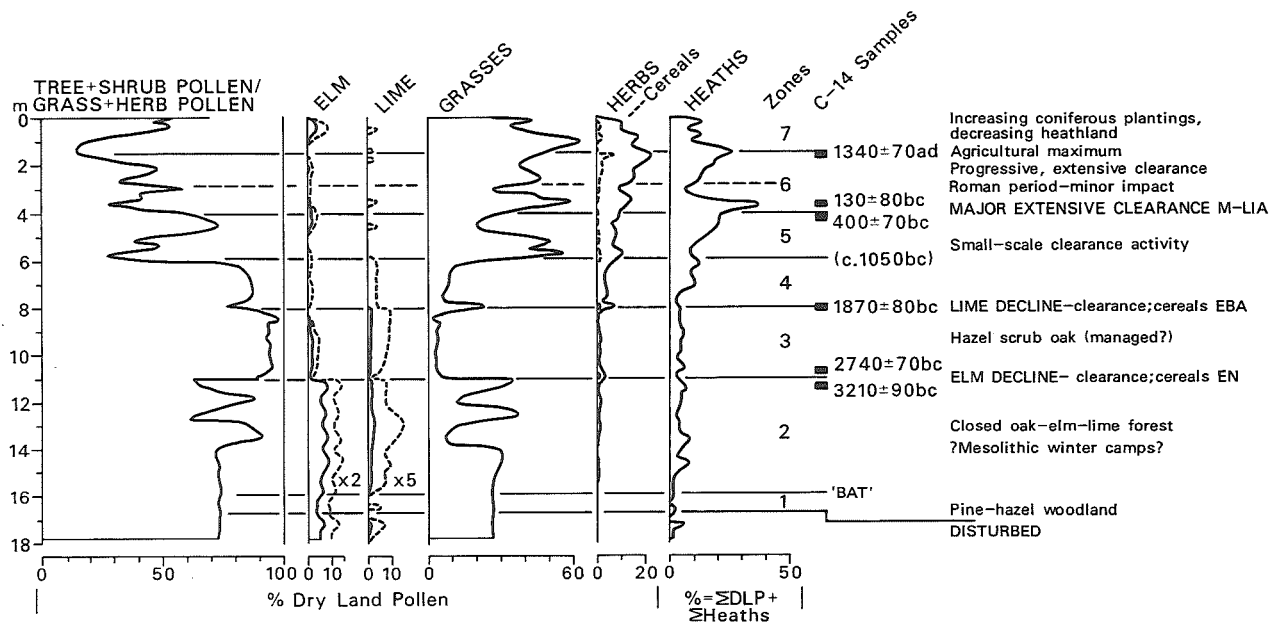
Figure 2 Rimsmoor: time:depth curve. Accumulation rates shown in boxes: upper figures yrs/cm, lower figures mm/yr

POLLEN ANALYSIS

The main core for analysis was taken from the deepest part of the bog. A modified Russian-type corer (Barber 1976) was used to sample the upper 11.5m but below this only a Hiller sampler would penetrate the compacted peat. The surface was too wet and the peat too fibrous for the use of longer piston-type corers. Pollen analysis was conducted at 10cm intervals in the upper 12.6m and 20cm intervals below 12.6m. More detailed analyses were made of the major clearance events with samples at 1cm intervals from subsidiary cores across the Ulmus and Tilia decline clearances and at 5cm intervals across the more extensive Middle Bronze and Iron Age clearances. Given the small size of the basin the majority of the non-mire pollen deposited on the bog will have been derived from within a few tens of metres of the edge of the bog (Jacobson & Bradshaw 1981). Consequently, the spectrum represents very localised palaeoenvironments. The pollen diagram presented here (figure 3) has been specially drawn to illustrate the main trends only. A detailed account will be published elsewhere. In summary, the pollen diagram shows the fairly typical Boreal-Atlantic Transition at about 16m, and from 16m to 11m the palynology suggests a fairly continuous forest canopy around the site dominated by Ulmus, Quercus, and Tilia with Alnus, Corylus, Fraxinus and Betula. During this time grass pollen deposition was fairly high, as a result of Phragmites and other grasses on the mire surface. At 11m there is a pronounced, but brief minor clearance characterised by a considerable fall in Ulmus pollen. Radiocarbon dates of 3200 ± 70 bp (HAR-3919) and 2740 ± 70 bp (HAR-3920) bracket the event and confirms this to be the Early Neolithic elm decline. Woodland regeneration ensues and the forest appears to have been largely similar in composition to that before the elm decline clearance, except for reduced Ulmus and possibly higher Corylus. At 8m there is another brief clearance similar in form to the Ulmus decline clearance, except that Tilia is the most markedly and permanently affected of the woodland types. This is dated to 1870 ± 80 bp (HAR-3921), the Early Bronze Age. Again regeneration is rapid with the forest community assuming its earlier aspect, except for an almost total absence of Tilia.

Two major and relatively extensive clearances are the next significant events and are recorded at about 6m and 4m respectively. The earlier is dated by interpolation to c.1070 bc, the Middle Bronze Age and the later to between 400 ± 70 bc (HAR-3922) and 130 ± 80 bc (HAR-3923), the Middle Iron Age. These appeared to have entailed clearance of woodland chiefly for pasture but with some arable cultivation also occurring. The two events are separated by some woodland regeneration and heathland development over areas which were probably formerly farmed.

Figure 3 Summary pollen percentage diagram from Rimsnoor



Following the Iron Age clearance there was also some woodland regeneration and heathland development. There was however a steady increase in the occurrence of open, presumably farmed environments with increases in cereal cultivation. This culminates at about 1.6m with major peaks in cereal and *Cannabis* type pollen (totalling 15% DLP). This is dated to 1340 \pm 60 ad (HAR-3924) which therefore appears to correlate with the late 13th - early 14th century peak of agricultural expansion. It is followed by a massive reduction in cultivars and increase in heathland and woodland which can probably be correlated with the late 14th Century recession. The uppermost 1m shows an increase of woodland pollen taxa due to the afforestation of the area over the last 200 years with various species, particularly *Pinus*.

It should be noted that below about 16.5m the pollen spectra are distorted, apparently showing a reverse of the Boreal-Atlantic Transition sequence. This is believed to have been caused by a combination of the Hiller corer veering to either side in markedly concave sediments, and possibly slumping of those sediments.

CONCLUSION

Rinsmoor is clearly a site of some palaeoecological and geomorphological interest. The pollen-analytical record has been thoroughly exploited, and with the time scale reported here there is clear potential for detailed macrofossil and chemical analyses. A nearby site, Okers, was also pollen-analysed by Waton (1982) and it would be worth surveying other dolines in Wessex and elsewhere for the presence of organic sediments.

ACKNOWLEDGEMENTS

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PORTLAND BILL: UPPER PLEISTOCENE MARINE AND PERIGLACIAL DEPOSITS

by

D. H. Keen

The Pleistocene deposits of Portland Bill are among the most famous in Wessex and the marine deposits have figured in virtually all summaries of Upper Pleistocene sea levels in the English Channel since Prestwich's first comprehensive description in 1875. Later workers have until recently fixed upon various aspects of the beach deposits, eg Baden-Powell (1930) on their shelly fauna, J.F.N. Green (1943) on their height above present sea level, but most work this century including the much quoted review by Arkell (1947) has drawn heavily on Prestwich's original work for most detail.

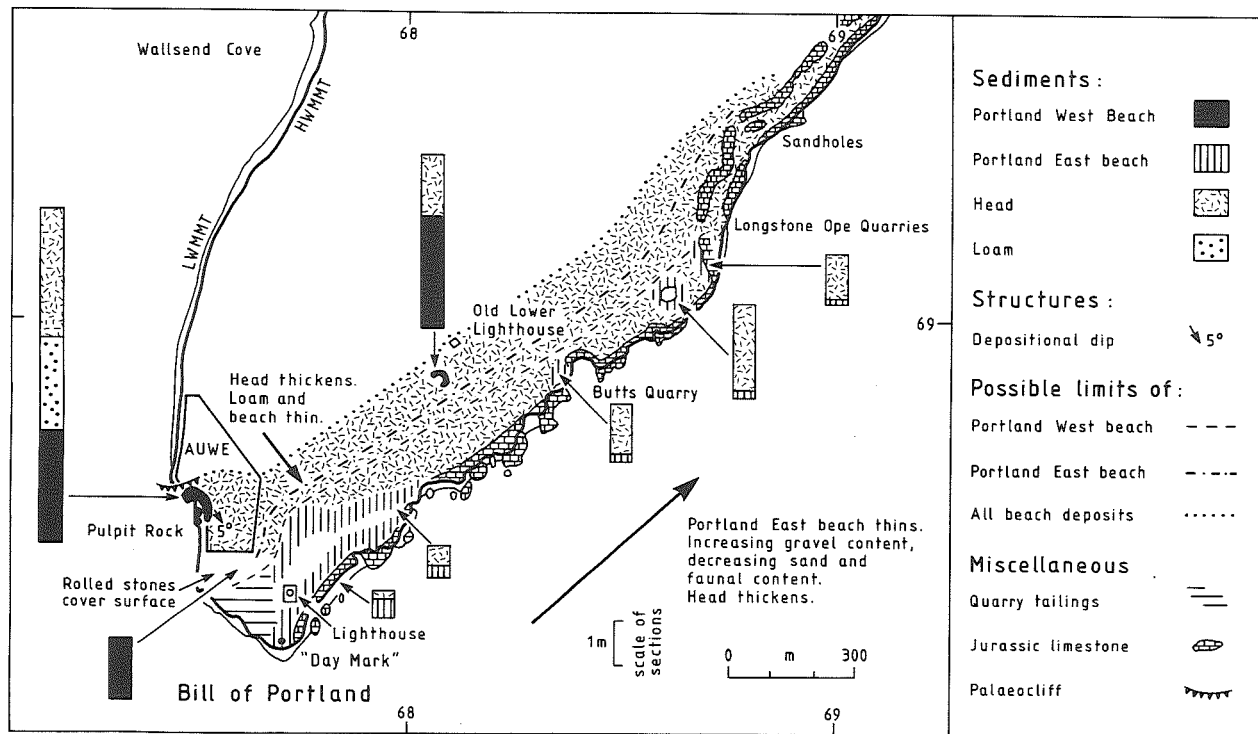
The summary of previous views eg Motterhead (1977a), Carr in Motterhead (1977b) suggests that there is one raised beach deposit with a slope from east to west from 6.1 to 18.3m O.D. Its shelly fauna is largely restricted to the east side of the peninsula and indicates a sea temperature 3° F (1.6°C) colder than the current English Channel. The beach is overlaid by a "loam" and a head which contains a molluscan fauna indicative of deposition under a temperate climate in a mere formed by a slight fall in sea level.

Work in the 1980s (Davies and Keen, 1985; Keen, 1985) involving resurvey and geological mapping of the deposits, bulk sampling of the mollusc-bearing units, both marine and terrestrial, and the application of amino-acid relative chronologies to the marine Mollusca and has allowed a new interpretation to be placed on the Portland deposits. Lithologically, altimetricaly and faunally the beach sediments on either side of Portland Bill differ. Because of this they have been divided into two lithostratigraphic units by Davies and Keen (1985).

THE EAST BEACH

The deposits of this beach are best seen in a near continuous 200m long section from Portland Bill north-eastwards, but patches of beach sediment occur for up to 1.5 km NE towards Sandholes (SY 68866940) and also to the west of the lighthouse in the Bill Quarries at SY 67676835 (Figure 1). The beach comprises sub-angular to rounded clasts of Portland and Purbeck limestones, with a few pebbles of flint and chert, as well as skeletal carbonate debris, in a buff sandy matrix. The southwestern-most exposures of the beach are represented by rolled boulders of local bedrock, up to 60 cm in diameter, with interstitial fine gravel and sand and shell pockets. The beach sediment becomes increasingly gravelly and less shelly to the northeast until, at Longstone Ope quarries, it is represented by a gravel with only a few abraded shell fragments. The thickness of the beach sediment declines from southwest to northeast, from 45 cm near the lighthouse to 15 cm at the northeastern limit of the beach.

Figure 1 Map of the Pleistocene deposits at Portland Bill



Sedimentologically, the beach is structureless, probably due to the destruction of any original sedimentary structures by post-depositional cryoturbation (Pugh & Shearman, 1967). The deposits are largely uncemented except for small patches observed in Butts Quarry (SY 68346896). A number of estimates of beach elevation have been reported in the literature (Prestwich, 1875; Green, 1943; Arkell, 1947) and these are summarised in Davies and Keen (1985). Levelling of the base of the beach by those authors showed that it lies between 6.95 and 10.75m O.D. with its highest elevation being immediately to the west of the Lighthouse. The beach contains a diverse molluscan fauna, comprising 62 taxa (Table 1). The faunal content of the beach declines from southwest to northeast. The deposit is most shelly within 200 m of Portland Bill, where a 2 kg sample yielded a total of 6670 Mollusca, dominated by Littorina spp., Gibbula spp., Patella spp., Nucella lapillus (L), Rissoa spp., and Turtonia minuta (Fab.), (Table 1). Foraminifera also occur in this sediment (Table 2); other skeletal debris includes branching fenestrate bryozoa, encrusting bryozoa, Balanus spp., crab claws and carapace fragments, echinoderm debris and annelid debris (Davies, 1984). The fauna indicate sedimentation in a rocky near-shore environment close to low-water mark. Baden-Powell (1930) suggested that the fauna indicated deposition in a sea with approximately 4°F (2.2°C) cooler surface waters than those of the present, on the basis of the presence of such 'northern' species in the sediment as a particular sub-species of Onoba striata (Adams), and Margarites helicinus (Fab.). By contrast, Baden-Powell also noted the presence of such 'southern' forms as Phasianella (Tricolia) pullus (L) and Ocenebra (Murex) erinacea (L), but preferred to discount the evidence of these species in deducing the climatic setting represented by the Portland East Beach.

In view of the conflicting evidence of Baden-Powell, and of the occurrence of large numbers of individuals with a distinct preference for southern British waters at present and the fact that the fauna as a whole is overwhelmingly similar to that of the present day English Channel, the Portland East beach faunal assemblage must be regarded as indicating a sea surface temperature at least as warm as at present. The tentative identification of a fragment of Haliotis tuberculata (L) (by means of the perforated ridges, characteristic of this species), gives further evidence of a warm sea temperature. At present, this species has a northern limit on the south coast of the English Channel around Cherbourg.

The restricted foraminiferan fauna recovered from the East Beach (Table 2) also indicates sea surface temperatures no colder than at present. Elphidium crispum (L) currently has a rather southerly British distribution, being found largely in the English Channel and not further north (J.R. Haynes, pers. comm.).

TABLE 1

MOLLUSCA OF THE PORTLAND EAST BEACH DEPOSIT
(From Davies and Keen, 1985)

GASTROPODA

Archaeogastropoda:

<i>Haliotis tuberculata</i> (L)	<i>Diodora apertura</i> (Mont.)	<i>Patella vulgata</i> (L)
<i>Patina pellucida</i> (L)	<i>Patellioda tessulata</i> (Muller)	<i>P. depressa</i> (Pennant)
<i>Margarites helicinus</i> (Fab.)	<i>P. virginea</i> (Muller)	<i>P. aspera</i> (Roding)
<i>Gibbula magus</i> (L)	<i>Gibbula cineraria</i> (L)	<i>Calliostoma zizyphinum</i> (L)
<i>G. umbilicalis</i> (da Costa)	<i>Tricolia pullus</i> (L)	<i>Skenea serpuloides</i> (Montagu)

Megagastropoda:

<i>Lacuna parva</i> (da Costa)	<i>Littorina littorea</i> (L)	<i>Acnea subcylindrata</i> (L)
<i>Cingula semicostata</i> (Montagu)	<i>L. littoralis</i> (L)	<i>Rissoa parva</i> (da Costa)
<i>C. cingillius</i> (Montagu)	<i>L. saxatilis</i> (Oliv)	<i>Rissoa</i> spp.
<i>Acilis</i> spp.	<i>L. neritoides</i> (L)	<i>Skeneopsis planorbis</i> (Fab.)
<i>Trivia</i> spp.	<i>Omalgrya atomus</i> (Philippi)	<i>Aporrhais pes-pellicani</i> (L)
<i>Turritella communis</i> (Risso)	<i>Lamellaria perspicua</i> (L)	

Stenoglossa:

<i>Trophon truncatus</i> (Strom)	<i>Nucella lapillus</i> (L)	<i>Nassarius reticularis</i> (L)
<i>Ocenebra erinacea</i> (L)	<i>Buccinum undatum</i> (L)	<i>N. incrassatus</i> (Strom)
<i>Lora</i> spp.		

Bullamorphia: *Retusa retusa* (M & R)Basommatophora: *Leucophytia bidentata* (Montagu)

CHITONIDA: species as yet unidentified

BIVALVIA

Protobranchia:

<i>Nucula sulcata</i> (Bronn)	<i>Nuculana minuta</i> (Muller)	
<i>Glycymeris glycymeris</i> (L)	<i>Anomia ehippium</i> (L)	<i>Mytilus edulis</i> (L)
<i>Mytilus/Modiolus</i> spp.	<i>Musculus marmonatus</i> (L)	

Pseudolamellibranchia:

<i>Ostrea edulis</i> (L)	<i>Chlamys distorta</i> (da Costa)	<i>Chlamys varia</i> (L)
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Teleodermacea:

<i>Astarte borealis</i> (L)	<i>Lucinoma</i> spp.	<i>Neolepton sulcatulum</i> (Jeffrys)
<i>A. sulcata</i> (da Costa)	<i>Mysella bidentata</i> (Montagu)	<i>Montacuta ferruginosa</i> (Montagu)
<i>Venus ovata</i> (Pennant)	<i>Macoma balthica</i> (L)	<i>Cerastoderma edule</i> (L)
<i>Turtonia minuta</i> (Fab.)	<i>Solen marginatus</i> (Montagu)	<i>Hiatella arctica</i> (L)

TABLE 2

FORAMINIFERAN FAUNA OF THE PORTLAND EAST BEACH
(From Davies and Keen, 1985)

<i>Elphidium crispum</i> (L)	<i>Massalina secans</i> (d'Orbigny)
<i>Miliolina seminulum</i> (L)	<i>Miliolinella subrotunda</i> (Montagu)
<i>Quinqueloculina seminulum</i> (L)	<i>Polystomella striatophunctata</i> (F & M)
<i>Q. intricata</i> (L)	' <i>Rosalina</i> ' <i>parisiensis</i>

THE WEST BEACH

Exposures of the Portland West Beach are far less extensive than those of the Portland East Beach. In situ beach gravel only occurs in a 40 m long coastal section, immediately south of SY 67506860 (Fig. 1), although the widespread occurrence of beach pebbles in the area 200m to the south of the section may indicate the former extent of this beach. Again, inland exposures are rare - only one section at SY 68056885 in a small disused quarry, approximately 100m southwest of the Old Lower Lighthouse (now the Portland Bird Observatory) was observed. This comprises 1.8-2.5m of cemented well-rolled beach gravel.

The beach consists of up to 2.5m thickness of well-sorted sandy gravel. Individual clasts range up to 6 cm in length, and a wide variety of lithologies are represented (Table 3). The 'exotic' clasts are probably largely derived from Devon and Cornwall (Prestwich, 1875) and the clast composition is in marked contrast to that of the Portland East Beach, which contains only rare 'foreign' stones, chiefly flint and quartzite, also probably derived from western sources.

The beach shingle above is composed of a series of fining upward units (from pebble-shingle to gravel-coarse sand), each approximately 25 cm thick. The shingle is planar bedded, with a 5°SSE depositional dip, and pebble imbrication can be observed in the coarser beds, which probably indicate deposition in a fairly high energy environment. The fining upward units may suggest a diurnal or seasonal fluctuation in the energy of the environment.

Several estimates of beach elevation have been reported in the literature (Prestwich, 1875; Baden-Powell, 1930; Green, 1943). Recent work by Davies and Keen (1985) shows that the base height of the West Beach is between 14.12 and 14.50 m O.D. thus up to 3.37 m above the highest base height recorded for the East Beach.

The Portland West Beach is cemented to a much higher degree than the Portland East Beach. The finer beds of the Portland West shingle exhibit a well-developed calcium carbonate cement. The coarser beds have a well-developed calcium carbonate rim-cement with dripstone textures, but lack any great development of void-filling cement. The cement conforms to a meteoric type, precipitated in the vadose zone (as defined by West, 1973). The Portland West Beach is almost entirely devoid of fauna. Prestwich (1875) reported 'one specimen of Buccinum undatum (L) and a few fragments of Mytilus spp.'. Additionally, in the smaller sediment-size fractions, Davies and Keen (1985) found fragments of Nucella lapillus (L), Cerastoderma spp., and Patella spp. The restricted fauna indicate deposition proximal to a rocky-shore environment, and the paucity of fauna suggest that either the depositional environment may have been that of a high-energy unstable shingle-bank, or that post-depositional decalcification of an intertidal shingle has occurred. The low abundance and diversity of the fauna is in marked contrast to that of the East Beach.

TABLE 3

COUNTS OF LITHOLOGIES IN THE PORTLAND WEST BEACH

Coarse Units (clasts in excess of 2.5 cm length):

	percentage				
	i	ii	iii	iv	mean
flint	89.5	90.1	90.0	85.2	88.7
Portlandian rocks	10.4	6.5	6.0	0.0	5.7
chert	0.0	1.6	2.0	0.0	0.9
white quartzite	0.0	1.6	2.0	0.0	0.9
purple quartzite	0.0	0.0	0.0	9.8	2.4

Fine Units (2.5-1 cm clast diameter)

flint	90.1	91.4	86.2	95.4	90.7
Portlandian rocks	3.9	2.1	3.9	4.5	3.6
chert	0.0	0.0	0.0	0.0	0.0
white quartzite	5.8	4.2	3.9	0.0	3.4
purple quartzite	0.0	2.1	5.8	0.0	1.9

data based on counts of one hundred stones within 0.5 m² areas of the beach chosen at random and enclosed by a quadrat.

In addition to the above counts, the following lithologies were also identified as isolated pebbles:

cementstone	'beef'	bioclastic limestone
(local)	(fibrous calcite-local)	(local)
nummulitic limestone	chalk	derived Jurassic fossils
(local)	(Cretaceous)	(local)
Cretaceous Greensand		

Prestwich (1875) also notes the following lithologies in the West beach:

flint	chert	sandstone
(Cretaceous)	(Cretaceous)	(Lower Tertiary)
ferruginous grit	red sandstone	purple sandstone
(Lower Tertiary)	(Triassic)	(Triassic)
grey and red quartzite	red feldspar porphyry	
(Triassic)	(Triassic)	
micaceous sandstone	red granite	
(Devonian)	(Cornwall)	

TERRESTRIAL DEPOSITS

Both East and West Beaches are overlain by terrestrial deposits. The East Beach is covered by up to 1 m of orange to chocolate-brown silty sand with angular fragments of Portland Limestone and chert, regarded by Arkell (1947) and Keen (1985) as an argillaceous head. The West Beach is covered by up to 5 m of head and 'loam' best seen in the Admiralty Underwater Weapons Establishment (A.U.W.E.) section. The thin deposits over the East Beach are mostly decalcified, but those over the West Beach, especially the Head are not, and contain a well developed molluscan fauna recorded as early as 1875 by Prestwich and recently re-examined by Keen (1985).

The major section now available is in the grounds of the A.U.W.E. (Figure 2) at SY 6750 6860 although Prestwich (1875) describes a very similar section, now lost, at Sandholes 1.7 km to the NE which perhaps indicates a continuous cover of head over the West Beach all along its outcrop. All workers on the Portland terrestrial deposits describe two units over the West Beach, a (lower) 'loam' and an (upper) head. All investigators prior to Keen (1985) suggest that molluscan faunas indicative of a temperate climate come from both units.

The section at the A.U.W.E. is as follows:

- Head (4) 2.2-3.4 m. Silty head with angular limestone clasts up to 20 cm long axis. Considerable disturbance by involutions, small quantities of Mollusca present.
- (3) 0.8-2.2 m. Silty head with scattered angular limestone clasts as above, numerous shells.
- (2) 0.5-0.8 m. Very silty head with few angular stones, very shelly.
- Loam (1) 0.0-0.5 m. Light brown, very silty sand ('loam') with small calcareous pellets; rolled flint pebbles in the lower 20 cm; no shell present.

The base of the section lies on the Portland Raised Beach.

Both head and loam are of variable thickness. The loam is thickest to the north against the cliff line of the raised beach, (Fig. 2), where it has a maximum thickness of 1.7 m. It thins southwards to be cut out by the head c. 30 m from the cliff. The head is thinnest to the northern end of the section (1.4 m) but thickness southwards to reach a maximum of 4.6 m at its thickest point c. 25 m south of the former cliff. From this point the head thins again until it disappears about 40 m south of the cliff.

The thickness of the loam is far less than in Prestwich's (1875) description where he suggests a maximum thickness of 10 ft (c. 3m). This greater thickness is accounted for when Prestwich's statement that the loam contains 'seams of angular debris' within it is considered. This must refer to the lower levels of the head, as the loam *sensu stricto* has no gravel in it whatever, except a very few well-rounded flints in its lower levels which have been derived from the underlying raised beach. The loam also contains small concretions or pellets of calcium carbonate, and fragments of these together with the silty sand which makes up the majority of the loam occur in the base of the head. This incorporation of material from the loam into the head does not mean that there is a gradational boundary between the two deposits as described by Arkell (1947). The boundary between the two units is a sharp one, and is best seen at the northern end of the exposure, where it forms a plane surface and shows an abrupt break between the fine-grained loam beneath and the coarse head above.

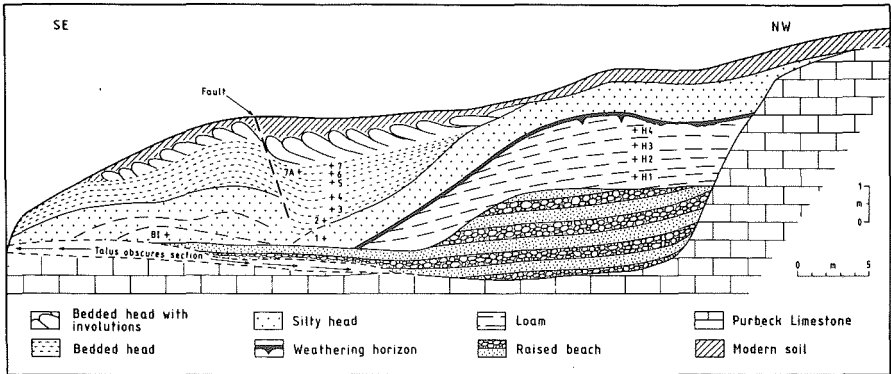


Figure 2 Stratigraphic section of the Portland West Beach deposits at A.U.W.E.

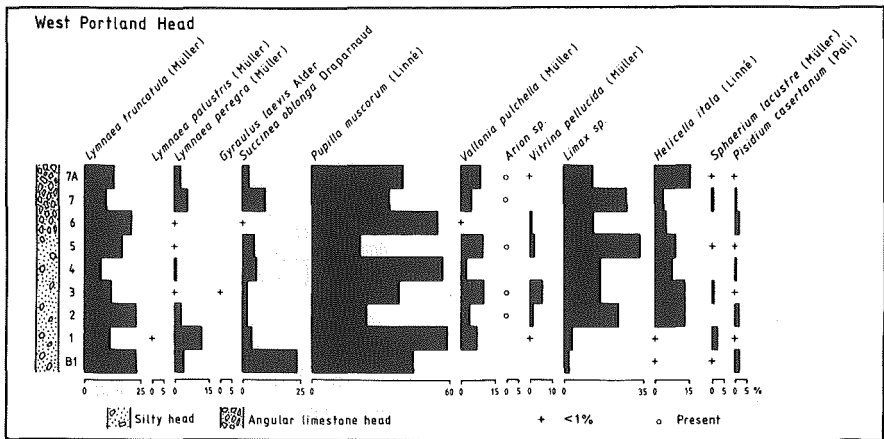


Figure 3 Molluscan diagram from the Portland West Beach head deposit

Both loam and head are crudely bedded with a shallow inclination to the south. The bedding of the loam is at a very low angle ($<3^\circ$) and individual bedding planes are marked by lines of calcareous pellets. The head is more massively bedded, and at a greater angle ($5-10^\circ$), with discontinuous beds of redeposited loam marking the structural pattern. This low-angle bedding is probably due to the deposition of both loam and head by slope wash.

The head and loam are also separate in terms of their texture. The head is composed of angular fragments of limestone up to 25 cm long axis in a matrix of sand and silt. The loam is a sandy silt without larger particles except for the calcareous concretions. Although both deposits owe their present form to slope processes as noted above, it is possible that the loam may owe part of its origin to aeolian activity in view of its uniform fine-grained nature. However, the quantities of sand and bedded calcareous concretions rule out an origin for the loam as primary loess.

The top of the head exhibits a range of involutions which totally distort the original bedding for c. 1 m below the modern soil. The involutions are the characteristic festoons found widely in southeast England (Williams, 1975). These structures are inclined to the south, the direction of maximum slope, and probably point to a second phase of frost action after the initial formation of the bedded head. With the involutions is a zone of disturbance inclined in accordance with them, with penetrates deeper than 1 m into the head. Because of the displacement of c. 5 cm of the edges of beds which occurs across this zone, it may be possible to interpret this structure as a small reversed fault formed by the ice-induced stresses which formed the involutions. Similar intense frost disruption has been described from the east side of Portland Bill by Pugh & Shearman (1967), where the head is thinner and the underlying bedrock is also broken.

The fossil content of the deposits was investigated by means of samples taken as continuously as the coarse nature of much of the sediments would allow. Nine samples, each weighting c. 2 kg and representing about 2 cm of sediment, were taken from the head (1-7, 7A, B1, Fig. 3 and Table 4) and four (H1-4) from the loam. Samples 1-7 and H1-4 were stratified samples, 7A and B1 taken from conspicuously shelly patches of head.

The samples from the head were all fossiliferous, with a majority of the shells occurring in the more silty horizons but with all levels yielding some shells. By contrast, the samples from the loam were entirely devoid of shell and a search of the exposed surface of the loam similarly showed no trace of shell. Both Prestwich (1875) and Arkell (1947) note that the loam is shelly. In fact only the silty layers of the head have shells; the in situ loam is unfossiliferous.

TABLE 4

WEST PORTLAND HEAD - MOLLUSCA
(from Keen, 1985)

Species	Sample number								
	Bl	1	2	3	4	5	6	7	7A
<u>Lymnaea truncatula</u> (Muller)	93	26	29	66	6	58	28	8	72
<u>L. palustris</u> (Muller)	.	1	.	.	.	.	.	.	.
<u>L. peregra</u> (Muller)	15	27	6	4	1	2	1	5	15
<u>Gyraulus laevis</u> (Alder)	.	.	.	1	.	.	.	.	.
<u>Succinea oblonga</u> Draparnaud	94	9	4	13	5	16	1	8	17
<u>Pupilla muscorum</u> (Linne)	175	132	30	203	45	72	74	27	214
<u>Vallonia pulchella</u> (Muller)	.	13	5	52	2	36	1	4	50
<u>Arion</u> sp. (granules)	.	.	+	+	.	+	.	+	+
<u>Vitrina pellucida</u> (Muller)	.	1	2	30	.	8	2	.	4
<u>Limax</u> (Deroceras) sp.	8	8	31	87	13	114	18	22	67
<u>Helicella itala</u> (Linne)	3	1	17	71	6	32	7	3	87
<u>Sphaerium lacustre</u> (Muller)	3	5	.	6	.	1	.	1	2
<u>Pisidium casertanum</u> (Poli)	8	2	3	3	1	1	3	1	2
Totals	399	225	127	536	79	340	135	79	530

Bivalve counts are individuals, calculated as total numbers of shells divided by two; + indicates present. Total individuals 2450.

The molluscan fauna is similar throughout the head and contains a restricted number of taxa (eleven species and Arion sp. and Limax (Deroceras) sp.). Mollusca from three habitats are represented: (a) small pools or strings (Lymnaea palustris (Muller), Lymnaea peregra (Muller), Gyraulus laevis Alder, Sphaerium lacustre (Muller) and Pisidium casertanum (Poli)); (b) marsh areas (Lymnaea truncatula (Muller), Succinea oblonga Draparnaud and Vallonia pulchella (Muller)); (c) dry, usually calcareous, grassland (Pupilla muscorum (L) and Helicella itala (L)). In addition Vitrina pellucida (Muller) and the two slug genera Arion and Limax (Deroceras) sp. may occupy a range of more or less damp conditions from grassland to marsh edges. Although all the Mollusca except G. laevis and L. palustris are present throughout, the lowest level of the head (1 and Bl) appears

to represent the dampest conditions, with the highest values for S. oblonga and low values for H. itala. Upwards, although the values for most taxa fluctuate, there is no one group which is dominant over the others and thus indicates a permanent change of environment. This restricted molluscan fauna is made up of taxa which are all found in Britain today. This was noted by Prestwich (1875) and Arkell (1947), and was taken to indicate that the climate of formation of the head and loam was little different from that of the present, although both of these authors recognised the cold-climate affinities of the upper parts of the head. Such a restricted fauna, despite the geographical ranges of individuals in it at present, cannot now be regarded as being of temperate type. Such faunas of grassland with wet areas are now generally regarded (see Kerney, 1963) as being of cool to cold aspect. The absence of such species as Columella columella (Martens) and Vertigo genesii (Gredler), however, suggests that the climate although cool was not extreme, as these arctic/alpine species occur in deposits formed under conditions of considerable climatic severity (Kerney, 1963). All the taxa recorded at Portland except H. itala and S. lacustre are however regarded by Holyoak (1982) as being typical of 'glacial' conditions in the Mid-Devensian.

Of the two exceptions, S. lacustre is of southern distribution according to Ellis (1962), although its current British range extends north to Ross-shire; H. itala reaches as far north as Denmark (Kerney & Cameron, 1979), although its major areas of distribution are southern and western. In summary, the molluscan fauna can be seen to be derived from an area which contained small ponds, marsh and grassland. Overall the local climate was cool, but not as cold as the most extreme conditions of glacial climates. The samples of head sorted for Mollusca also yielded nineteen valves of four species of Ostracoda (identified by Dr. J.E. Robinson). The occurrence of these can be seen in Table 5. Three of these species of ostracods confirm the local environmental conditions suggested by the Mollusca. I. olivaceus is found in calcareous springs at present, while the two species of Ilyocypris occur in small pools with a good amount of vegetation. C. torosa is, however, a brackish-water species usually found in estuarine or lagoonal areas with salinities of 1-2‰. It would not usually be found with the other ostracods or the Mollusca.

Two possibilities exist to provide the small quantities of salt necessary for C. torosa to occur. Firstly the salt may have been

TABLE 5

WEST PORTLAND HEAD - OSTRACODA
(from Keen, 1985)

Species	Sample number		
	5	3	2
<u>Cyprideis torosa</u> (Jones)	-	-	9
<u>Ilyodromus olivaceus</u> (Brady & Norman)	1	3	4
<u>Ilyocypris bradyi</u> (Sars)	-	-	1
<u>Ilyocypris gibba</u> (Ramdohr)	-	1	-

provided from nearby marine sources. The loam and head rest on a raised beach, and the coast may have been close by during the deposition of the lower part of the sequence. Secondly salt may have been derived from salt seepages from the Purbeck Limestones. Arkell (1947) notes the occurrence of salt in the Broken Beds of the Purbeck at Durdle Door, 17 km northeast of Portland. The Broken Beds form the solid platform on which the Pleistocene deposits rest at Portland. There can be no confirmation of either of these two hypotheses, although the provision of salt from local marine sources would require a high sea level, which is not generally regarded as occurring during the formation of the head.

In view of the occurrence of derived marine fossils in the head (Keen, 1985) it may also be possible that the specimens of C. torosa were washed from one of the local marine formations. However, despite a careful search, samples from these proved to be devoid of ostracods, although foraminifera were present. Also the various facies of the Portland Raised Beach are all high-energy, rocky, open shoreline deposits, not those to provide a suitable habitat for C. torosa. The probable explanation for the occurrence of this brackish ostracod is therefore some kind of salt seepage, but this cannot be confirmed.

DATING OF THE DEPOSITS AND PALAEOENVIRONMENTAL SYNTHESIS

The original model of the sequence of the deposits at Portland is exemplified by Arkell (1947). This regards the complex of beach and terrestrial sediments as product of one interglacial high sea level stage and one cold phase with the base of the loam/head sequence representing the transition from warm to cold conditions. Summaries of the raised beach sequence of the Channel coast (eg Mottershead 1977a) regard the beach as Ipswichian and the overlying terrestrial deposits as of Devensian age.

Recent work (Davies 1983; Rowe and Atkinson, 1985; Davies and Keen, 1985; Keen, 1985) has modified this earlier view. The methods used to investigate the ages of the Portland deposits have been amino-acid and uranium-series geochronology, although critical re-examination of the sediment, fauna and stratigraphy of the deposits have all assisted in allowing the suggestion that the deposits occupied a longer timespan than the simple chronology of Arkell or Mottershead.

Attempts to date the calcareous matrix of the West Beach by U-series (Rowe and Atkinson, 1985) have yielded only Flandrian dates (8,700 and 3,400 bp). While it is probable that the beach cement may be wholly or partly of Holocene date, it is impossible that the beach itself is so recent. The amino-acid method has proved more successful in providing a chronology. Full details of the Portland analyses are set out in Davies (1983) and Davies and Keen (1985), but the results summarised here show a clear separation between the D-allo and L-isoo ratios for the shells from the West and East Beaches. The ratios indicate a consistent amino group 4 (sensu Davies, 1983 1984) age for the West Beach fauna and an amino group 3 age for the East Beach fauna, although the latter also includes some elements of group 4 faunas which are held by Davies and Keen (1985) to represent derived shells from the earlier deposits.

Because amino-acid geochronology is a relative means of dating which allows separation of faunas into groups but does not allow dates in years to be produced unless the amino-acid ratios are calibrated by a geochrometric technique, the ratios from Portland alone merely allow the separation of the two beach deposits, not their 'absolute' dating.

For raised beaches in the English Channel a local amino-acid chronology can be calibrated by means of the site of the Belle Hougue Cave, Jersey c. 100 km of Portland (Keen, Hamon and Andrews, 1981). Here shells subjected to amino-acid analysis have yielded ratios (for P. vulgata) with a mean of 0.12. The raised beach at this site is cemented by stalagmite which has yielded a U-series date of 121 ± 14 ka. - 12

The amino-group 3 ratios for P. vulgata from Portland East have a mean (of fourteen determinations) of 0.134 (Davies & Keen, 1985) which compares well with the Belle Hougue ratio. This then dates the East Beach to c 121 ka and to oceanic stage 5e and probably to the Ipswichian Interglacial. The dating of the West Beach cannot be so exact as although amino-acid ratios show clearly that the West Beach is older than the East, exactly by how much is uncertain. The separation of the two beaches is on the basis of the amino-acid ratios from L. littorea and N. lapillus which are common to both East and West Beaches. The only means of dating the West Beach is to extrapolate from the known age of the East Beach and the correlation with the Belle Hougue date via the rates of racemisation of these two species which provide a correlation. If this is done (Davies and Keen, 1985) an age of 200 ± 30 ka is achieved which places the West Beach in oceanic stage 7.

The ages of the terrestrial deposits can then be found by reference to the marine horizons. The West Beach is overlaid by the loam and the head. As stated above the loam is decalcified and topped by a weathering horizon. It is clear that this unit post-dates the deposition of the West Beach and was deposited by slope wash and/or aeolian deposition, probably in oceanic stage 6. Its original form must have been as a calcareous sediment, but later decalcification and reworking of the calcite has entirely altered the original deposit. It is probable that this decalcification phase was under a warm climate and may have occurred under interglacial conditions in stage 5. The weathering horizon on top of the loam shows some of the characters of a palaeosol in this section (work in progress J.A. Catt and P. Bullock pers. comm.) but it is not clear whether this is of an interglacial type. Probably at the same time as the loam was being weathered the East Beach was being deposited under conditions similar to or perhaps a little warmer than the present. The end of this interglacial (oceanic stage 5e?) is marked by the retreat of the sea and the beginnings of head deposition. Whether the whole of the head or only part of it was deposited early in the Devensian glacial stage is uncertain (Keen, 1985), but the deposition of the head over the East Beach probably occurred through much of this episode. After the deposition of the head it was cryoturbated by a later phase of cold climate.

SEQUENCE OF DEPOSITION AND DATING OF THE PORTLAND DEPOSITS

<u>Unit</u>	<u>Age</u>
Head	Late Devensian Early (Cryoturbation?)
Weathering of Loam	?Ipswichian (Oceanic stage 5?)
East Beach	Ipswichian (Oceanic stage 5e)
Deposition of loam	?Oceanic stage 6
West Beach	Oceanic stage 7

ACKNOWLEDGEMENT

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CHESIL BEACH

by

A. P. Carr

Chesil Beach is one of the three major shingle structures on the coast of Great Britain but, unlike Dungeness and Orfordness, it has no trace of a cusped foreland. The beach extends at least 18 km from Chesilton (Chiswell) in the east, where it terminates against the cliffs of the Isle of Portland, to an essentially arbitrary limit in the west. At both ends the shingle structure is joined to the mainland but over the remaining 13 km it is backed by the shallow, tidal, Fleet lagoon (Fig. 1). The Fleet varies in width from under 100 m to some 900 m, and in depth from less than -0.3 m to nearly -3.0 m below mean sea level.

Opposite the Fleet, Chesil Beach is between 150 and 200 m wide, but it is narrower both adjacent to the cliffs to the west and at the extreme eastern end. The crest is intermittent at the western end but extends continuously from west of Abbotsbury beach to Chesilton. The broad picture is of a progressively increasing ridge height from west to east, with the current maximum of approx. 14 m OD being found near Chiswell. Pebble size above low water mark also increases from west to east.

Offshore, the beach drops at a broadly similar gradient to that of the seaward face above low water mark for a horizontal distance of about 70 m. Thereafter it shelves gently to about -18 m OD, some 270 m offshore from Wyke Regis, and to -11 m OD at a comparable distance near West Bexington.

Chesil is one of the most exposed sites along the English Channel coast. Maximum fetch from the Atlantic can affect the Chesilton (east) end at directions between $220^{\circ}00'$ and $240^{\circ}30'$; Abbotsbury between $218^{\circ}30'$ and $232^{\circ}00'$ and Bridport (west end) between $215^{\circ}30'$ and $224^{\circ}00'$. Thus not only is the range of angles within which maximum fetch is possible greater at Chesilton but there is also the closest coincidence between maximum fetch and prevailing wind direction there. The most frequent wave period (T_z) is between 10.0 and 10.5 seconds, while 50 per cent of the significant waves (H_s) exceed 0.26 m at Wyke and 0.23 m at West Bexington.

A good overall view of the Beach and the Fleet may be had from the Portland Memorial (688730). It also incidentally shows the degree of disturbance resulting from various, mainly sea defence, works since 1980.

A very extensive literature on Chesil Beach and the Fleet exists and much of this has been summarised by Carr and Blackley (1973). The main interest has lain in: (i) The origin of the pebbles. About 98.5% of the present day beach comprises flint and cherts which would be locally derived. The remainder consists largely of quartzites, similar to those from an outcrop on the coast some 35 km to the west; various types of limestones; and a small

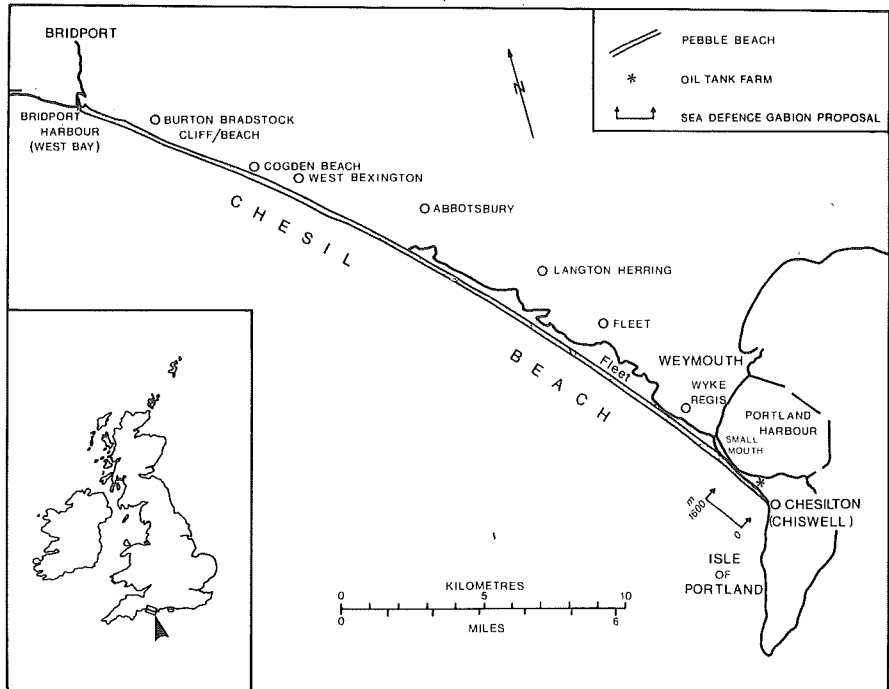


Figure 1 Map of Chesil Beach

percentage (of the order of 0.04%) of mainly igneous and metamorphic material all of which could have been derived from the southwest of England. (ii) The date of formation of the barrier beach; its possible analogue to the west (eg Hope's Nose, Torquay) and the relationship of Chesil Beach to the Portland Raised Beach whether in terms of geological composition, particle size, orientation, or height relative to sea level. Most of the sedimentation in The Fleet appears to have occurred between about 7000 and 5000 years BP and to be underlain by planed off bedrock at about -15m or more. (iii) The consistent rate of change in particle size grading of the modern beach: this is approximately exponential, with the largest pebbles/cobbles at the east end (ca 40mm mean long diameter) and the smallest towards the west (ca 15mm near West Bexington and smaller again towards Burton Bradstock and Bridport). Contemporary grading is restricted to the area above low water mark but discordant, although apparently systematic, elements of size grading do occur both on the surface of the landward slope of the beach near Wyke Regis, and below the present beach at depth. These deeper deposits are of interest not only for their much higher percentage of local geological constituents (reaching a known maximum of 46.6% limestone at -13.7m in one borehole) but also for their greater angularity. This increasing angularity even applies to some extent to the resistant flint and chert constituents. A further point of interest is the indication of pebble and limestone boulder deposits at the break of slope along the landward side of the Fleet near East Fleet at approx. -15m OD. These data imply active marine processes affecting the coastline prior to the genesis of the modern Chesil Beach and suggest, further, that the present structure is probably not all contemporaneous.

While the present day beach crest appears to be receding only slowly and locally landwards there is evidence to suggest that over the greater part of the beach east of Abbotsbury the crest height (but not the volume) has increased during the last two centuries or so. This phenomenon would appear to be the result of a very small number of major events.

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EVOLUTION OF THE UPPER REACHES OF THE SOLENT RIVER AND THE FORMATION OF POOLE AND CHRISTCHURCH BAYS

by

R. J. Nicholls

The Pleistocene evolution of the Hampshire Basin was dominated by a substantial easterly flowing river, the Solent River (Fox, 1862; Reid, 1902a; West, 1980; see Figure 1). During cold periods when sea-level was very low, it flowed across the sites of Poole and Christchurch Bays, the Solent and Spithead forming a system of gravel-floored channels and terraces up to 46m beneath contemporary sea-level (Everard, 1954a; Dyer 1975). During interglacial conditions, sea-level probably rose to elevations similar to or even above those of today, submerging the lower reaches of the river, forming broad estuaries (eg Brown, et al 1975).

Wide almost horizontal gravel terraces occur above sea-level at a range of elevations up to 128m OD in Hampshire and Dorset, with more scattered remains in the Isle of Wight (Codrington, 1870; Everard, 1954b). They are variously mapped as Plateau Gravel and Valley Gravel, although Everard (1952) demonstrated the inconsistency of these terms as presently used. They are retained in this guide for convenience of description, but in the longer term some revision is required. Beneath 40m OD, three groups of terraces can be distinguished, which Keen (1980) termed the High, Middle and Low Terraces. This terminology is followed in this paper. The gravels appear to have been deposited by the Solent River and its tributaries at relatively high base levels in the transition from interglacial to full glacial conditions (Keen, 1980). Only the Low Terrace can be dated, it having a late Ipswichian/early Devensian age (Brown et al, 1975; Keen, 1980).

The Solent River System was effectively disrupted by the breaching of the former chalk ridge between the Needles on the Isle of Wight and Handfast Point on the Isle of Purbeck (the Wight-Purbeck Ridge, Figure 1). This breaching is conventionally assumed to have been due to marine processes, but with the present state of knowledge the role of fluvial and periglacial processes cannot be assessed. By whatever process, the breaching allowed the southerly capture of a number of the Solent Rivers headwaters and also led to the formation of Poole and Christchurch Bays and the Isle of Wight.

The breaching was originally considered to have occurred in the Pliocene (Reid 1902a; 1902b), but was later considered to have occurred in the mid-Pleistocene (Reid, 1915; White, 1917; Bury, 1923; Green, 1946). The intensity of dissection around Poole Harbour as compared to Christchurch Harbour supports a pre-Flandrian date for the breaching. However, Everard (1954b) considered the breaching to have occurred during the Flandrian Transgression, citing the evidence of the buried channels of the

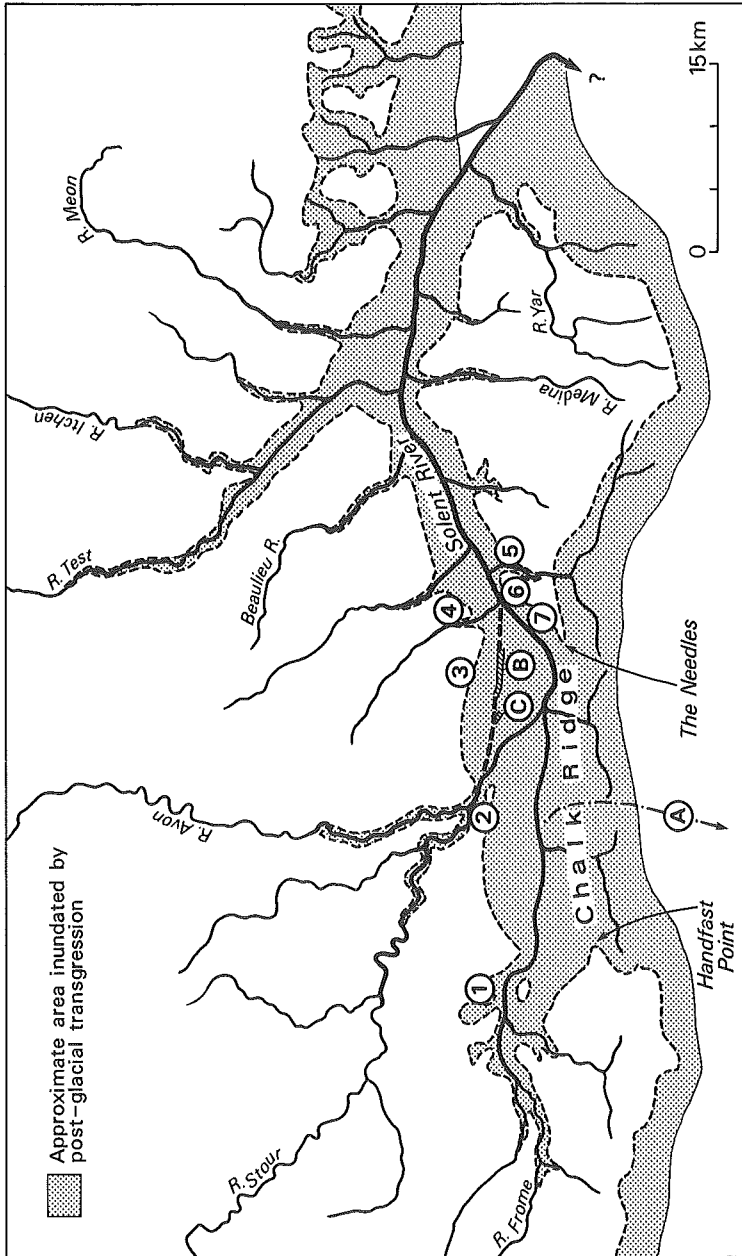


Figure 1 A reconstruction of the Solent River adapted from Small (1964) and West (1980), together with the seven sites described. A indicates the approximate position where the Wight-Purbeck Ridge was breached. B and C indicate the infilled channels described by Hooper & Kelland (1974) which are probably an easterly extension of the Stour and Avon

Solent River and the rapid coastal erosion of Poole and Christchurch Bays. Keen (1975) considered the Ipswichian/Devensian sequence at Stone Point (SZ 456984) to support this interpretation and it is most widely quoted (eg Small, 1970; Jones, 1981; Melville and Freshney, 1982). This view has been challenged by West (1980) and Wright (1982) who both concluded that the breaching occurred in pre-Flandrian times, the latter author tentatively favouring a period of relatively high sea-level during the Devensian. Clearly, the evolution of the upper reaches of the Solent River and its subsequent break-up has had important influences on Quaternary processes and sedimentation in the Hampshire Basin. The Plateau Gravel has recently been described by Keen (1980) and therefore, it is not considered in detail. The aim of this account is to examine and illustrate the evidence for:

- (a) incised Pleistocene channel systems in the upper reaches of the Solent River
- (b) the chronology of the breaching of the Wight-Purbeck Ridge.

Seven sites around Poole and Christchurch Bays are considered (Figure 1). The actual and the linear extrapolation of the Devensian longitudinal profile of the Solent River, as determined by Dyer (1975) (Figure 2), forms an invaluable datum to which the base level of the channels at these sites can be compared. Unfortunately, much of the evidence discussed is unavailable for direct examination as it is submerged.

SITE 1 - POOLE QUAY, POOLE (SZ 010904)

From Poole Quay, one can look south across the docks at Hamworthy where an infilled Pleistocene channel has been reported (Godwin, Suggate and Willis, 1958; Bird and Ranwell, 1964; West, 1980; Wright, 1982). The author has examined the borehole records of the Poole Harbour Commissioners, and a preliminary analysis confirms the presence of a substantial infilled Pleistocene channel and associated submerged terraces. The Pleistocene deposits comprise sands and gravels overlain by up to 11.9m of Flandrian peats, clays, silts, sands and gravels. The lowest Flandrian/Pleistocene contact occurs at an elevation of -13.4m OD, while the base level of the Pleistocene channel is not seen, being lower than -15.8m OD.

This channel is of considerable significance as it is too deep to fit the extrapolated longitudinal profile of the Solent River (A in Figure 2). It implies that the Frane was flowing southwards through a breach in the Wight-Purbeck Ridge no later than the Devensian and the catchment of the Solent River had been considerably reduced.

SITE 2 - HENGISTBURY LONG BEACH, NEAR SOUTHBOURNE, BOURNEMOUTH (SZ 160909)

At Hengistbury Long Beach, between Southbourne and Hengistbury Head, a 1500m width of Valley Gravels, up to 3m thick, is exposed

Solent River and the rapid coastal erosion of Poole and Christchurch Bays. Keen (1975) considered the Ipswichian/Devensian sequence at Stone Point (SZ 456984) to support this interpretation and it is most widely quoted (eg Small, 1970; Jones, 1981; Melville and Freshney, 1982). This view has been challenged by West (1980) and Wright (1982) who both concluded that the breaching occurred in pre-Flandrian times, the latter author tentatively favouring a period of relatively high sea-level during the Devensian. Clearly, the evolution of the upper reaches of the Solent River and its subsequent break-up has had important influences on Quaternary processes and sedimentation in the Hampshire Basin. The Plateau Gravel has recently been described by Keen (1980) and therefore, it is not considered in detail. The aim of this account is to examine and illustrate the evidence for:

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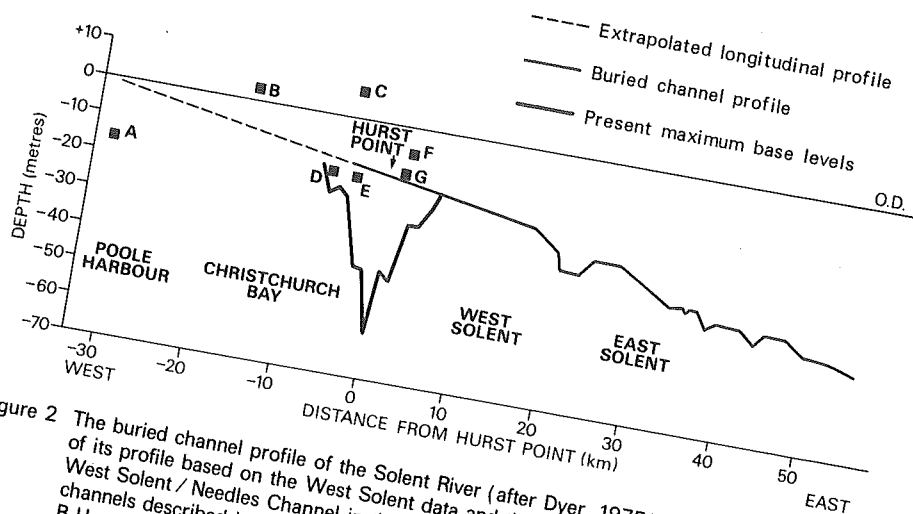


Figure 2 The buried channel profile of the Solent River (after Dyer, 1975), a linear extrapolation of its profile based on the West Solent data and the present base levels of the West Solent / Needles Channel in the vicinity of Hurst Point. The elevation of the channels described in the text are also indicated, these being: A Poole Harbour (Site 1), B Hengistbury Long Beach (Site 2), C Rook Cliff (Site 3), D and E Avon-Stour (?), F Pennington Marshes (Site 4), G Western Yar (Site 5)

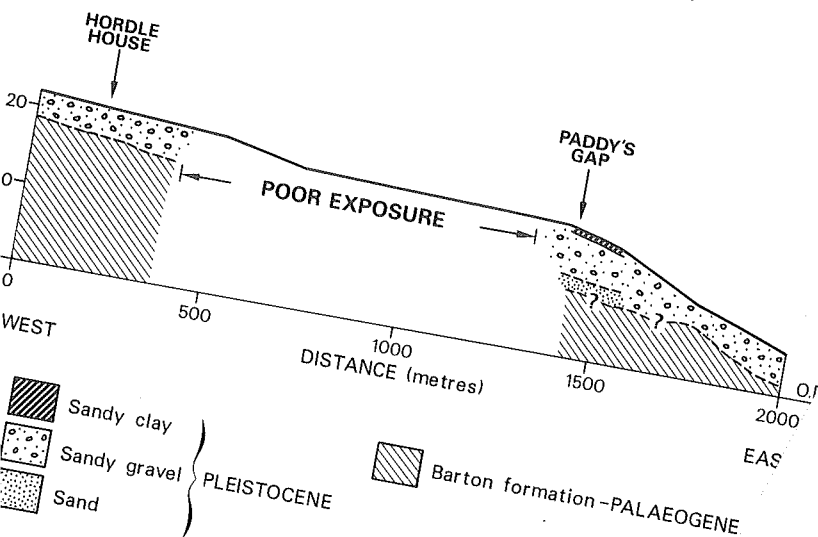


Figure 3 The approximate Pleistocene sequence in Rook and Hordle Cliffs

in a 3m to 4m high cliff. The gravel rests on surface of Palaeogene Boscombe Sands and fills the valley. It is composed predominantly of typical pebbles (cf Keen, 1980) but near its base, where cobbles and pebbles occur locally in the present, these being seen occurring and pebbles can also be seen. Leas ironstone and clay in the recent beach and in situ valley present at the base of the cliff components. The ex- being contain similar sedimentological components. The ex- being increasingly obscured by the construction of defences.

The channel occupies by far the largest dry valley in the coastal zone of Poole and Christchurch Bays and indicates a phase of substantial downcutting. It was thought to be a former southern course of the Stour (Codrington, 1870) but White (1917) demonstrated that it was, in fact, a tributary of the Stour on the grounds of its orientation, size tributary and gradient. White (1917) favoured a southerly tributary, a former southern course of the Stour and the Frame which is presently occupied by Poole Bay. However, two factors are worth considering:

- The present western limit of the gravel at Southbourne (SZ 150901), together with the topography, suggest that the course of the channel was more west to east rather than south to north.
- Was the suggested catchment sufficient, in itself, to produce a channel of the dimensions already described?

Could the channel represent a former course of the Frame? As such, its confluence with the Stour and Avon would define a former course of the Solent River. However, the Valley Gravel/alluvium fill of the Frame at Wareham (SY 925875) is 3000m wide, twice the width of the channel at Hengistbury. Long Beach, making the hypothesis the channel may represent the wide gravel-filled channel at Hengistbury. Alternatively, the confluence of several tributaries on the south bank of the Stour.

White (1917) and Green (1946) describe the gravels in the Stour and Avon graded to levels beneath present sea-level. These phases of downcutting are not represented in the channel described, and this base level is that of the Solent River (B in Figure 2). This demonstrates that whatever were the headwaters of the Hengistbury channel, they were lost before the lowest base levels of the Devensian were attained.

SITE 3 - ROCK CLIFF, MILFORD-ON-SEA (SZ 281916)

The thickness of Plateau Gravel reported as being exposed in cliffs between Barton and Milford-on-Sea has declined with as the rapid cliff recession (<1m/yr) has created fresh

in a 3m to 4m high cliff. The gravel rests on an undulating surface of Palaeogene Boscombe Sands and fills the bottom of a dry valley. It is composed predominantly of typical sub-angular flint pebbles (cf Keen, 1980) but near its base, well-rounded flint cobbles and pebbles are present, these being similar to those occurring locally in the Bracklesham Beds. Less frequently, ironstone and clay pebbles can also be seen. Care must be taken to distinguish between recent beach deposits which are often present at the base of the cliff and *in situ* Valley Gravel, as they contain similar sedimentological components. The exposure is being increasingly obscured by the construction of coastal defences.

The channel occupies by far the largest dry valley in the coastal zone of Poole and Christchurch Bays and indicates a phase of substantial downcutting. It was thought to be a former southerly course of the Stour (Codrington, 1870) but White (1917) demonstrated that it was, in fact, a tributary of the Stour on the grounds of its orientation, size and gradient. White (1917) favoured a southerly tributary draining the area between the Stour and the Frome which is presently occupied by Poole Bay. However, two factors are worth considering:

- (a) The present western limit of the gravel at Southbourne (SZ 150901), together with the topography, suggest that the course of the channel was more west to east rather than south to north.
- (b) Was the suggested catchment sufficient, in itself, to produce a channel of the dimensions already described?

Could the channel represent a former course of the Frome? As such, its confluence with the Stour and Avon would define a former course of the Solent River. However, the Valley Gravel/alluvium fill of the Frome at Wareham (SY 925875) is 3000m wide, twice the width of the channel at Hengistbury Long Beach, making this hypothesis unlikely. Alternatively, the wide gravel-filled channel at Hengistbury may represent the confluence of several tributaries on the south bank of the Stour.

White (1917) and Green (1946) describe the gravels in the Stour and Avon graded to levels beneath present sea-level. These phases of downcutting are not represented in the channel described, and the base level is above that of the Solent River (B in Figure 2). This demonstrates that whatever were the headwaters of the Hengistbury channel, they were lost before the lowest base levels of the Devensian were attained.

SITE 3 - ROOK CLIFF, MILFORD-ON-SEA (SZ 281916)

The thickness of Plateau Gravel reported as being exposed in the cliffs between Barton and Milford-on-Sea has declined with time, as the rapid cliff recession (<1m/yr) has created fresh exposures:

Gravel ThicknessSource

54-60 ft (16.5 - 18.3m)

Anonymous (1757)

50 ft (15.2m)

Webster (1822)

18-20 ft (5.5 - 6.1m)

Codrington (1870)

Only 800m inland from the 1870 cliff-top the Plateau Gravel is 9ft (2.7m) thick (Codrington, 1870). The diagrammatic geological section of Poole and Christchurch Bays at Lyell (1826) also suggests that a substantial thickness of Plateau Gravel formerly occurred at the localities described.

This reported change in thickness of the Plateau Gravel could indicate that:

- (1) The coastal landslides which characterise much of Christchurch Bay (eg Barton, 1973) were misinterpreted and colluvium was included in the gravel thickness.
- (2) A longitudinal section of an infilled pre-Devensian channel of the Solent River was formerly exposed in the cliffs of Christchurch Bay (Keen, 1975).

The former interpretation is considered to be unlikely as the Plateau Gravel presently forms a distinct scarp, which exposes the Pleistocene/Palaeogene unconformity. However, any debate concerning these different interpretations was limited as it was thought that all the deposits had been destroyed by coastal recession (Codrington, 1870). However, at Rook Cliff the cliff-top recession has only locally exceeded 10m since the first accurate map of the area (1843), the maximum recession being 45m. This is largely due to a protective beach. Thus, Rook Cliff provides a pertinent section, although it is mostly obscured by degraded landslides, more recent talus and vegetation. The complete Pleistocene succession can be seen at a few locations (Figure 3), being up to 7.0m thick (excluding up to 1m of brickearth). It comprises up to 2.5m of medium sand, containing scattered sub-angular flint granules and pebbles overlain by more typical gravels with channel fills of sand, as noted by Keen (1980). This is an exceptional thickness of Pleistocene sand and gravels for the area (cf Keen, 1980). Local thickening of the gravels often occurs at the edge of bluffs because of hillwash (Green, 1946). The presence of primary sedimentary structures in the deposit demonstrates this has not occurred at Rook Cliff. Therefore, the reported change in the thickness of the Pleistocene deposits exposed in the cliff of Christchurch Bay is, at least in part, real. These deposits are consistent with the interpretation that they include the infill of a substantial channel. If so, it was formed before the deposition of the Middle Terrace, which forms the surface at this site. The base level indicated is 7 to 8m OD, which is significantly above any large channel known in the area (C in Figure 2). The historical accounts of gravel thickness already discussed suggest a similar base level. More conclusive

proof of the interpretation presented is required and further, more detailed mapping is planned at this important site.

A subsidiary feature of interest at Rook Cliff is a sarsen at least 0.4m long which is becoming exposed by the degradation of the cliff beneath the Rook Cliff car park. In the interests of geological conservation, the author undertook no excavation. Similar sarsens are described in this vicinity by Everard (1952).

Hooper and Kelland (1974) located another infilled Pleistocene channel at a significantly lower base level than that indicated in Rook Cliff (D and E in Figure 2), about 2.5kms to the south on the seabed of Christchurch Bay (Figure 1). It is about 300 to 600m wide and extends over a distance of at least 4km (B in Figure 1) with a possible westerly extension (C in Figure 1). It indicated an easterly flowing river, this probably being the Devensian Avon and Stour. The base level (c-16m OD) implies that it is not part of the Devensian Solent River (D and E in Figure 2). However, this overdeepening is probably more apparent than real, being only of the order of 3m. Dyer (1975) noted a discrepancy of a similar order for the thalweg of the Solent River in the vicinity of the East Solent. Thus, these infilled channels indicate that the Avon and Stour remained part of the easterly flowing Solent River for much, if not all, of the Devensian.

SITE 4 - PENNINGTON MARSHES (SZ 325923)

A series of boreholes has demonstrated an interesting Quaternary sequence at this site (Figures 4 and 5). Two distinct gravel deposits of Pleistocene age can be distinguished, these being a lower and an upper gravel. The lower gravel occupies a channel cut into the underlying Palaeogene deposits which on the line of the cross-section is about 700m wide and 2m thick. The upper gravel is present across the entire cross-section and appears to consist of two distinct terraces up to 4.5m thick. The maximum elevation of the higher terrace is OD, and it probably belongs to the Low Terrace. The upper and lower gravels are compositionally similar to the Plateau Gravel. They are partly separated by up to 1.3m of Pleistocene very soft, dark grey organic silty clays and clayey silts, with subsidiary gravel, sand, wood and peat. Brickearth is present on the upper surface in one borehole, probably being a remnant of a more extensive deposit.

The Flandrian deposits are thin (up to 1.2m) and variable. The edges of both Pleistocene terraces are overlain by grey silts, containing pebbles and sand which appear to be derived from the underlying gravel. These deposits are overstepped by organic peaty and grey silty deposits, particularly above the lower terrace.

The channel occupied by the lower gravel indicates a phase of significant Pre-Devensian incision of the Solent River system. The side of a significant channel at a similar base level has been proved near Hurst Beach (SZ 298910 - see Nicholls, 1985). It is likely that they are part of the same channel, henceforth described as the Hurst-Pennington channel (Figure 4). Its base

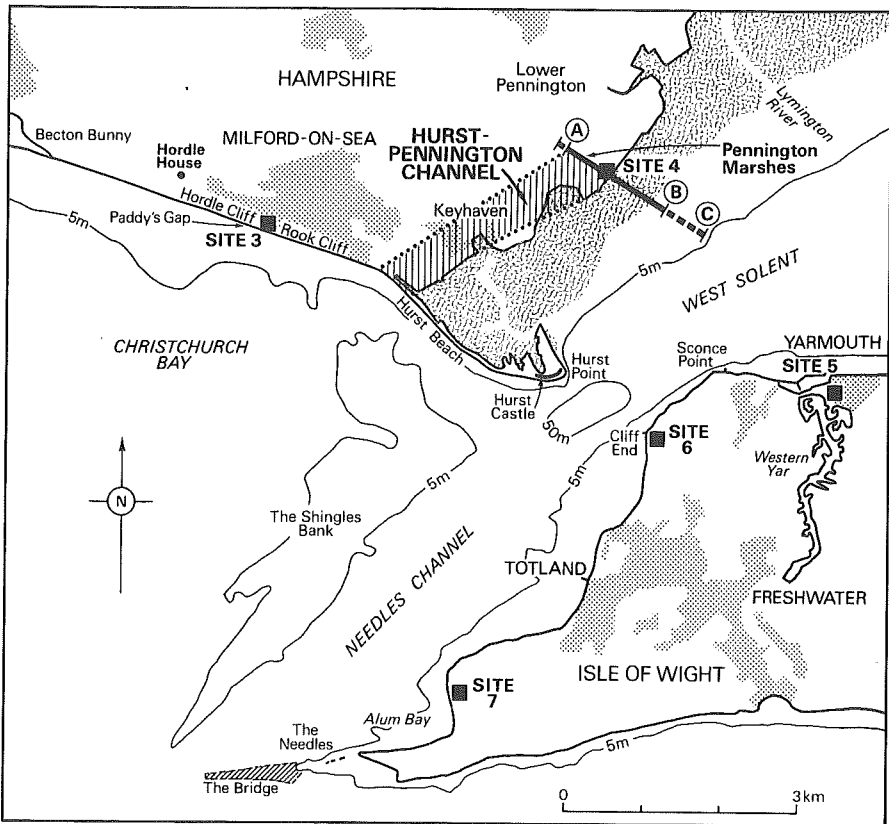


Figure 4 The eastern half of Christchurch Bay and West Wight, including the location of Section AB, illustrated at Site 4 (Fig. 5), the likely position of the Hurst-Pennington Channel and the bathymetry, relative to chart datum

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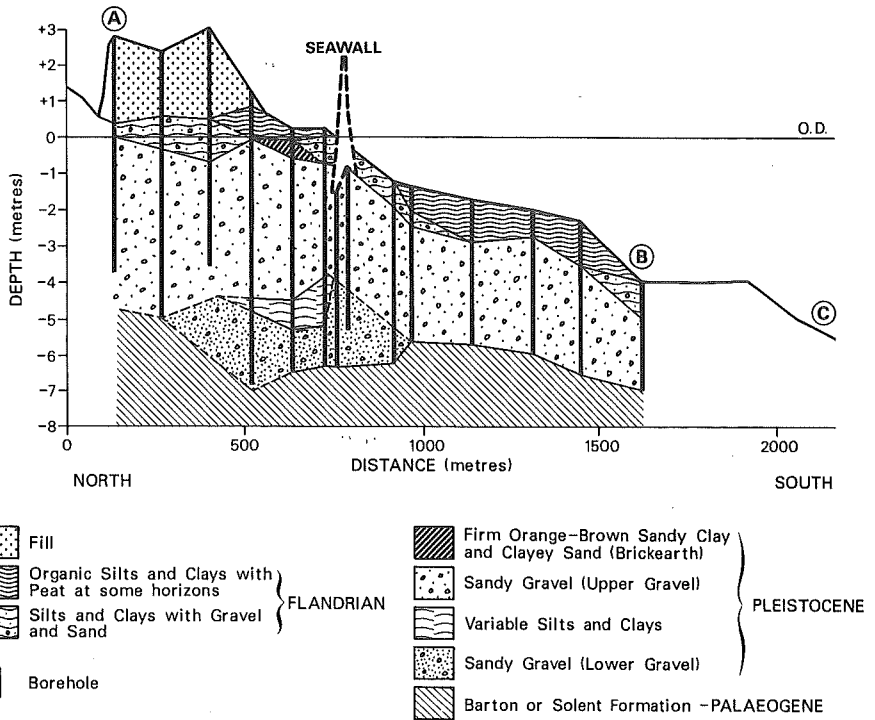


Figure 5 Geological section at Pennington. For location see Fig. 4

level is not recorded, but appears to be about -7m OD which is substantially above that reported by Dyer (1975), but beneath that indicated at Rook Cliff (F in Figure 2). The Hurst-Pennington channel is a substantial feature and parallels the present West Solent. It probably indicates a former course of the Solent River formed before the deposition of the Low Terrace.

The overlying Pleistocene sediments show a similar stratigraphy to that at Stone Point (cf Brown *et al.*, 1975). The age and detailed environmental implications of the interglacial Pleistocene silts and clays is unknown. However, the lithology suggests an estuarine environment, which in turn indicates that the sea submerged the Solent River as far as Pennington during at least one interglacial period.

The thin Flandrian sequence is in marked contrast to Southampton Water where up to 21m of Flandrian sediments are found (Hodson and West, 1972). The difference is partly due to the greater elevation of the Pleistocene surface at Pennington. In addition, the greater wave exposure and the faster tidal currents in the West Solent, as compared to Southampton Water are probably significant.

The thick sequence of Pleistocene gravels described is being reworked by coastal processes in Christchurch Bay. This has contributed substantially to the formation and stability of Hurst Castle Spit (Nicholls and Webber, 1987).

SITE 5 - YARMOUTH, ISLE OF WIGHT (SZ 353895)

Yarmouth is situated on the eastern side of the Western Yar, where it joins the West Solent. The Western Yar is a former tributary of the Solent River. A series of boreholes demonstrates that the Western Yar was excavated to at least -13.4m OD during the Pleistocene. The channel is filled with up to 1m of gravel, overlain by up to 12m of Flandrian deposits, comprising silts, clays and peats. The channel approximately fits the longitudinal profile of the Solent River (G in Figure 2). Therefore, it demonstrates that the Solent River was intact as far west as Yarmouth during the Devensian.

SITE 6 - CLIFF END, ISLE OF WIGHT (SZ 330891)

The Devensian channels recorded by Dyer (1975) have been modified by the Flandrian Transgression. In Southampton Water, the East Solent and Spithead, net sedimentation has occurred (Dyer, 1975; West, 1980). However, the present base levels in much of the West Solent and the Needles Channel in Christchurch Bay are substantially deeper than the longitudinal projection of the Solent River (Figure 2), although the thalwegs almost certainly do not coincide. This overdeepening is due to the rapid tidal currents in the West Solent which have scoured the bottom, a process which is still occurring (Dyer, 1972). The maximum depth (-60m OD) and scour (c 45m) occurs between Cliff End and Hurst Castle Spit where the channel is most constricted, being only 1250m wide. The present tidal currents exceed 2m/s on mean spring

tides and on calm days the strength of the tidal action is clearly visible from the shore. Thus, the Solent Deep of Kellaway, Redding, Shephard-Thorn and Destombes (1975) can be explained by present processes and this feature provides no evidence for glaciation.

SITE 7 - ALUM BAY, ISLE OF WIGHT (SZ 306854)

The cliff-top at Alum Bay forms an excellent vantage point. On a clear day both the chalk cliffs and the stacks of the Needles in the foreground and the chalk cliffs of Handfast Point on the Isle of Purbeck 25km to the west, are visible (Figure 1). The large area (c200km²) occupied by Poole and Christchurch Bays is also apparent. The base level evidence already presented at Site 1 demonstrates that a southerly flowing river had breached the Wight-Purbeck Ridge at the latest during the Devensian. Therefore, the formation of Poole and Christchurch Bays may have had one or more pre-Flandrian phases. Wright (1982) developed geomorphological evidence for such an interpretation by considering: (a) likely Flandrian erosion rates and sediment budgets and (b) the depth, relief and inclination of the planation surface of the former Wight-Purbeck Ridge.

Erosion of the chalk ridge and the Tertiary and Pleistocene sediments to its north would have generated very large quantities of sand and shingle suitable for beach development. This would have impeded coastal recession. Nonetheless, modern erosion rates do not preclude the possibility that the Bays were formed entirely during the Flandrian. However, if so, where is all the sediment produced by this erosion?

A 2km long submerged chalk ridge, the Bridge, is present west of the Needles (Figure 4). However, between the Bridge and Handfast Point there appears to be a planation surface at about -20m OD which uniformly truncates the chalk and the softer Cretaceous and Tertiary beds to the south and north. Erosion of the Wight-Purbeck ridge during the Flandrian would be expected to form a sloping erosion surface, in response to rising sea-level. Furthermore, the marked contrast in lithological resistance to erosion between the harder chalk and adjacent deposits would be expected to produce some morphological expression of the chalk outcrop. Wright (1982) argued that the ridge had been largely destroyed in a period when sea-level was reasonably stable and near -20m OD.

DISCUSSION

Keen (1980) identified three groups of gravel terraces beneath 40m OD in the upper reaches of the Solent River. They were deposited at high base levels in the transition from interglacial to full glacial conditions. It has been demonstrated that at least two, and possibly three distinct phases of channel formation related to the lower base levels of glaciation also occurred (Figure 2):

Phase 1 (?) - C (Site 3)

Phase 2 - F (Site 4) and possibly B (Site 2)

Phase 3 - A (Site 1), D and E (Site 3), G (Site 5)

A relatively chronology for the phases of downcutting can be developed relative to the groups of terraces. Phase 1, which must be considered as tentative, predates the deposition of the Middle Terrace at Rook Cliff (Site 2). If this channel was formerly present at Barton-on-Sea as suggested by the description of Codrington (1870), it predates the deposition of the High Terrace. Phase 2 predates the deposition of the Low Terrace. The base level of the channel at Hengistbury Long Beach (Site 2) is above that formed during the glacial maximum of the Devensian and it was possibly formed during this earlier phase of downcutting. Phase 3 post-dates the deposition of the Low Terrace (cf Keen, 1980) and can be related to the downcutting at the height of the last glacial maximum (Devensian). However, the channel at Hamworthy (Site 1) belongs to a different river system to that described by Dyer (1975). This chronology indicates that the Solent River has migrated south during the Pleistocene, a pattern which is also demonstrated by the gravel terraces (cf Keen, 1980).

Following aggradation of the two earlier channel systems, they were abandoned and any morphological expression was obscured by the deposition of terrace gravels. A possible exception to this pattern occurs at Hengistbury Long Beach (Site 2) where the channel forms a dry valley, and it is possible that the preservation of this channel is related to the southerly capture of the Frome.

Each phase of channel formation would have been in response to low base levels. It is logical to assume that each phase of channel formation would have been preceded by the deposition of a gravel terrace at relatively high base levels as described by Keen (1980). Thus, there may be one, as yet, unrecognised phase of downcutting as only two such post-High Terrace events are recognised, while three terraces are distinguished. In view of the large number of cold phases indicated during the Quaternary by the oxygen isotope record from deep sea sediments (Bowen, 1978), further phases of channel formation may be recognised in the Pleistocene deposits of the Solent River.

The Pleistocene silts and clays at the Pennington Marshes (Site 4) provide the most westerly evidence reported to date of estuarine conditions in the Solent River and indicate the extensive submergence which occurred during interglacial conditions.

The break-up of the Solent River is more complex than the conventional model of Everard (1954b). Southerly capture of the Frome (Site 1) occurred, at the latest, during the Devensian, but the Avon and Stour (Site 3), with the Western Yar (Site 5) as a tributary, maintained an easterly flowing Solent River System. Wright (1982) suggested several bathymetric features in

Christchurch Bay which may indicate southerly capture of the Avon and Stour after the formation of the channel found by Hooper and Kelland (1974). However, without a seabed survey, this evidence is inconclusive. Wright (1982) also ascribed the breaching of the Wight-Purbeck Ridge and the formation of Poole and Christchurch Bays to a period of relatively high and stable sea-level of about -20m OD during the Devensian. The dating depends critically on the assumption that the late Ipswichian/early Devensian upper gravel of Brown *et al* (1975) at Stone Point demonstrates that the Solent River was still intact. This is questionable, particularly as the Avon and Stour certainly maintained an easterly flow during much of the Devensian. Thus, the breaching of the Wight-Purbeck Ridge could have been a polyphase event.

Following the low sea-levels of the last glacial maximum, the Flandrian Transgression submerged both the Solent River and Frane channel systems. This, together with the accompanying erosion, separated the Isle of Wight from the mainland, quite probably for the first time. The Solent River valley has been partly infilled in Southampton Water, the East Solent and Spithead (Dyer, 1975; West, 1980). However, in the vicinity of Hurst Castle Spit (Site 6) it has been substantially enlarged and deepened by tidal scour. Poole and Christchurch Bays have experienced erosion largely due to wave processes.

Our understanding of this region is far from complete. On land, the recognition of gravel-filled channels is important. In addition to preserving information concerning base levels and aggradation, they also form suitable sites for the preservation of interglacial deposits. Such deposits are probably more common in this area than has previously been supposed. The location and analysis of a number of interglacial sites is required so that a chronostratigraphical framework of the otherwise monotonous unfossiliferous Pleistocene gravel deposits of this region can be developed. Much of the relevant evidence concerning the break-up of the Solent River and the formation of Poole and Christchurch Bays is submerged. Offshore geophysical and geological examination of both Bays is clearly required. In particular, the ideas of Wright (1982) concerning the breaching of the Wight-Purbeck Ridge require critical examination.

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THE ESTUARY OF THE WESTERN YAR, ISLE OF WIGHT:
SEA-LEVEL CHANGES IN THE SOLENT REGION

BY

R.J. Devoy

The river valley of the Western Yar forms one of only a few sites in the Solent region that have been studied in detail for the purposes of examining the problems of Holocene sea-level change. Discovery and initial investigation at the site was first made by Devoy (1972). Subsequent and more detailed studies were undertaken by Sutherland (1984), and it is intended to re-examine the site and river valley as a whole in the immediate future (Smyth, 1986, personal comm.).

The study area (SZ 350896) at Yarmouth lies at the northern, estuary end of the now shallow and sediment choked valley-creek system of the Western Yar. This valley separates the western tip of the Isle of Wight from the main body of the island, and probably represents all that remains of a former northward flowing river, which is presumed to have drained the now eroded Chalk ridge area to the south and west of Freshwater Bay. (Everard, 1954; Dyer, 1975).

LITHOSTRATIGRAPHY

Stratigraphic and sediment sampling work has been concentrated at three points within the site (Fig. 1). A profile approximately east-west across the river, constructed from borehole work carried out by Ground Exploration Ltd (1964), shows the development of a sequence of clays and silts interleaved with biogenic sediments. Together these overlie bedrock formed by the Headon Beds of Eocene to Oligocene age. In section, three separate organic levels may be identified (Fig. 2), the upper contacts of these lying sequentially in the altitudinal ranges of -8.4 to -9.6m O.D and between -4.6 to -5.5m O.D. The uppermost peat at a height of -4.3 to -5.2m O.D. is recorded from only one borehole (Y3). The exact lithostratigraphic relationship of sequences shown in these boreholes with those established at neighbouring points is unclear, largely due to the lack of both an integrated borehole sampling network between studies and to the absence of any 14C dates.

Later commercial borehole studies (Wimpey and Co., 1973) to the east of the river (SZ 35508955) record biogenic levels at comparable heights to those in section, from -3.1m to -6.8m O.D. Work undertaken by Devoy (1972), extending the cross-profile line westwards, shows essentially a single organic level. This is composed of a monocotwood peat, the wood fraction dominated by alder with oak and hazel wood also common. At the landward margin alder wood peat overlies the weathered and possibly reworked surface of the Headon Beds. Eastwards the bedrock surface and wood peat dip rapidly, the wood peat being replaced upward (Y1) by a

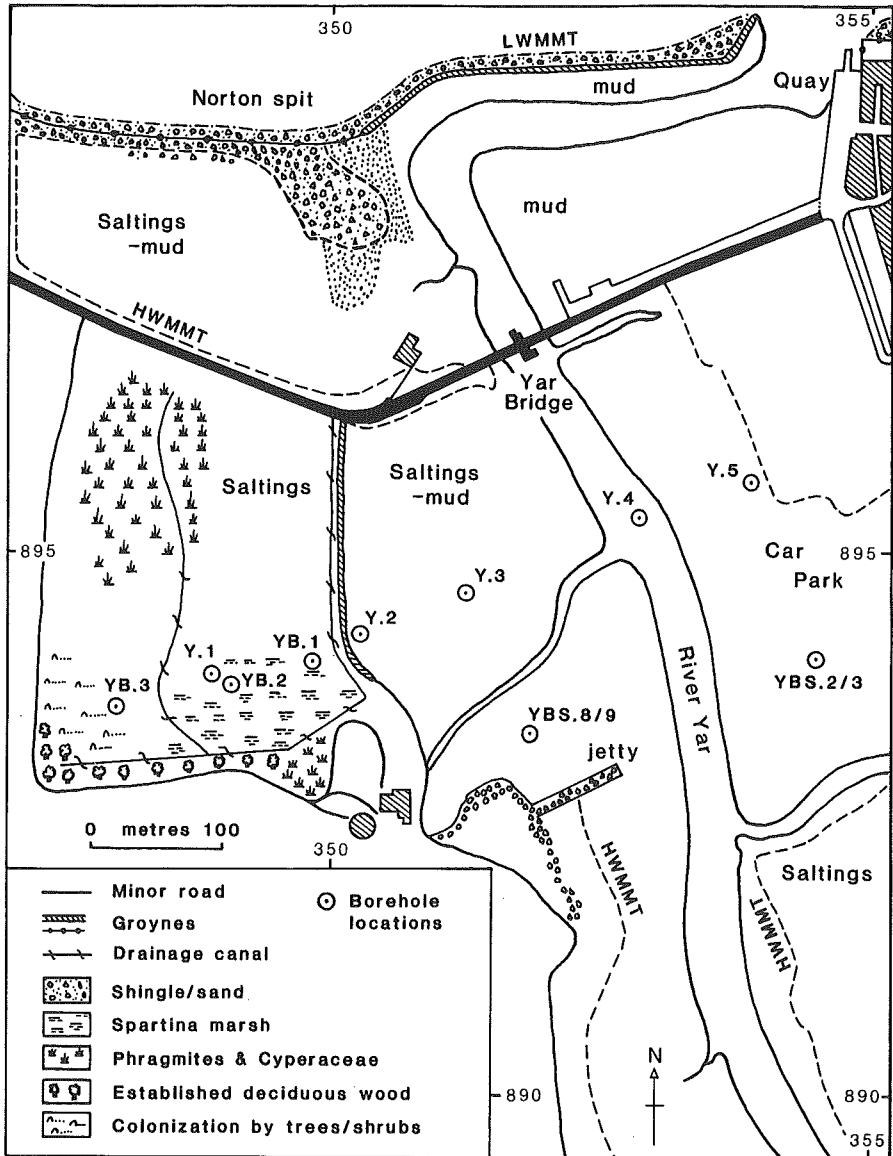


Figure 1 Yarmouth Harbour

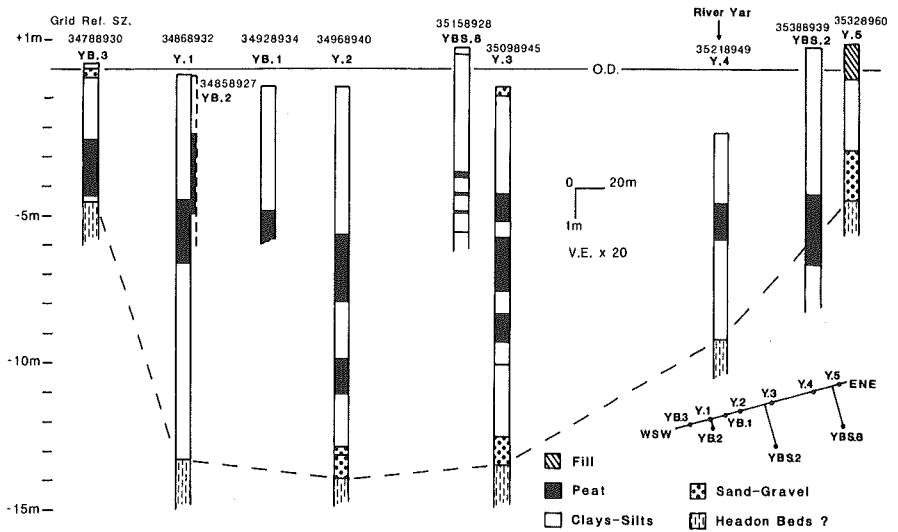


Figure 2 Yarmouth Harbour Stratigraphy

Phragmites and Cyperaceae dominated monocot peat. Here the presence of an inorganic fraction also increases upward, with the monocot peat commonly containing thin (2-5cm) clay-silt partings in the transitional levels with the overlying grey clays-silts. Shells of Cardium edule, Macoma balthica, Hydrobia ulvae (Pennant) and Littorina saxatilis (whole and broken) found in the clay-silts show the accumulation of this uppermost inorganic unit under shallow, low energy, blackish water conditions.

Southward from here in the 'Car Park Area' (YBS 1-7) (Fig. 1), Sutherland (1984) identified a single main organic horizon interleaved with grey clay silts. Particle size work on the inorganic levels here below the peat (altitudinal range of the upper contact occurring between -6.55m to -5.47 O.D.), showed the presence of a high clay sized fraction (38.7%). Above the organic layer the inorganic sediments become coarser, with the silt sized fraction rising generally to above 70%, and with the recording of two sandier (sand size fraction ~6-7%) phases of sedimentation. Shell remains and diatoms identified in these uppermost clays-silts again suggest accumulation under brackish water-marine conditions. The upper contact of the organic levels varies in height in the boreholes between -3.55m to -4.07m O.D., and with a maximum recorded thickness of 2.48m (reaching -6.55m O.D. in YBS 2).

Across the river in the Yarmouth Boatyard area (YBS 8-15, Sutherland, 1984) the stratigraphic picture appears as more complex. On the basis of height two main levels of biogenic accumulation may be recognised. The upper contact zone of the lowest peat here occurs in the height range of -3.5m to -3.98m O.D. The height of the second, uppermost peat varies between boreholes from -2.25m to -2.80m O.D. at its basal contact with the underlying clay-silt, with an upper contact from -1.62m to -2.53m O.D. As in the other areas grey clays-silts interleave these organic levels, and are locally variable in composition. The lowest inorganic level sampled at YBS 8/9 (Fig. 2) is dominated by the silt (53%) and sand (27%) fractions, fining upward toward the transition with the overlaying peat at levels of -4.75 and -4.88m O.D. Southward of YBS 8/9 the bedrock surface is interpreted as rising in elevation and a thin inorganic level (sandy clay-silt) is seen as occurring above this surface and underlying the main organic level identified in boreholes YBS 11-14. Above the uppermost biogenic level in all boreholes the clay sized fraction rises generally to dominance, and again shell remains are recorded in this final phase of inorganic sedimentation.

BIOSTRATIGRAPHY

Pollen and Vegetation changes

Pollen and macro-fossil work from the biogenic levels show the existence at the site over time of a range of plant communities. Throughout, oak-alder-hazel and willow form the dominant tree-tall shrub vegetation components, representing areas of alder dominated

carr to fen environments, or drier oak-alder woodland. Wetter zones are indicated by the presence of Gramineae and Cyperaceae pollen, at points reaching levels of 35-50% and 30-40% LP respectively, together with significant values of *Typha* ang., *T.Lat.*, *Lythrum*, *Myriophyllum* spp., *Potamogeton*, *Hydrocotyle* type and *Alisma* pollen. These taxa may indicate the existence of standing water reedswamp to full open water conditions. The latter forming perhaps as freshwater pools with fringing reedswamp and alder carr. In the transitional zones to inorganic sedimentation, reedswamp to saltmarsh vegetation become dominant in the pollen spectra. These are represented by the pollen of Gramineae, Cyperaceae, Chenopodiaceae, *Plantago* spp. and Compositae tub. In examination of the peats Sutherland (1984) recognises a spatially variable, vertical sequential development of these plant communities; in broad outline changing upward from saltmarsh-reedswamp, to fen-alder carr, to alder-oak woodland, returning to reedswamp and finally saltmarsh. In some localities (e.g. the Boatyard) a more complex sequence is recognised, showing return to wetter standing freshwater conditions between phases of alder-oak scrub woodland development. These inferred vegetation changes are interpreted as resulting from fluctuating water levels in response to local groundwater level changes, and, presumably in this coastal environment, in turn, to alternations in a controlling sea-level position. Although this may have been the case, and phases of rising water level are recognised in the peats on both sides of the river, these fluctuations are not shown to be synchronous between all boreholes. Alternatively, therefore, the phases of wetting and drying recognised during biogenic accumulation may also in part represent simply localized changes in plant community development, forming in response to spatial variability in site topography, groundwater-table shape, rates of vegetation growth and other local environmental factors.

Diatoms

Detailed work on the diatom flora (Sutherland, 1984) from the minerogenic levels has been undertaken in a number of the boreholes. In outline this shows that the basal clays - silts, at YBS 3 and 9, accumulated under predominantly brackish water conditions, as represented by the abundance of *Diploneis interrupta*, *Navicula peregrina*, *Nitzschia navicularis*, and *Achnanthes* spp. In the upper inorganic levels throughout the site, the diatom assemblages remain similar to those found in the lower clay-silt, but show an increase in brackish-marine elements, as represented by *Nitzschia filiformis*, *Caloneis formosa*, *Actinopterychus undulatus*, *Diploneis didyma*, *Grammatophora oceanica*, *Melosira sulcata* and *M. westii*. These indicate the development of a more brackish water-marine environment, transitional locally to full marine conditions in the final phase of sedimentation. This evidence supports the interpretation from the shell data (Devoy, 1972) of accumulation of the uppermost inorganic levels under estuarine conditions. Over the transitional zones to biogenic accumulation, the diatom assemblages show a significant rise in a freshwater influence and progressive decrease in salinity.

DATING

Lack of any radiocarbon determinations means that the dating of the changes found at Yarmouth are of a relative age nature, based on the pollen data. The basal brackish clay-silts identified in YBS 2/3 and 8/9 are interpreted from the overlying peats as having formed prior to ~ 6,000 BP (6,385 BP, Sutherland, 1984). In the pollen spectra the Elm Decline is identified stratigraphically as occurring in the lower levels of the peats at YBS 2/3 and 8/9, but this event has not been clearly defined at the site in biogenic levels forming at higher elevations. Development of the biogenic accumulation identified in most boreholes thus dates from, or post dates ~ 5,000 BP. The ending of biogenic accumulation at the site, together with the final phase of rising water level identified, is dated by Sutherland (1984) to chronozone F III, at about 2,500 BP. This is based on the decline of *Tilia* pollen frequencies, re-establishment of *Pinus* and the expansion of *Fraxinus* pollen values. However, this dating is speculative, depending on the recognition of a regional significance of these trends and their correlation with events at 14C dated sequences at predominantly inland sites elsewhere in the region. The nature of the changing vegetation communities described, variable lithology-sedimentation patterns, and estuarine situations would suggest strong local influences, and these relative ages must, therefore, be treated with caution.

SITE INTERPRETATION - EVIDENCE OF SEA-LEVEL CHANGES

In altitude two main phases of biogenic accumulation may be recognised (excluding possibly that of the lowest peat identified in borehole Y2, for which no further date is available). The basal clay-sand-silt beneath YBS 10-15 would thus, in this context, be seen as representing an intervening phase of brackish water-marine sedimentation. However, although containing evidence of marine inundation, this basal inorganic level at boreholes YBS 10-15 is not necessarily lithostratigraphically correlatable, or synchronous with the lowest levels of clay-silt deposition immediately above the peat at YBS 2/3 and 8/9. The pollen and macro-fossil evidence show that although biogenic accumulation in YBS 2/3 and 8/9 pre-dates that elsewhere, all boreholes show an overlap in the timing of peat growth, with the recording of an Elm Decline or immediately post Elm Decline pollen spectra everywhere. Further, whilst the top of the biogenic sequence at YBS 8/9 remains undated (Sutherland, 1984), a similar stratigraphic position in YBS 2/3 is dated at ~ 2,500 BP. These data together suggest that biogenic accumulation in all boreholes was part of a continuum, with peat growth initiated broadly later at progressively higher elevations. Explanation of the early accumulation of biogenic sediments at apparently lower heights in some areas, may be the result of variations in site topography (as would be expected in an estuarine-slobland environment), and differential compaction/consolidation between sequences. Phases of rising water level, probably in response to a regional upward

movement of sea level during the Holocene, and the accompanying close proximity of estuarine conditions, may have resulted locally in intervening phases of brackish water sedimentation, particularly toward the end of biogenic growth. More site-marginal situations, as in YB 1-3, recording peat growth throughout over the altitudinal range of ~ -4.0 to -1.5m O.D. , before final marine incursion, may have remained protected from inundation by temporary blocking sedimentary structures, or the local rates of vegetation growth. However, detailed evidence is lacking in these areas.

Accepting the stratigraphic interpretation given, two phases of marine inundation (positive sea-level tendency after Shennan et al., 1983; Sutherland, 1984) may be recognised at the site. These are separated by a long phase of removal (or partial removal) of estuarine-marine conditions (a negative sea-level tendency) as represented by the accumulation of biogenic sediments. The nature of this negative tendency is difficult to gauge, and real removal of the sea at the site can perhaps only be equated with the times of drying out of the peats and accompanying woodland expansion, however real these may be. As indicated, the stratigraphy is open to a more complex interpretation. Therefore, until more detailed palaeogeographic-lithostratigraphic work is undertaken and radiometric age data obtained, then stratigraphic correlation and answers to these related questions will remain open to debate.

THE SITE AND SEA-LEVEL CHANGES IN A REGIONAL CONTEXT

As indicated initially, the Western Yar forms one of only a few sites in the region shown to record clear evidence of alterations in sea-level tendency. Many other sites from Poole to Chichester harbours do contain sea-level information, recording the progress of Holocene inundation. Reviews of these sites is given in Devoy (1972, 1982), Hodson and West (1972) and Sutherland (1984). However, the records are often primarily of only local significance, showing peats formed in topographically confined situations and behind blocking beach barrier structures. Breaching of these barriers in the later phases of Holocene sea-level recovery led to the widespread, but differential inundation of peats forming in these situations; the timing of inundation dated broadly to chronozone F III (post Elm Decline).

At Browndon (SZ 585989), between the Western Yar and Fawley, a single phase of marine incursion is recognised (Sutherland, 1984). This begins at a height of -19.2m O.D. , and is dated on the basis of pollen to the period between 7,000-8,000 BP. Opposite the Western Yar at Hurst Castle Spit (SZ 305900) and Pennington Marshes (SZ 325925), work by Nicholls and Clarke (1986) record the existence of peats in former coastal environment situations, at heights from ~ -4.0 to -2.0m O.D. Dating of these is unclear, although they ascribe a Flandrian age to them on the basis of plant evidence and their comparison with the Western Yar and neighbouring sea-level sites. Further, they suggest that the broad conformity of age and height data in the region indicates that the biogenic deposits here, as in the Western Yar and at other sea-level sites, were formed in response more to a regional sea-level influence than a local one, namely, a Mid-Holocene removal of marine conditions. However, the evidence for the

operation of former beach-sediment barrier structures remains. This, together with the common occurrence of such features today in the region, as at Chesil Beach, Hurst and Calshot Spits and Norton Spit on the Western Yar itself, suggests that their former existence and influence on the Western Yar and at other sites cannot be discounted.

Regarding the timing of the separation of the Isle of Wight from the mainland, the recording of brackish-marine environments at Brownston and at higher elevations in the Western Yar prior to ~ 6,000 BP, suggests an Early Holocene data for this event.

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SOME COASTAL LANDSLIDES OF THE SOUTHERN ISLE OF WIGHT

by

J N Hutchinson

The geology of the southern Isle of Wight is dominated by the Cretaceous outlier of the Southern Downs (Fig. 1). Truncations of the southern side of this by marine erosion has resulted in the formation of a large coastal landslide complex, known as the Undercliff, which involves chiefly the Gault, the Upper Greensand and the Chalk. This feature extends for about 12 km along the coast with an average width of around 0.5 km. It seems first to have been recognised as of landsliding origin by Worsley (1781). Structurally, the outlier forms a shallow syncline, plunging gently to the SSE. This structure has a profound influence on the nature and degree of activity of the Undercliff landslides (Hutchinson, 1965).

The Lower Greensand strata are exposed in the coastal cliffs towards each end of the Undercliff (Figs. 1 & 2) and in those extending beyond each of its extremities. These strata are predominantly arenaceous, but do contain some beds of clay. The latter influence strongly the stability of the associated cliffs, partly by providing weak layers in which shearing can take place and partly by contributing to the occurrence of seepage erosion in the overlying sands.

The prevailing wind comes from about the SW, that is in roughly the same direction in which the greatest fetch lies. Thus, the strongest marine attack in this vicinity is experienced on the SW-facing facet of the coast, extending to the NW from Rocken End into Chales Bay (Fig. 1). The degree of marine attack along the main, SSE-facing length of the Undercliff is slightly less strong and more sheltered conditions prevail on the E-facing cliffs N of Dunnose.

On the present excursion, it is planned to demonstrate two sites on the strongly eroding length of coast NW of Rocken End, at Chale Cliffs outside the Undercliff and at Gore Cliff within it, and two sites within the less exposed main length of the Undercliff, at St Catherine's Point and at Ventnor (Fig. 1).

SW-FACING CLIFFS

Chale Cliffs (viewpoint at The Terrace, SZ 482 772).

The combination of strong marine attack with the lithology and hydrogeology of the Lower Greensand cliffs (chiefly Ferruginous Sands), gives this length of coast a high rate of recession. For example, in the vicinity of The Terrace, comparison of the 1861 and 1980 O.S. maps indicate an average rate of recession of around 0.5 m/year during that period (Hutchinson *et al.*, 1981). The

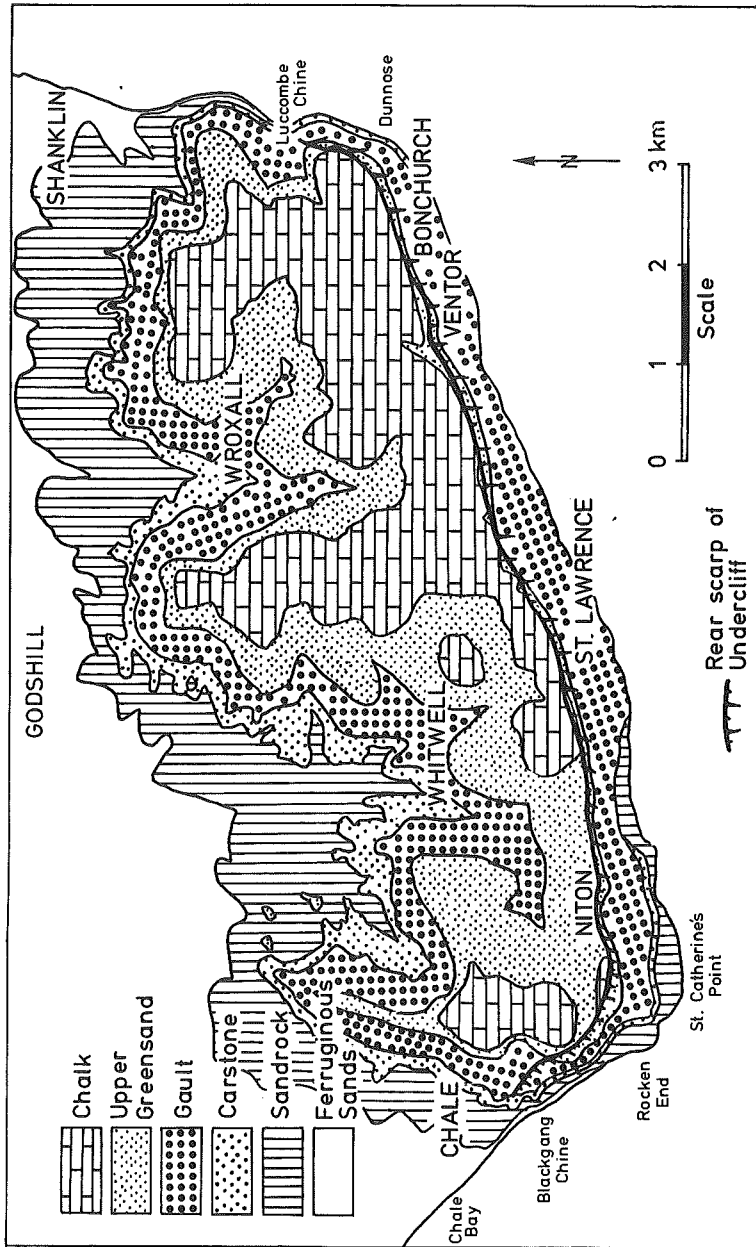
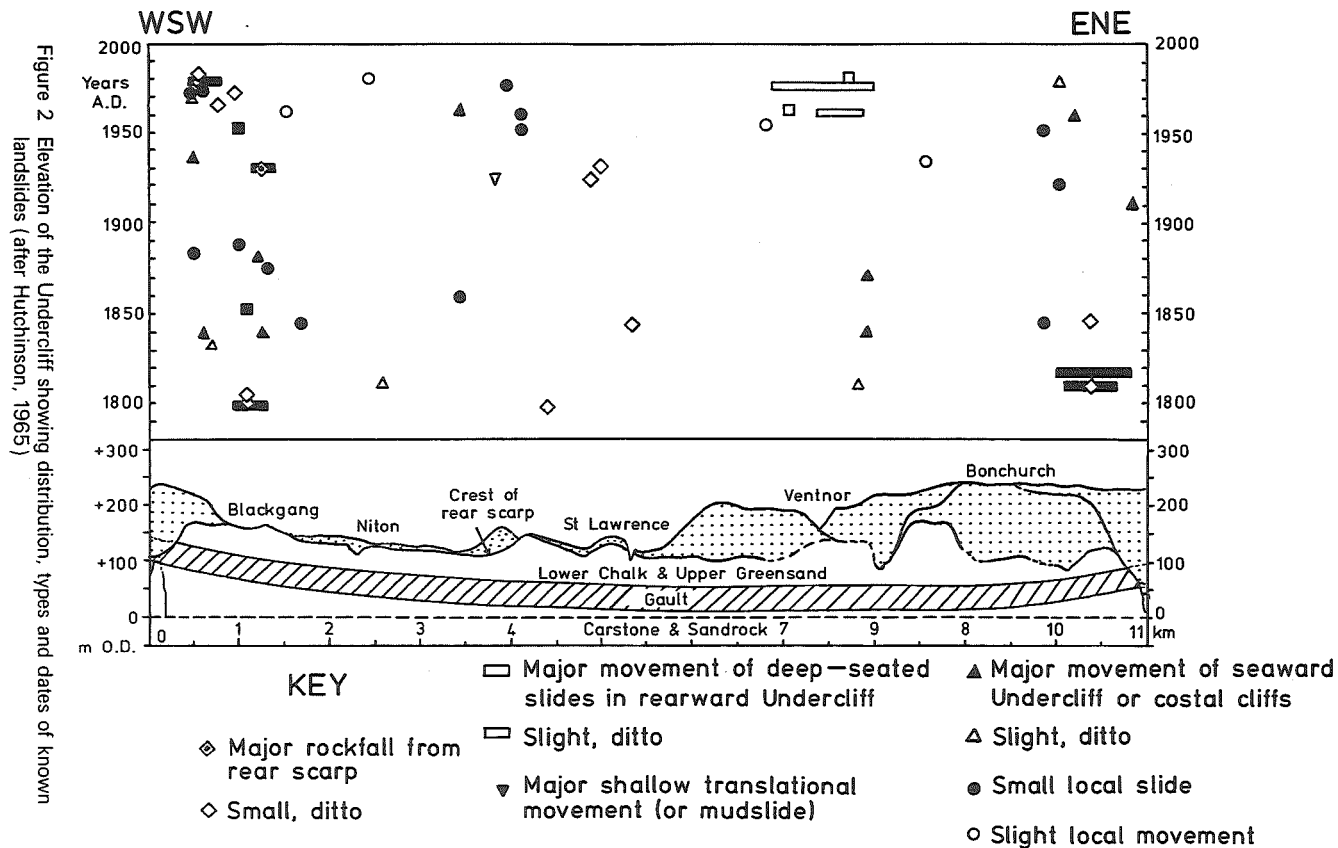


Figure 1 Geological map of the Southern Downs and Undercliff of the Isle of Wight



stratigraphy of these cliffs was worked out originally by Fitton (1847). He also suggested that the benches in the cliff and thus part of the cliff-top recession resulted from a process which is now termed "seepage erosion", taking place above clayey aquicludes, in particular the clays of the Foliated Clay and Sand (Fitton's Bed XII). This was confirmed by Hutchinson *et al* (1981), who observed this process operating within Bed XII in the NW face of Walpen Chine (Fig. 3a). Some of the rock falls in the Ferruginous Sands of the Shanklin-Lake cliffs may be caused in a similar manner. In the Chale Cliffs generally, seepage erosion and the resulting falls lead to a rate of cliff-top retreat which is currently greater than that produced in the cliff-foot by marine erosion: the debris-covered benches thus develop (Fig. 3b).

Gore Cliff (viewpoint at SZ 494 758).

This is the most exposed part of the Undercliff proper and suffers strong toe erosion in its friable cliffs of Sandrock and Ferruginous Sands (amounting to about 0.6 m/year between 1862 and 1980; Chandler, 1984). The rear scarp, on the other hand, is historically a relatively old feature, having been affected only by a few rockfalls during the past 200 years. The largest of these occurred in 1928 (Colenutt, 1928). Hence the Undercliff here is at its narrowest and least stable. A map showing the chief landslides in the Gore Cliff area during the past two centuries is shown in Fig. 4. Most of these have comprised renewals of movement in the old slide debris occupying the Undercliff.

The first sub-surface investigation here was carried out in 1981-82 on the landslide of March 1978 (Fig. 4). The resulting cross-section is shown in Fig. 5 (after Bronhead *et al*, in *prepn.*). Of particular interest is the finding that the basal slip surface of this failure is located about 18 m above the base of the Gault. This is doubtless a reflection of the markedly less clayey and less plastic nature of the lower 15 m or so of the stratum at this location. In the cliffs of Lower Greensand, beneath the base of the Gault, seepage erosion is active in places.

A study by Preece (1980) of the chalky hill wash deposit which caps Gore Cliff, shows that this is derived from a north-eastward facing slope which formerly must have existed to seaward. The occurrence of Romano-British artefacts at the base of this deposit demonstrates that it accumulated after about the second century A.D. Landsliding or rockfall must, therefore, have produced a significant retrogression of Gore Cliff since that time. The continuing, severe toe erosion, the narrowness of the Undercliff and the opening of joints behind Gore Cliff indicate that a further phase of such retrogression is approaching.

SSE-FACING CLIFFS

St. Catherine's Point (viewpoint at SZ 495 757).

The contrast between the highly unstable Undercliff from Blackgang to Rocken End and its relatively stable continuation from St.

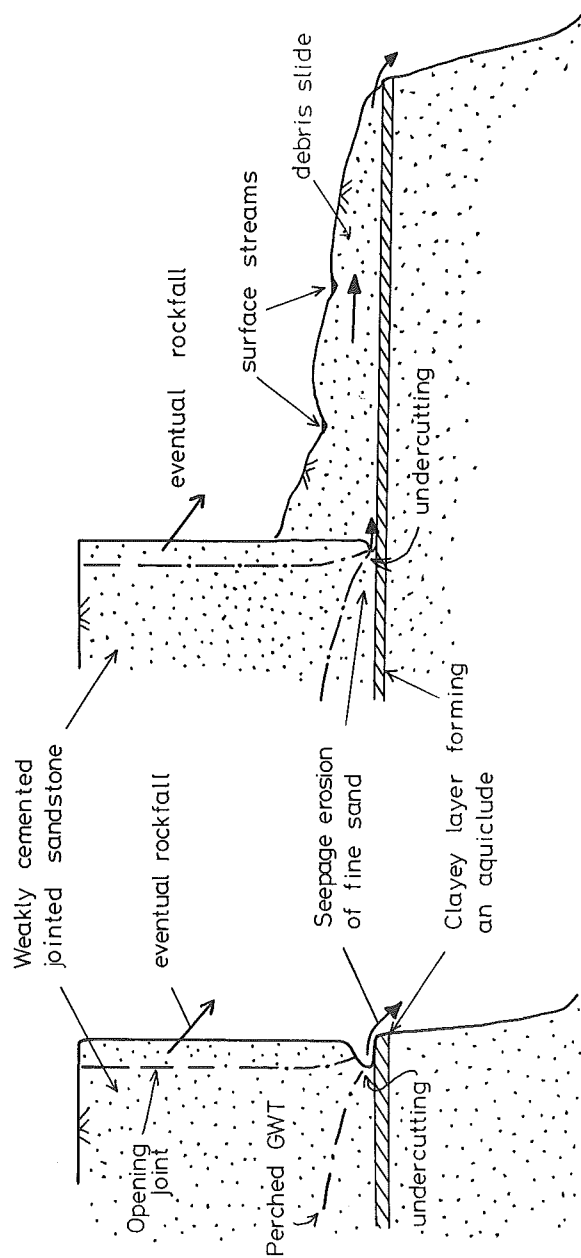


Figure 3 Diagrammatic sections showing action of seepage erosion in Lower Greensand cliffs, Isle of Wight

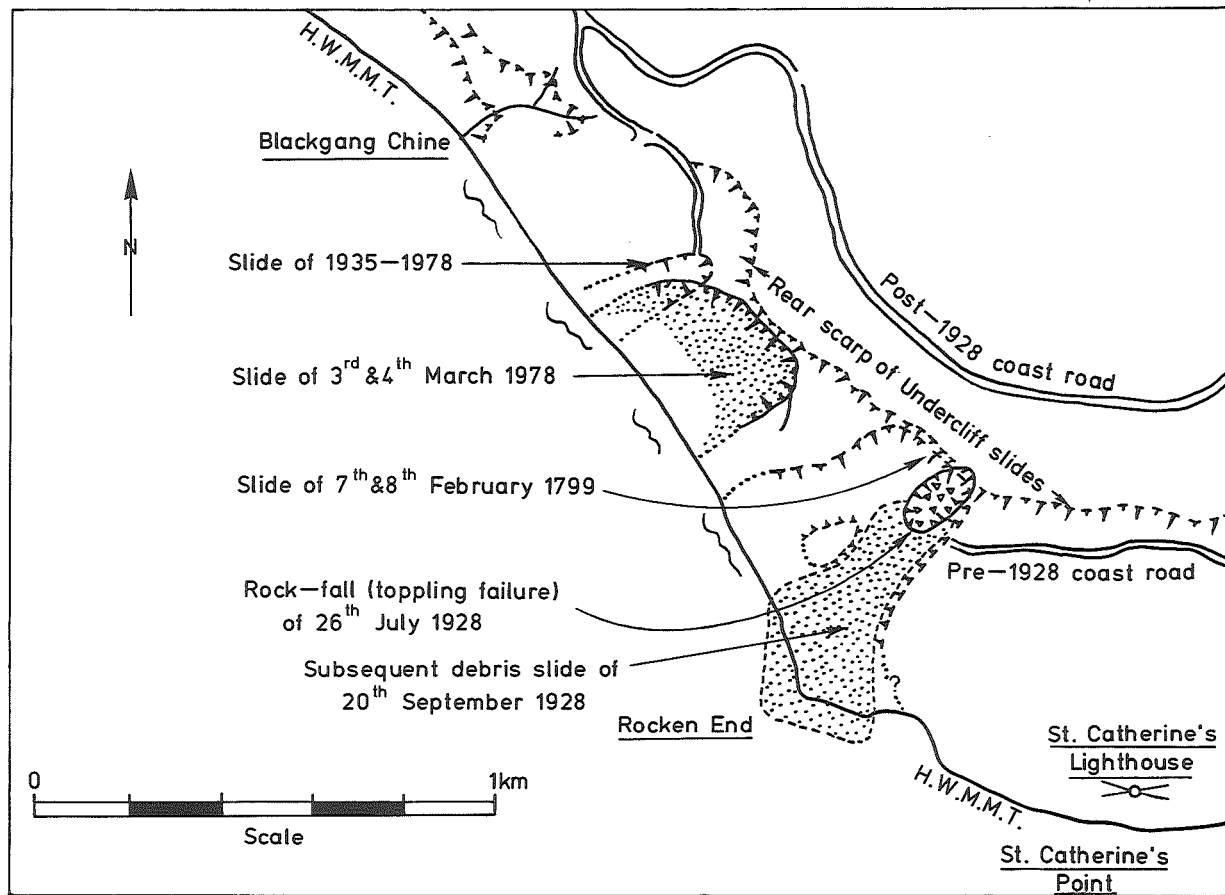


Figure 4. Main landslides of the past 200 years, Blackgang to Rocken End

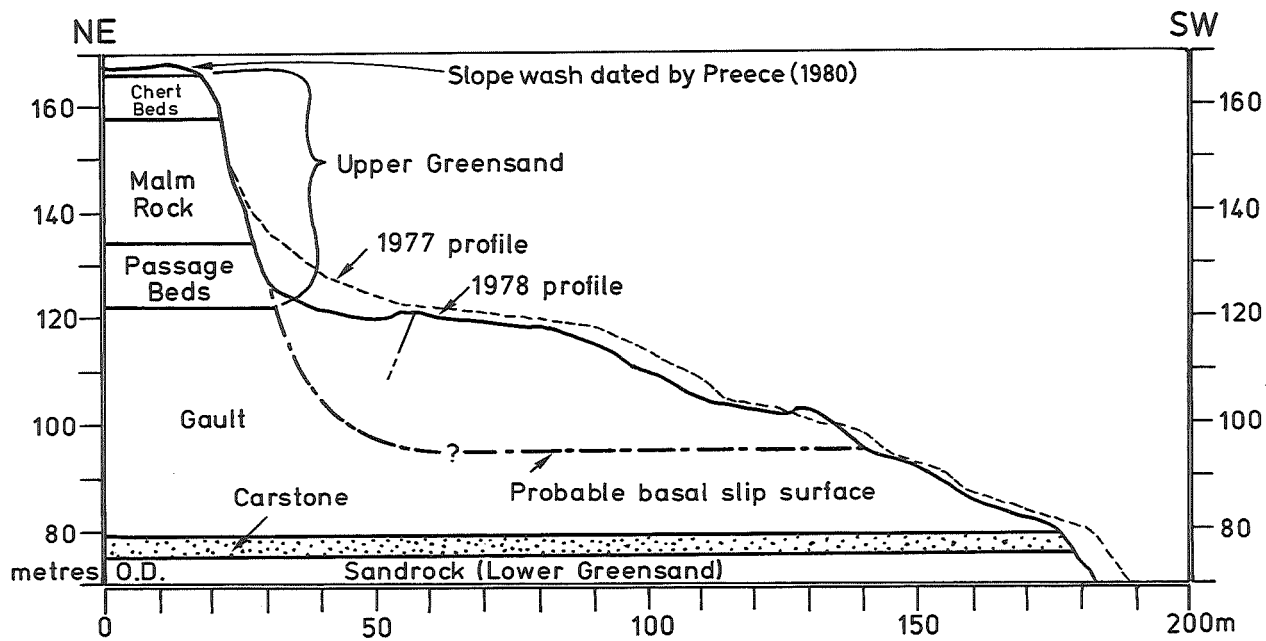


Figure 5 Section of the landslide of March 1978 at Gore Cliff (after Bromhead et al, in prepn)

Catherine's Point eastwards is most striking, both in absolute terms and in the rapidity of the transition. Of the several factors which give rise to this situation, the predominant one is the presence of considerable debris aprons along the toe of the latter slopes and their absence from the former.

Such aprons extend, discontinuously and with varying widths, along the toe of much of the main Undercliff, from St. Catherine's Point to the Ventnor area. They act both as a natural sea defence, largely by virtue of the contained fallen blocks of Chert Beds from the Upper Greensand which provide an effective armouring, and as a toe weighting. The effect of these aprons on the present degree of stability of the old slips behind them is very significant.

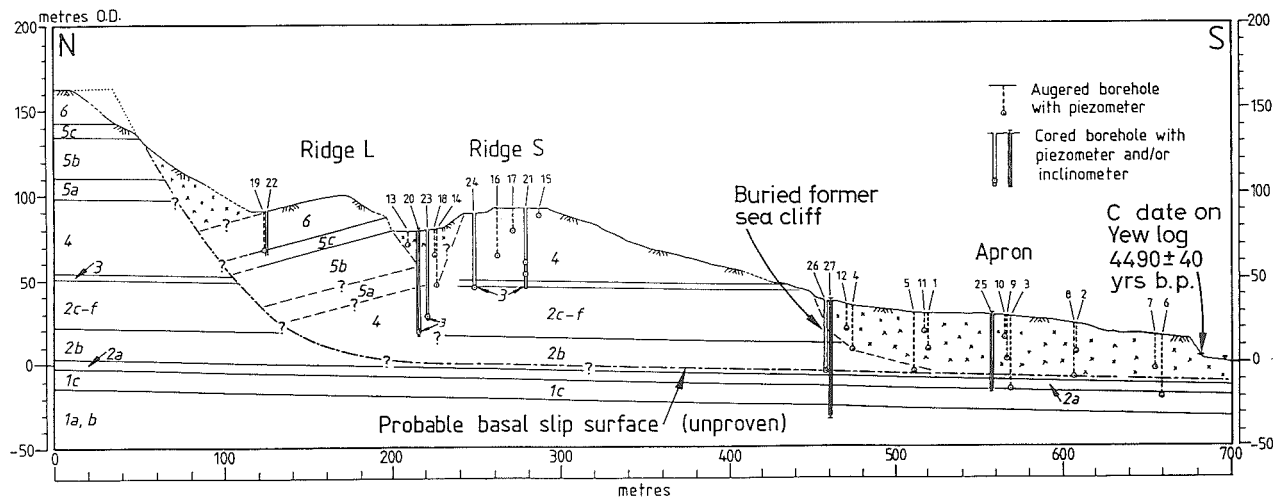
At St. Catherine's Point itself, the well developed apron has resulted in the preservation of an interesting assemblage of landslips which, with the support of the NERC, have recently been investigated in some detail (Hutchinson *et al* 1985a). The main findings are summarised in the section of Fig. 6. When viewed from the W, the rearward slipped blocks, forming Ridges L and S, may appear to be of multiple (double) rotational type. The borings, however, show that this is not the case, the slide being approximately of graben type, with a front block (including Ridge S) which has slid seawards translationally on the bedding and a rearward block which has subsided behind this. Graben formation may well have been accompanied or followed by a rotational failure of its landward scarp, forming Ridge L. The rear scarp thus formed has subsequently degraded to form a scree slope. Ridge S consists largely of Gault; its seaward face is occupied by a succession of overgrown mudslide embayments and mudslides. The latter over-ride the rear of the debris apron. The apron itself extends over 220 m down to the sea cliff and a further unknown distance out to sea, beneath the shore platform. In its landward part, the base of the apron appears to be concordant with the bedding at elevations of between about -7 to -11 m OD. The overlying landslides debris is up to about 35 m thick. It consists of fragmented material deriving chiefly from the Upper Greensand, but also from the Lower Chalk and the Gault.

Of particular interest is the buried former sea cliff, against which the rear of the debris apron abuts, with its foot at an elevation of around - 7m OD. This feature has been traced morphologically throughout most of the main Undercliff by Chandler (1984). Also of great interest is the finding that the basal slip surface of the main slide is seated in a clayey stratum just above the base of the Sandrock, 50m below the base of the Gault. Within the debris of the apron, organic material was found in the sea cliffs, at broadly similar elevations, at several places at St. Catherine's Point and at Binnel Point, some 3 km further east. Radiocarbon dates were obtained as follows:

St. Catherine's Point (through the NERC, to the Scottish Universities Research and Reactor Centre);

At SZ 4952 7533, SRR-1813. Wood (Taxus) at + 3.8 m OD, 4490 \pm 40 yrs b.p.

At SZ 4953 7532, SRR-1947. Wood (unidentified) at + 3.3 m OD, 3960 \pm 50 yrs b.p.



Geological Key:- 1a, b Sandy strata in Ferruginous Sands, 1c Clayey stratum in Ferruginous Sands, 2a, c-f Predominantly sandy strata in Sandrock, 2b Clayey stratum in Sandrock, 3 Carstone, 4 Gault, 5a Passage Beds (Upper Greensand), 5b "Malm Rock" (Upper Greensand), 5c Chert Beds (Upper Greensand), 6 Lower Chalk, ☆☆ Landslipped debris.

Figure 6 Section of the landslides forming the Undercliff at St. Catherine's Point (after Hutchinson et al. 1985a)

Binnel Point (through R.C. Preece and R. Burleigh to the British Museum Radiocarbon Laboratory);

At SZ 5253 7579, BM-1737. Charcoal (Alnus and Ulmus at + 5.3 m OD, 4480 \pm 100 yrs b.p.

We were fortunate that Dr Richard Preece was able to accept our invitation to help with the dating at these sites, particularly through a study of their vertebrate and molluscan fauna. His detailed findings are given in Preece (1986).

In the light of these dates, the following outline may be suggested for the late Quaternary history of the landslides at St. Catherine's Point. A broadly similar pattern is likely to apply to the main Undercliff generally. During the Devensian, strong periglacial activity would have produced considerable masses of predominantly rather fine debris. These would have buried any coastal landslides persisting from the Ipswichian and have tended to form accumulations of debris extending southwards over the exposed former sea bed. As sea levels rose again towards their present level during the Flandrian, these accumulations will eventually have been exposed to marine erosion. The continuation of this erosion appears to have removed essentially all of the Devensian debris as well as any Ipswichian landslip or other coastal features. It then cut into the in situ cliff strata to form the now buried shore platform and former sea cliff. The levels of the landward part of this platform, around 9 m below present mean sea level, suggest that it may have been formed some 7000 to 8500 years ago, possibly during the virtual still-stand in sea level at approximately the corresponding high tide elevation identified by Tooley (1978) and others. As a consequence of this latter stage of marine erosion, a new phase of major coastal landsliding was brought about. The resulting debris buried the landward portion of the shore platform and pushed the high tide mark well to seaward. At the site where the yew log was found (Fig. 6), this debris was about 13m thick, reaching an elevation of just above + 3m OD.

A period of relative stability then followed, during which a soil horizon developed on the surface of the debris and a tree cover probably formed. Several decimetres of tufa accumulated over the soil horizon in the vicinity of springs emerging from the landslip debris (Preece, 1986). A slight deterioration in stability then appears to have ensued, sufficient to cover the surface of the tufa with fallen trees and some slope debris (the two yew logs lie in attitudes which suggest that they had been pushed over towards the sea by pressure from upslope). The layer containing the fallen trees was then buried by a few decimetres of slope-wash. As noted above, one of the yew logs has been dated to about 4500 years b.p., that is, in the waning stages of the Flandrian climatic optimum.

A second, major phase of landsliding then took place, burying the above mentioned horizons by around 10m of debris. This instability may have occurred as a consequence of swelling and softening of the clay strata within the cliff following the unloading produced by the first phase of sliding or in response to

the climatic deterioration of the early Sub-atlantic (Iron Age).

As the depression between Ridges L and S (Fig. 6) contains mainly fine chalky debris, quite unlike that in the apron, it is evident that the major slide which produced the latter features must post-date the second phase of apron formation. This is also indicated by the morphology of the apron, which is buckled and distorted in its rearward parts by the thrust of the slide. In response to the continuing marine erosion, secondary landslides are affecting the debris forming the seaward parts of the exposed apron. St. Catherine's Point lighthouse is situated on such a slide and is moving very slowly seawards, fortunately in an essentially translational manner.

Other sites which show evidence of a major phase of coastal landsliding commencing in response to rising Flandrian sea levels are Folkestone Warren (Hutchinson, 1969) and Lympne (Hutchinson *et al*, 1985b), both in Kent. The date of initiation is naturally a function of the geological configuration at the slide toe, tending to be earlier for lower elevations of the associated shore platform (Table 1).

Site	Approx. level of landward edge of shore platform m. O.D.	Approx. date of start of Post-glacial landsliding years B.P.
St. Catherine's Point	-7	8000 to 4500
Folkestone Warren	slightly below O.D.?	5500 to 3000
Lympne	-1	5000 to 4000

Table 1. Evidence for the initiation of major coastal landslides by rising Flandrian sea levels between about 8000 and 3000 BP.

Work on the geotechnics and dating of the landslides at St. Catherine's Point is continuing.

Upper Ventnor (viewpoint at SZ 558 778).

Over 6000 people live on the old landslides of the Undercliff chiefly in the town of Ventnor. There, the protective debris aprons are narrow or absent and this, probably combined with the proximity of the area to the axis of the syncline, where ground-water tends to accumulate, renders the local degree of stability lower than in the main Undercliff generally. Slight movements are common, especially in wet winters: houses and services are damaged or destroyed from time to time, particularly where they straddle or traverse the intermediate slip surfaces which separate the main slipped blocks.

Comprehensive monitoring of these movements has not yet been undertaken. However, in 1982-84, exploratory monitoring was carried out at the rear of this slip complex, in Upper Ventnor. At this position, the slip masses are pulling away from the in situ strata forming the rear scarp. As a result, a graben, having a coastwise length of over 400m and an average width of about 20m, has formed just seaward of this scarp (Chandler and Hutchinson, 1984). During the past century, progressive movements in this graben have resulted in the destruction of ten or more houses (Chandler, 1984) and the continuing need to repair the main Ventnor to Wroxall road.

Between January 1982 and February 1984, the seaward boundary of this graben was monitored using a rod extensometer gauge. During this period, the average rates of movement were up to 45mm/year vertically and 40mm/year horizontally. Precise re-levelling of O.S. benchmarks in the graben area showed that settlements of up to 0.63 m had occurred there between 1960 and 1982 (Chandler and Hutchinson, 1984).

A preliminary landslide hazard map of the Ventnor areas has already been published (Chandler and Hutchinson, 1984) and this is currently being extended to cover the whole Undercliff. It is hoped that, as is already the case in many other countries, such maps will come to be used as an aid in arriving at planning decisions.

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PLEISTOCENE SEA-LEVEL HISTORY IN THE BEMBRIDGE AREA OF THE ISLE OF WIGHT

by

R.C. Preece and J.D. Scourse

BEMBRIDGE SCHOOL

Our examination of the Pleistocene sea-level history of the Bembridge area (Fig. 1) begins with a discussion of a deposit first discovered over sixty years ago. In 1924, a Pleistocene deposit containing remains of spruce (*Picea*) and fruits of an arctic buttercup (*Ranunculus hyperboreus*) was discovered in a sewer trench in the grounds of Bembridge School (Jackson, 1924; Reid & Chandler, 1924). This deposit was recently re-investigated by Holyoak & Preece (1983) who formally named it the Steyne Wood Clay and who showed from the contained fossils (plants, Mollusca, Ostracoda and Foraminifera) that it accumulated in an estuarine environment. The pollen diagram (Fig. 2) suggests that this occurred during the post-temperate zone of a Middle Pleistocene interglacial.

The Steyne Wood Clay occurs between 38-40m OD, rests on Bembridge marls (Lower Oligocene) and is overlain by up to 3m of mottled orange-brown clay with scattered flint pebbles, interpreted as solifluxion. Jackson (1924) reported seams of "compact peat" towards the top of the deposit but only very thin lenses of plant-rich debris were found in the two boreholes made by Holyoak & Preece (1983).

In 1985, further work on the Steyne Wood Clay was undertaken. Through the courtesy of the Nature Conservancy Council (GCR unit) and the headmaster of Bembridge School, a deep hole was dug by means of a Hymac excavator. This pit was located on waste ground behind the squash courts about 50m south and downslope of borehole A (Holyoak & Preece, 1983). Here the cover of solifluxion was about 1m less (ie only 2m thick) and the Steyne Wood Clay, unlike its occurrence in the other two boreholes, was virtually devoid of shells. Moreover here there were discrete lenses of black carbonized wood (10 cm thick) resting on the surface of the Steyne Wood Clay. This may well be the "compact peat" mentioned by Jackson (1924).

In an attempt to improve the dating of the Steyne Wood Clay, two further series of analyses have recently been undertaken. Firstly, the palaeomagnetic polarity was determined from nine samples taken at three different levels through the deposit. This was undertaken for us by T.J.F. Austin (University of East Anglia) who reported that all the samples (except one anomalous measurement) yielded NRM directions of Normal Polarity. Second, amino acid ratios (alloleucine: isoleucine) have been determined from shell fragments of *Macoma balthica* by Dr G. Miller (University of Colorado). These have produced values apparently consistent with a Hoxnian age.

The age of the Steyne Wood Clay is hard to establish with any precision. The biostratigraphical data are difficult to interpret for two reasons. First, the depositional environment was estuarine. This has resulted in considerable over-representation

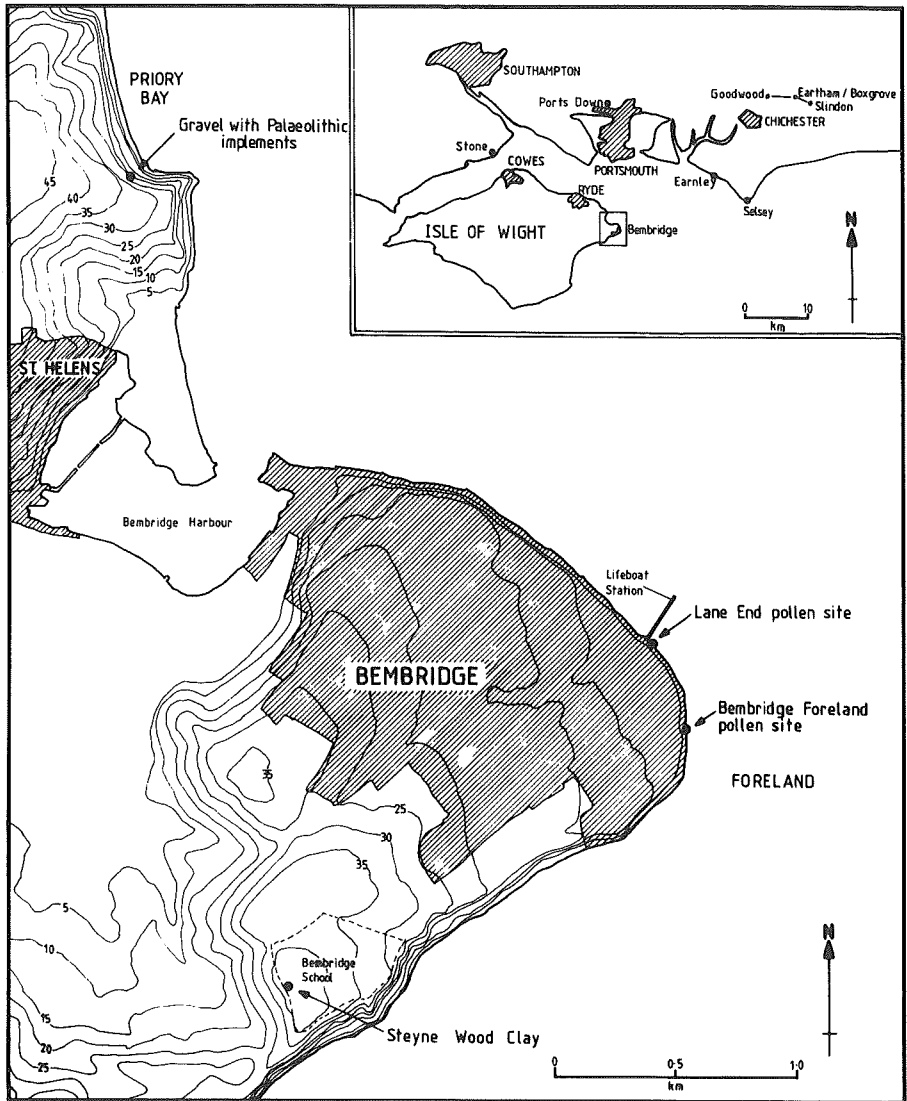


Figure 1 Location map showing critical sites in Bembridge area and related deposits on the mainland (inset)

of certain pollen taxa (particularly bisaccate conifer pollen). Second, faunal remains from estuarine contexts vary little through the Pleistocene and so cannot assist in dating. Moreover the deposit appears to have accumulated during the post temperate zone of an interglacial. Such zones in isolation (ie when not overlying a late temperate zone) are somewhat undiagnostic since they lack the distinctive vegetational characteristics of the earlier substages of the interglacial. Nevertheless the palynological data indicate a pre-Ipswichian age on the basis of the abundance of Picea and presence of Abies. The palynology generally imparts a 'Middle' rather than 'Lower' Pleistocene aspect and this is borne out by the amino acid ratios and possibly the palaeomagnetic data, although periods of normal polarity do occur within the Lower and Middle Pleistocene.

The Steyne Wood Clay is one of a number of marine deposits that occurs at 40m OD in the Solent area (Fig. 1). Other marine deposits at this elevation include the raised beaches on Ports Down (ApSimon et al 1977) which are thought to be lateral equivalents of the so-called 'hundred foot', 'Goodwood' or 'Slindon' raised beach. Although no Palaeolithic artifacts have been reported from the beaches on Ports Down, sites in the Chichester-Arundel area have yielded several hundred artefacts including many hand-axes (Fowler, 1932, Calkin, 1935). The site at Boxgrove, currently being excavated by Mark Roberts (Institute of Archaeology) is of particular importance since a rich in situ Palaeolithic working surface is preserved together with associated faunal remains. The industry at Boxgrove is Acheulian and now includes many ovates and other tools. It was thought that these Palaeolithic horizon rested on the marine Slindon Sands but several artefacts have recently been found within the upper part of this unit confirming the contemporaneity of the industry with the high sea-level event. The dating of the Slindon Sands and Boxgrove industry has also proved problematic. Evidence from the vertebrate fauna currently offers the best idea. Significant elements of this fauna include Arvicola cantiana, Sorex savini, Pliomys episcopalus and Dicerorhinus etruscus. The last three species have apparently not been reported from any British Hoxnian deposit but only from the early Middle Pleistocene (Stuart, 1982). However Mimomys savini, a species common in many Cromerian and earlier interglacial deposits, is absent from Boxgrove and is replaced by A. cantiana. According to A. Currant (pers. comm.) the Boxgrove fauna most closely approaches the upper faunas (groups 2 and 3) of Westbury-sub-Mendip which have been thought to represent either an additional temperate stage between the Cromerian sensu stricto and the Hoxnian (Bishop, 1982) or to belong to the late Cromerian (Stuart, 1982). Although correlations based purely on altimetric concordance are always equivocal, it nevertheless seems likely that the Slindon Sands and Steyne Wood Clay are of similar age.

The complexity of the Middle Pleistocene sea-level history in this region is demonstrated by the occurrence of a channel containing marine sediments on the foreshore at Earnley, Bracklesham Bay, Sussex (West et al, 1984). These sediments accumulated during the late temperate substage of a Middle Pleistocene interglacial at a

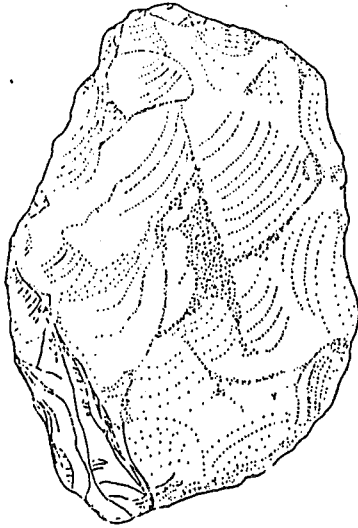


Figure 3 Worn hand-axe from the gravel at Priory Bay, found April 1986.
(drawing by Rebecca Leader)

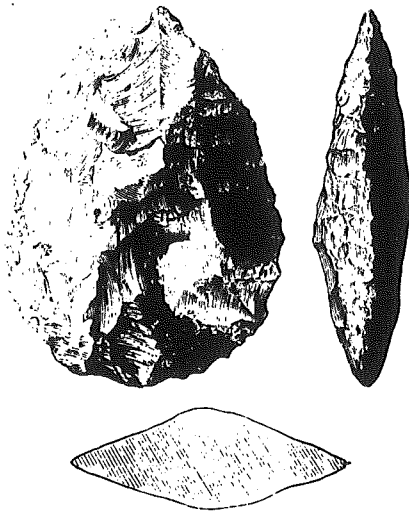
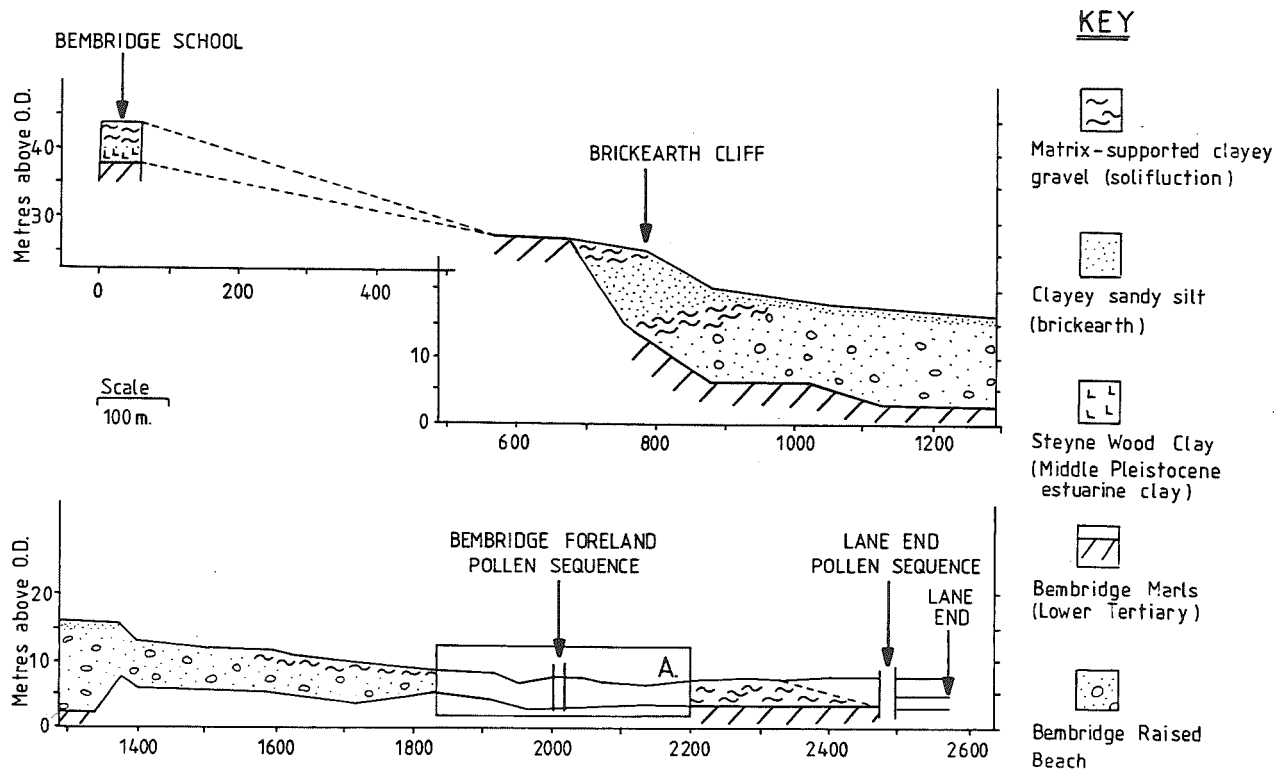


Figure 5 Ovate from the brickearth near Howgate found by Codrington (from Evans, 1897)

Figure 4 Levelled cliff-section from Lane End to Bembridge School (simplified)



time of falling sea-level. At the close of sedimentation mean tidal level is thought to have been 0.7-1m below its present position. Although assigned to different substages, there are other important palynological differences (eg much higher frequencies of *Abies*) between these deposits and the Steyne Wood Clay despite the fact that they both accumulated in intertidal environments. These differences, together with the enormous discordance in height, suggests that these deposits belong to different interglacials. Clearly there is scope for much further work.

PRIORY BAY

This site, at SZ 635900, has yielded the largest assemblage of Lower Palaeolithic artefacts from the Isle of Wight. The assemblage comprises over 300 Acheulian and Mousterian of Acheulian tradition implements mostly in the B. Elcox collection (Samson, 1975/6, Basford, 1980). Although most of the artefacts were unstratified and found amongst modern beach shingle, several have been found in the gravel that caps the cliffs. Through the courtesy of the Nature Conservancy Council (GCR unit) a section in this gravel was cleaned in April 1986. At this point (SZ 6351589975) the gravel occurred at an elevation of between 29-33m OD, rested on Bembridge Marls and was overlain by a thin unit of brickearth (1m thick). Several artefacts, including a worn hand-axe (Fig 3) were found in this small section and there is little doubt that this gravel is the source of all the other artefacts. Although many of the implements are abraded, several are not and some are in a relatively fresh condition. The origin of the gravel as either due to marine or fluvial activity remains open. The site awaits detailed investigation.

BEMBRIDGE RAISED BEACH AND ASSOCIATED DEPOSITS

Few raised beaches in southern Britain are so clearly displayed in cliff-section as the example which forms the coastal terrace between Bembridge Point and Howgate. This, the 'Bembridge Raised Beach', is composed of well-bedded, rounded chalk-flints with a true dip to north-east of between 8° and 13°, indicating lateral accretion by longshore drift from south-west to north-east. Fragments of sarsen, chert and sandstone are present as minor constituents and lenses of sand are not infrequent. The lower surface of the beach rests on an eroded surface of Bembridge Marls, which rises gently south-westward, from near highwater mark at Ethel Point to about 18m OD at its abrupt termination near HHowgate (Fig. 4). The surface of the ground rises in the same direction but at a slightly steeper angle, so that the gravel expands from only a metre or so near Ethel Point to over 15m south-west of the inn at Foreland.

Codrington (1870) noticed that the gravel could be separated into two units. A lower 'deep red-brown shingle gravel' is overlain by a 'white gravel' that lacks the heavy iron-staining of the lower unit. This upper unit becomes increasingly clay-rich towards the north-east such that the gravel here is completely matrix-supported. Many pebbles in this upper unit have their long axes oriented vertically and there is clear evidence of cryoturbation in the form of small involution structures and 'stone-nests'. This deposit, which is interpreted as soliflucted

beach, is in turn blanketed by 'brickearth'. This probably represents the re-working of loessic sediments since the relatively poor sorting and, in places, clear bedding with pebble stringers, militate against a purely aeolian origin. Towards the south-western limit of the raised beach, the gravel thins and is overlain by a thick bluff (10m) of brickearth near Howgate. A series of samples through this brickearth has been taken for TL dating by Dr H Rendell (University of Sussex).

At least three Acheulian ovates have been discovered in this immediate area (Holyoak & Preece, 1983), the first and most important being that recorded by Codrington (1870) actually from the brickearth itself. This fine, unabraded specimen has been figured by Evans (1897, Fig. 467) which is reproduced here (Fig. 5). The other implements came from the face of the cliffs in the vicinity of Bembridge School but their stratigraphic provenance is less secure.

It is clear that both the Raised Beach and brickearth abut against a cliff of Bembridge Marls that trends at approximately right-angles to the present coastline. The Steyne Wood Clay caps this feature at 40m OD. The anomalously high elevation (up to 18m OD) of the Raised Beach at this point might well be due to storm activity resulting in shingle being banked against this cliff, well above the contemporary high-water limit.

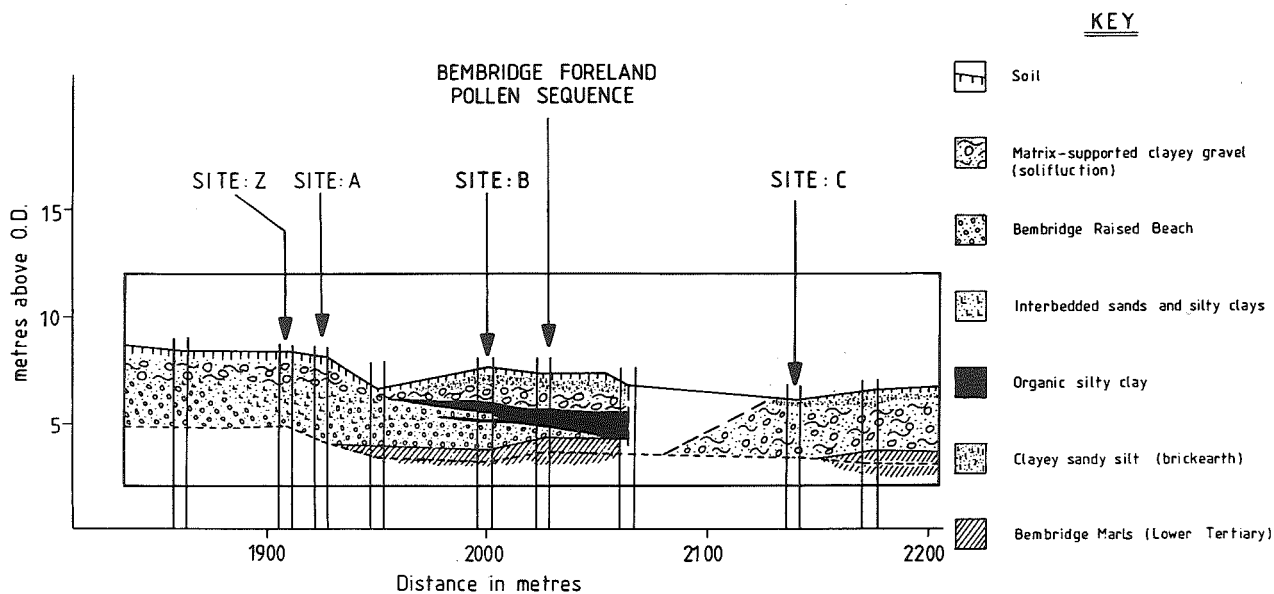
The general lack of fossiliferous deposits associated with many raised beaches in southern Britain has meant that most of these deposits remain poorly dated with correlation resting only on the very unsatisfactory basis of height. Although the gravels of the Bembridge Raised Beach are completely devoid of fossils, organic deposits overlying them but genetically related to them occur at The Foreland. The Bembridge area is therefore quite exceptional in possessing two altimetrically separate marine/estuarine deposits both yielding important biostratigraphical data demonstrating that two different interglacials are represented.

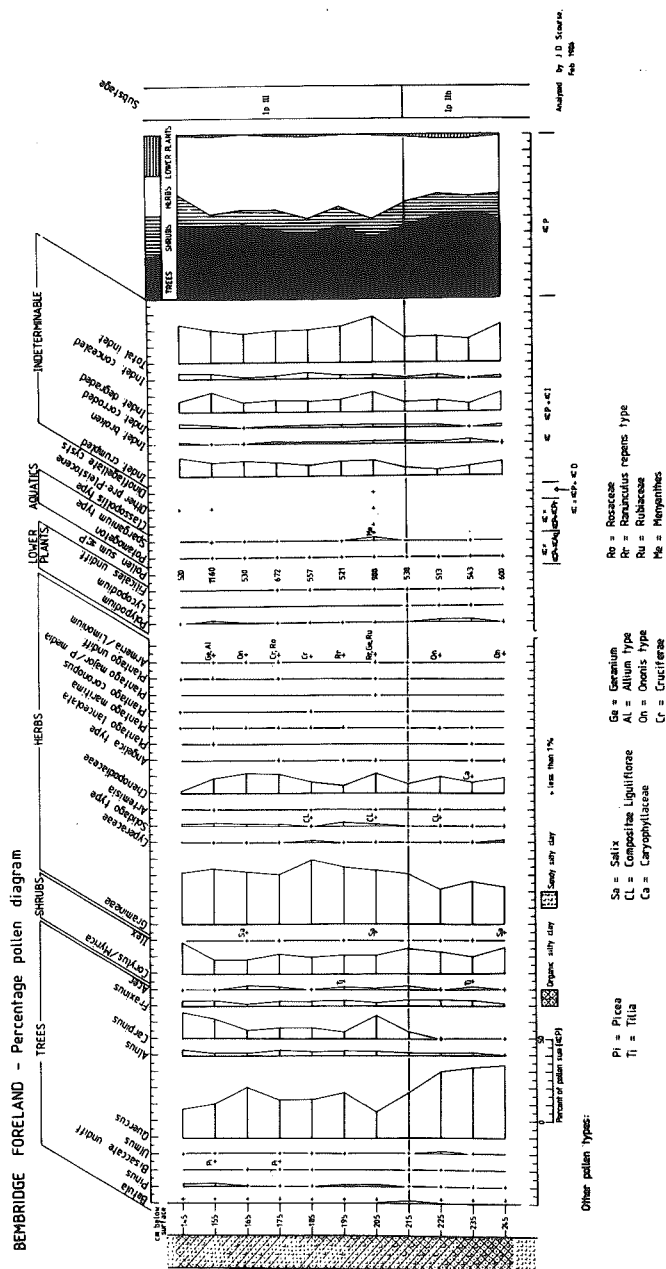
BEMBRIDGE FORELAND

The occurrence of organic deposits at Bembridge Foreland (and near Lane End) has been known since before 1850. They were observed by Godwin-Austin and Edward Forbes who noted the remains of "large trees, hazel nuts and beetles" (Codrington, 1870). Codrington's (1870 : 542) own description of the deposits is the best available hitherto and his stratigraphical drawing (op cit, Fig. 12) matches our levelled section (Fig. 4) remarkably well. The stratigraphy at our sampling site was as follows (Fig. 6):

- 6 - 70 cm Brickearth with scattered flints.
- 70 - 165 Matrix-supported gravel with coarse sand at base. Pebbles subangular to rounded. Cryoturbated.
- 165 - 255 Very dark grey (10YR 3/1) organic mud becoming paler downwards. Top 1 cm weathered to yellowish-brown (10YR 5/6), basal 5 cm grey (5Y 6/1). Flint pebbles up to 3.5 cm diameter scattered throughout. Pebbles subangular to rounded. Occasional pale grey sand lenses.

Figure 6 Detail of the stratigraphy at the Foreland





- 255 - 270 Bright orange-grey mottled stony clay with sand lenses.
- 270 - 305 Grey-green sand (5Y 6/4) becoming finer downwards.
- 305 - 340 Coarse sand and fine gravel.

We believe that the basal beach gravels were deposited in a high-energy coastal environment during a period of high relative sea-level. The gravels are overlain by a unit of sand. This is relatively thin at our sampling point but reaches 1m thickness a short distance to the south-west. Thin lenses of clay within the sand typify deposits that have accumulated in intertidal environments. The sand is overlain by a metre or so of organic mud that has yielded well preserved pollen.

A pollen diagram (Fig. 7) from the organic mud is dominated by Quercus, Corylus/Myrica with subordinate Alnus indicating deposition during an interglacial. High values of grass pollen (Gramineae) also occur throughout.

We believe that these three lithological units relate to a single fining-upwards sedimentary sequence. Palaeoenvironmental support is provided by the high frequency Chenopodiaceae which often characterise brackish environments and a number of other plant taxa suggest proximity to coastal habitats. The cause of these sedimentary changes is harder to explain since it could be related to a fall in relative sea-level (regression), creation of an offshore barrier or be due to some other purely local physiographic change.

The pollen data indicate that the organic mud began to accumulate towards the end of the early temperate substage (zone IIb) but were mostly deposited during the succeeding late temperate substage (zone III) of the Ipswichian interglacial. This late temperate substage (Ip III) is characterised by relatively high values of Carpinus (West, 1980) which here exceed 10%.

An Ipswichian age for the Raised Beach is also independently suggested by direct dating of the beach sediments themselves. Preliminary analyses by G.A. Southgate (University of Cambridge) have yielded dates of 110 ka BP, consistent with an Ipswichian age.

This means that the beach gravels at this point accumulated either during Ip IIb or earlier and that the high sea-level phase extended into Ip III. At other sites in the Solent area, such as Stone and Selsey, the marine transgression is also recorded during Ip II although at both of these sites the raised beach deposits overlie brackish silts (West & Sparks, 1960). However, although there is general agreement that the overlying gravel unit at Selsey is indeed a raised beach, doubts have been cast on that at Stone which Brown et al (1975) interpret as of fluvial origin.

As mentioned earlier, the organic deposits are overlain by a matrix-supported gravel, interpreted as soliflucted beach, and then brickearth. The Ipswichian age assigned to the beach deposits means that these two upper units almost certainly

accumulated during the Devensian. TL dating of the Howgate brickearth and that at our sampling site at the Foreland is currently under study. A Late Devensian age (20 ka BP) has already been obtained for the equivalent brickearth at Selsey (Dr. H. Rendell, pers. comm.).

LANE END

The organic deposits here comprise a sedge-peat that overlies a clay-rich gravel and which is overlain by orange sand and then gravel. The organic deposit was formerly much more extensive, for the word 'peat' is actually marked on the 1" Geological Survey Map. Codrington (1870) also describes the peat as extensive but only a remnant now survives behind the recent sea-defences. The stratigraphy at our sampling point is as follows:

- 0 - 50 cm Modern soil.
- 50 - 200 Matrix-supported flint gravel.
- 200 - 240 Bright orange silty sand with clay seam towards base.
- 240 - 247 Olive-grey silty sand.
- 247 - 267 Humified sedge-peat containing macrofossils of Carex and Menyanthes. Some scattered small flints.
- 267 - 287 Grey silty sand containing some small flints, becoming coarser and gravelly downwards. Seeds of Menyanthes.

The interpretation of this sequence is problematic. Plant macrofossils including Menyanthes and various sedges are present in the upper part of the basal gravel and throughout the sedge-peat. These indicate that accumulation occurred during a temperate period in a non-marine environment. This interpretation is also supported by the limited fossil insect fauna (G.R. Coope, pers. comm.). The pollen diagram (Fig. 8) is completely dominated by grasses (Gramineae) and sedges (Cyperaceae) reflecting their local abundance but hampering an interpretation in terms of age. An age towards the end of the Ipswichian (?Ip IV) is tentatively suggested.

The stratigraphical relationship between this site and the Foreland sequence is not clear since the intervening section is heavily overgrown and, in places, slumped. All the low level gravels in this vicinity as far as Ryde have been mapped as 'marine'. However the occurrence of a freshwater peat beneath the gravels at Lane End indicates that the story is more complicated. It is significant that the Lane End site occurs at the mouth of a palaeo-valley (Fig. 1) and it is possible that the gravels here are of fluvial origin and unrelated to the Benbridge Raised Beach. Good sections of typical raised beach sediment can be seen a few hundred metres to the north towards Benbridge Harbour.

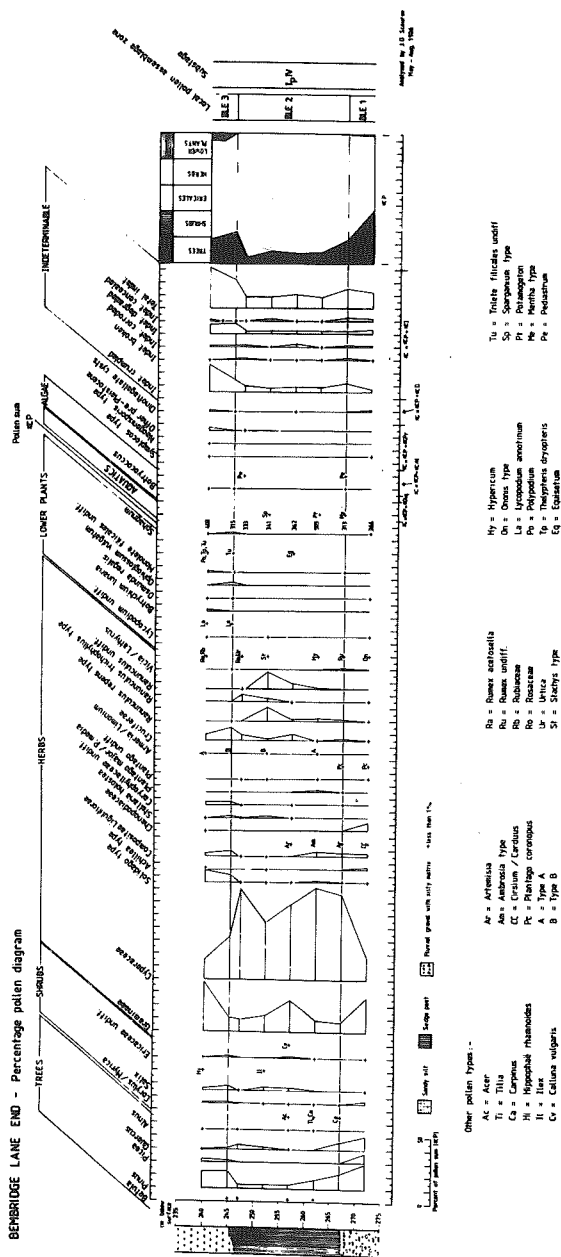


Figure 8 Pollen diagram from Lane End

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BIOSTRATIGRAPHY AND ENVIRONMENTAL ARCHAEOLOGY OF THE
POST-GLACIAL SLOPE DEPOSIT ON GORE CLIFF, ISLE OF WIGHT

by

R. C. Preece

The slope deposit on Gore Cliff is important for two reasons. First, it provides an opportunity to study the late Post-glacial environmental history by means of land snail analysis. Second, the dating of this deposit has an important bearing on the history of landslipping. From the site one also has an excellent view of The Undercliff landslips (Hutchinson, this volume).

The slope deposit was first observed by Bowerbank (1838) and subsequently referred to by Trimmer (1854), Forbes (1856) and Reid & Strahan (1889). Preliminary analyses of the contained land snails were published by Kennard & Woodward (1901, 1925) but the most detailed account is that by Preece (1980a).

The deposit forms a vertical or slightly overhung face to the SW stretching for about 600m. A narrow ledge, about 15m wide, formed by differential erosion has formed on the surface of the Chalk/Upper Greensand. The slope deposit is of variable thickness, attaining a maximum of just over 3m at SZ 49327603. It is essentially a calcareous mud with scattered fragments of Chalk, flint and Upper Greensand and derived Cenomanian fossils. Examination of the derived microfossils, principally foraminifera, reveals that the deposit was derived entirely from zones 10 and 11 (i) of the Lower Chalk (*sensu* Carter & Hart, 1977) although a single specimen of a double keeled Marginotruncana of the pseudolinneiana group indicates some derivation from the Upper Turonian (High Middle Chalk). Other foraminifera are derived from the top of the Upper Greensand (Preece, 1980a).

The molluscan fauna of the slope deposit is relatively impoverished with just over twenty species recorded. Virtually all are species characteristic of calcareous grassland. The mollusc diagram (Fig. 1) does reveal some significant changes. Thus Helicella itala, a xerophilous species that has not been found living on the Isle of Wight in recent years (Preece, 1980b), is almost exclusively confined to the basal third of the deposit where it reaches c.5% of the fauna. The basal levels also yield a more diverse fauna including the odd shade-demanding species. In contrast, Cernuella virgata first appears at the point that H.itala declines, and completely dominates the fauna thereafter, reaching values of over 60%. This replacement may be due to habitat changes resulting from anthropogenic disturbance (eg more intensive tillage). It is noteworthy that there is a slight lithological change at about this point. The basal silts are distinctly darker (5Y 6/2) and more indurated than the lighter (5Y 6/1) friable, upper levels. Trimmer (1854) recorded that a "line of dark clay, in some places black" divides the deposit from the underlying Chalk but no trace of this horizon survives.

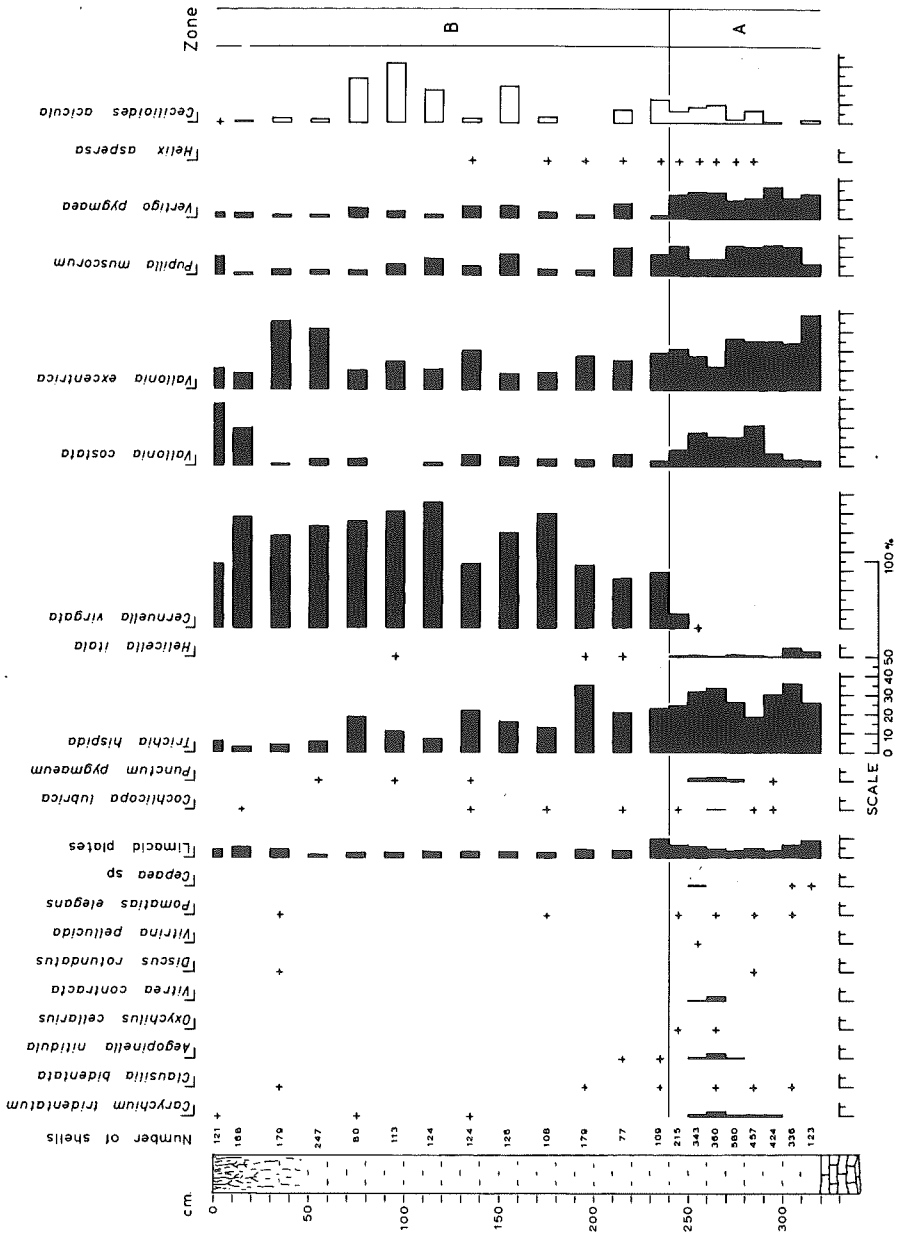


Figure 1 Mollusc diagram from Gore Cliff (from Preece, 1980)

The molluscan fauna includes two species, Helix aspersa and Cernuella virgata, which are unknown in Britain before the Roman period. Indeed the latter species is absent from most Romano-British deposits and has been thought to be a mediaeval introduction (Kerney, 1966). One other fossil deserves special mention. A specimen of Truncatellina callicratis, a rare xerophile in Britain today has been recovered from the deposit, one of very few British fossil records (Preece, 1980a).

The deposit is clearly of late Post-glacial age, a conclusion confirmed by the occurrence in it of late Iron Age and Romano-British artefacts (Preece, 1980a). Of particular importance was the discovery in 1932 of a bronze trapeze-shaped brooch at a depth of 9 feet (Mew, 1932). "The centre of the brooch is crossed by a raised plate which divides in into two equal triangular areas, coated with green paste, in each of which are set three small black dots resembling pin-heads" (Mew, 1932). Although the brooch itself cannot be traced, an unpublished sketch of it by G.A. Sherwin does exist and is reproduced here (Fig. 2). In Sherwin's accompanying notes he thought that the green enamel of the brooch might originally have been crimson. From Mew's description and Sherwin's drawing, it does appear that Mew was correct in thinking that it "probably dates from the 2nd century AD".

In order to sharpen this dating, attempts were made to obtain some radiocarbon dates. Since there was insufficient charcoal for conventional dating, the shells of Cernuella virgata (from the level of their first appearance) were selected for this purpose. Living shells of this species, which were significantly larger and had a higher proportion of unbanded morphs, from the adjoining coastal grassland were also collected and analysed as a control. The results were as follows:

Modern shells	:	130 ± 50 BP (BM-1481)
Fossil shells	:	3940 ± 65 BP (BM-1482)

Both these dates are older than expected. Taking into account the raised level of $\delta^{14}C$ in contemporary living material, the modern shells appear to be about 2500 years too old. If there were no incorporation of dead carbon these shells would have an apparent age of c.4500 AD (due to enhancement by artificial $\delta^{14}C$ derived from thermo-nuclear weapon tests). Assuming that this difference gives an indication of the general behaviour of this species, it might be reasonable to apply a similar 'blank' of some 2500 years to the fossil specimens. This would imply a date of c. 500 AD for these shells which is consistent with the date expected on archaeological grounds. It is important to state that this is a very simple interpretation of these results but one that does not seem unreasonable on the basis of the limited evidence available (Preece, 1980a).

All lines of evidence (palaeontological, archaeological and radiocarbon dating) indicate that the deposit accumulated during the late Post-glacial. Since the deposit was clearly derived from a slope that must have existed to the south (Reid & Strahan, 1889) and that accumulation was active during (and after) the 2nd century AD (as suggested by the brooch), it follows that a substantial part of Gore Cliff must have slipped during the very recent geological past (Preece, 1980a). The more recent landslips of 1799 and 1928 have been documented by Webster in Englefield

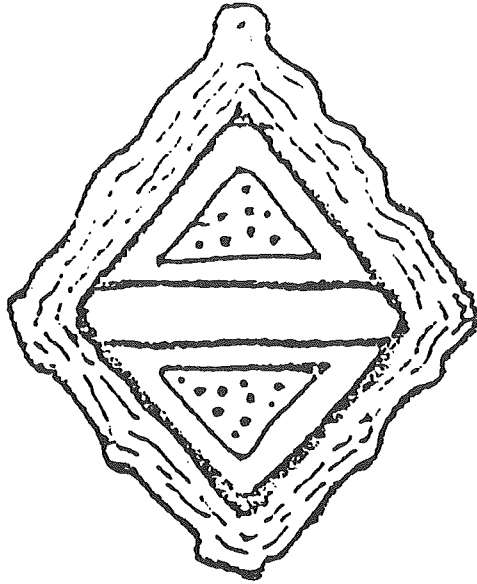


Figure 2 Drawing of the bronze brooch from Gore Cliff
(modified from sketch by G. A. Sherwin)

(1816 : 144) and Colenutt (1929) respectively and it is clear from historical accounts that Gore Cliff had essentially assumed its present form by 1799. Both these landslips removed portions of the slope deposit. Soils buried by landslide debris have yielded radiocarbon dates of c.4500 BP from two sites in The Undercliff and give further evidence of late Post-glacial landslipping (Preece, 1986). Indeed there is even some direct evidence of landslipping during Romano-British times. At Ventnor, Martin (1849 : 267) reported the skeleton of a young female apparently buried by "a fall of earth". An associated amulet was believed to date from about 300 AD. There are several other examples of human (and other) skeletons apparently buried catastrophically from The Undercliff but the ages of most of these remains unknown, although one at least is Iron Age (Dunning, 1951).

The Undercliff, as it exists today, is therefore entirely the product of late Post-glacial landsliding and related processes. Evidence of earlier activity has either been effectively obscured by subsequent debris or completely removed by marine erosion. However, the discovery of two species of helicellid snails *Trochoidea geyeri* and *Helicopsis striata* from the surface of unstratified talus near Ventnor (Preece, 1977) suggests that older deposits are present in this vicinity. These two species are both now extinct in Britain but were present in southern Britain during the Late-glacial (Kerney, 1963) and it therefore seems probable that the Ventnor specimens were derived from a deposit of this age (Preece, 1896). It therefore seems likely that some periglacial activity was responsible for partially shaping the form of the proto-Undercliff but the evidence has been obscured or removed by late Post-glacial geomorphological activity.

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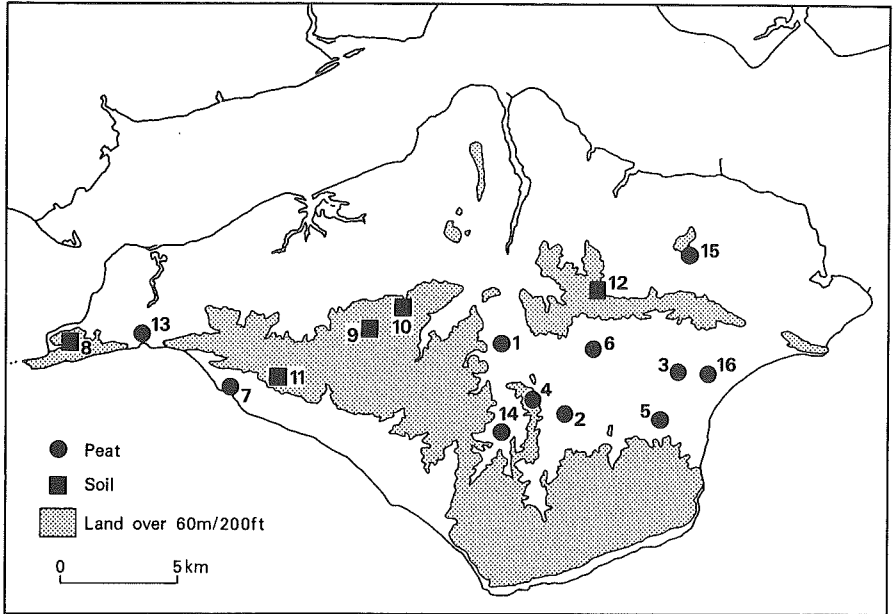
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THE LATE-DEVENSIAN AND FLANDRIAN VEGETATION OF THE ISLE OF WIGHT

by

Robert G. Scaife

South East Britain in general has until recent years been an area devoid of detailed palaeoecological and palaeovegetational information. The reasons for this are exemplified in the Isle of Wight where there exist a wide combination of natural environmental (largely lithological) and anthropogenic factors. Climatically, the rainfall deficit of South East England has negated the development of acid, ombrogenous and blanket peat mires typical of upland Britain. In contrast, those mires which do exist are groundwater controlled, soligenous mires and thus subject to the base status of lithology in the fluvial catchment. The widespread influence of the chalk on the groundwater is highly detrimental to pollen preservation thus rendering large areas of valley fen peat accumulations unsuitable for pollen analysis. It is now recognised that peat cutting was especially important in southern Britain as a source of fuel in a landscape which in many areas had become devoid of woodland, except for the non-accessible hunting parks of the aristocracy. Thus, many areas of peat have been extensively disturbed and there is much evidence of this having occurred on the Isle of Wight both from the stratigraphical record, as at Munsley Bog (SZ 526825) and from documentary evidence. More recent effects of human environmental disturbance have been the changing base status of areas of acid valley bog in the Isle of Wight which, through the use of nitrate fertilisers now support fen vegetation communities. The Wilderness region of the upper Medina valley during Victorian times had a well documented rich bog and fen flora surrounded by heathland and lateral flush bogs. The extension of agriculture on these surrounds, and draining of the mire, changed the flora to its current status of rough grassland and fen carr woodland. This effect plus extensive draining from the 1820s caused the degradation of many areas of fine bog and fen communities. Despite the relatively small area of the Isle of Wight, greater than 100 areas of peat have been investigated during the period 1973-1986, the majority of which were found to be devoid of pollen. However, due to the lithological microcosm of the island, a substantial number of areas have now produced palynological data (Fig.1). The longest Flandrian record and best preserving conditions have been found in association with the Cretaceous Lower Greensand lithologies providing acid groundwater conditions. These include the two only remaining areas of acid *Sphagnum* bog at Bohemia (SZ 513833) and Munsley valley bog. Until recently (1985) little information has been forthcoming from the Tertiary lithologies to the north of the chalk downland ridge. Although early floras of the island describe acid peat communities, these have almost totally disappeared for reasons described. A recently discovered Romano-British kiln site at Newnham Farm (SZ 565916) rests intercalated within peats accumulating on the Tertiary



- | | |
|---|---|
| 1. Gatcombe Withy Bed | 9. Newbarn Down (Bronze Age) |
| 2. Munsley Bog | 10. Apes Down (Bronze Age) |
| 3. Borthwood Bog | 11. The Longstone, Mottistone (Neolithic) |
| 4. Bohemia Bog | 12. Combley Roman Villa |
| 5. Ninham Bog | 13. Freshwater Gate |
| 6. Redway (preliminary analysis) | 14. The Wilderness |
| 7. Brook Bay (Clifford 1936 and partial analysis) | 15. Newnham Farm |
| 8. Headon Warren (Bronze Age) | 16. Sandown Water Works |

Figure 1 Topographical map and distribution of sites selected for analyses

deposits and provides the first substantial evidence as to the age of the vegetation of this large Tertiary tract during the later prehistoric and Romano-British period. The value of carr woodland coppice management in the historical economy has meant that these vegetation communities were valued for their withy/coppice. In consequence, unlike other areas cut for their peat, many areas of alder and willow carr woodland were maintained and their peat-silty substrates remain intact giving in some cases long records of vegetational history. This is especially the case at Gatcombe Withy Bed (SZ 502858) which has provided a long type sequence extending from the late Devensian (?ZII, ZIII) to present. In addition to these peat sequences are soil pollen data obtained from archaeologically buried soils dating from the Neolithic and from coastal transgression peats around the coast and in the submerged valleys.

LATE-DEVENSIAN AND HOLOCENE PEAT AND SEDIMENT ACCUMULATION

From the pollen investigations of a large number of peat and sediment sequences in the Isle of Wight, and the more detailed pollen and C14 studies on a number of these, it is clear that certain periods of peat and sediment initiation can be defined and attributed to one of the following:

Inorganics

1) Late Devensian-Zone III. Typical inorganic sequences, largely bedrock derived but with some loessal component. Deposited in a harsh open periglacial environment dominated by herbaceous plant communities which indicate unstable soils. These deposits are clearly seen at Gatcombe Withy Bed (see below) and Munsley Peat Bed.

2) A notable phase of inorganic sedimentation took place during Flandrian Ib-c (Late Boreal) throughout the length of the Medina and Eastern Yar rivers. These sediments are typically blue-grey silts with strong aeolian size characteristics. This lithostratigraphical unit occurs at Gatcombe Withy Bed but is clearly evident as far up valley as the Wilderness where the pollen spectra again attest to their FIB-c date. This, however, is likely to have been away from the effects of Boreal base level changes causing ponding back. The source of such sediments in an environment which was clearly dominated by Pinus, Corylus, Quercus and Ulmus on the interfluvies remains a problem. Very substantial depths of sediment and of wide geographical extent have similarly been studied in Sussex river valleys (Scaife and Burrin 1983, 1985; Burrin and Scaife 1983 and in press). It is difficult to envisage such quantities of sediment being derived from what are likely to have been largely stabilised interfluvial soils and perhaps the effects of Mesolithic man and fire have been underestimated as a cause of such early Flandrian valley/floodplain sedimentation. It has been shown (Scaife and Burrin op. cit.) that later prehistoric activities resulted in widespread floodplain accretion.

Peat Initiation

1) Peat initiation has been noted at the beginning of Flandrian Ia, dated at Gatcombe Withy Bed (9970±50 SRR-1433) an Munsley

peat bed. This corresponds with the rapid colonisation of tree *Betula* on the interfluvies. *Salix* carr became important in valley bottom niches. This represents increasing groundwater and precipitation at the end of the Devensian combined with stabilisation of the interfluvies.

2) Environmental changes at c.7000 bp (climatic and base level) are evidenced by peat initiation after a period of dryness in Flandrian Ic. Alder carr woodland became widespread in valley bottoms and peat accumulation from this community is evidenced at Borthwood, Brook Bay and Gatcombe. At the latter this has been dated to 6450±50bp.

3) Bohemia Bog and Ninham Farm illustrate the effect of prehistoric activity upon local hydrology. At both sites, there is evidence of local prehistoric activity at their base. It is likely that such activity resulted in localised changes in hydrology, higher water tables, and lower overall evapo-transpiration rates resulting in the initiation of peat accumulation in valley mire communities. Such phenomena have also been noted at other sites in southern Britain both in terms of peat accumulation (Moore and Willmott, 1976) and valley floodplain situations (Burrin and Scaife 1984, Scaife and Burrin 1983, 1984), and dry valley colluviation (Bell 1983).

THE MEDINA RIVER SYSTEM

There is an almost continuous spread of valley peat and sediments extending from the source of the Medina river at Chale Green (SZ 495800) northwards to the tidal reaches at Cowes. The extent of these valley sediments has long been recognised (Osborne White 1921, 174) but extensive survey of the peats in 1974 indicated that much recent anthropogenic disturbance had caused disjunction of the peats into isolated pockets through peat cutting and draining. Deposits containing pollen were located at the Wilderness (SZ 505823 - found to be badly cut), Blackwater (SZ515855) and in the remaining valley fen carr associations between Blackwater Mill (SZ 503862) south towards Chillerton (SZ 498846). This is typical swamp carr woodland dominated by *Alnus glutinosa* and *Salix* dominated carr communities (*Alnetum*, *Salicetum*) with a rich and typical flora which is at times impenetrable.

GATCOMBE WITTHY BED; REGIONAL TYPE SEQUENCE FOR THE FLANDRIAN

Gatcombe Withy Bed (SZ 502858) is part of this expanse of valley sediments and peats. A late Devensian (Zone III) and full Flandrian pollen and stratigraphical sequence has been studied and has provided the basis for interpretation of many other temporally less continuous stratigraphical sequences found in the island.

Stratigraphy

The point at which core samples were taken for analysis lies on the Sandrock beds adjacent to its junction with the Ferruginous Sandstone series and at the widest extent of the valley gap where a tributary valley enters from the west. Stratigraphical survey

revealed a maximum depth in this area of 295 cm, lying approximately central in the R. Medina valley. The core obtained from this locality shows the most representative sequence of deposits found at Gatcombe. Lateral variation in their thickness is great. This is attributed to the differential effects of drainage in the upper peats and to the marked morphological variation in the sub-peat and sediment surface. Late Devensian and early Flandrian (Fl) deposits were found to occur in hollows in the valley bottoms.

- 0-104 cm Upper, well humified sedge and detrital peat. Silica present in lenses (8-16 cm, 40-48 cm, 58-76 cm, 104 cm) is attributable to valley side anthropogenic activity and resultant inwash to the valley bottom. Walkley Black organic determination averaged 78% (33 samples). Average pH 5.5. Generally the peats are penetrated by Phragmites rootlets from a depth of 48 cm. Large Alnus and Salix roots are present in the peat. At 30 cm a layer of cut Alnus stakes is present, dated to 490±90 (HAR-2839) and are the result of coppice/withy exploitation. Date: contemporary to c.4500 bp. Pollen assemblage zones GIW: 9-11.
- 104-132 cm Highly humified detrital and monocot peat containing large Alnus branches. Little silica present. Pollen frequencies high. Dating: 4850±45 bp at 108-109 cm (Ulmus decline) to 6385±50 bp at 128-132 cm. Thus a Flandrian II (Atlantic) sequence. Pollen assemblage zone GIW:8.
- 133-176 cm Light grey homogeneous silt with low organic content (av. 12.6% for 12 samples but 2.8% at 152 cm in the centre of the silt levels). Penetrated by Phragmites roots. At the upper junction of silts and peats, a layer of concretions occurs; 3-4 cm sized nodules of silt (see below). It can be noted that this lithostratigraphical unit occurs throughout this and adjacent valleys. Date; Flandrian Ib, Ic (late Boreal). Pollen assemblage zone GIW:6 (top)-GIW:7.
- 176-220 cm Lower peats. Dark brown-black highly humified with little structure other than monocot fragments and occasional bryophytic material. Sphagnum cf. palustre and wood fragments are present. The latter are present especially at the basal junction with the lowest inorganic unit (below). Dating: Flandrian Ia (pre-Boreal) dated at their base to 9980±bp. Pollen assemblage zone GIW:5- bottom GIW:6.
- 230-235 cm Transition zone between humified fen peat above and relatively inorganic sediments below. Date: Late Devensian (ZIII) to F1a (sub-boreal) transition corresponding with a Juniperus peak 10,000 bp. Pollen assemblage zones GIW:4.

- 235-263 cm Relatively inorganic, coarse grey sandy deposits of Lower Greensand derivation. Some rootlets. Plant macrofossils include bryophyte remains (Sphagnum cf. palustre and Drepanocladus sp.) and Carex seeds. More clayey between 263-285 cm. Date: Late Devensian, Zone III (Loch Lomond). Pollen assemblage zones GIW:2-4.
- 285-290 cm Grey, sandy sediments, coarser than above. Junction with underlying full Devensian gravels is sharp with no apparent bedrock rotting. Date: ?Late Zone II (Allerod)-early zone III. Pollen assemblage zone GIW:1-bottom GIW:2.

Pollen analysis

Three pollen sequences have been analysed; the Late Devensian basal sediments (220-290 cm; 2 cm intervals), the Holocene/Flandrian (220-0 cm; 4 cm intervals) and a close sampling systematic study (2mm contiguous) across the Primary Ulmus decline. The former is not presented here and restricted sections only of the latter are given. The results of the analysis (Fig. 2-3) are calculated as a percentage of arboreal pollen plus the group of which the taxon forms a part. Nine biostratigraphical pollen assemblage zones have been delimited.

- GIW: 1-3
290-235 cm These basal zones (diagrams not presented) are all characterised by abundant herbs which attain 80-90% TP. AP and shrub pollen values are relatively low (to 18% TP). The latter are predominantly Betula and Pinus with sporadic occurrences of Quercus. Dwarf shrubs are important with Juniperus and ericaceous (Calluna, Erica and Empetrum) consistently important. These basal zones are interpreted as being typical late-Devensian (Zone III) character which show dominance of heliophytes growing in a number of different plant communities which have been recognised (see below).

- GIW: 4
237-229 cm The predominant feature of this zone is the sharply increased status of Juniperus (to 10% TP) and Filipendula (to 22%) along with extremely high herbaceous totals. This zone represents a period of rapid changes with modification of pre-existing plant communities. Valley fens become richer in those taxa whose threshold temperatures would be exceeded with climatic/temperature amelioration (eg Juniperus and Filipendula). The zone illustrates a period transitional between the open character of the Late Devensian (Zone III) and the early Flandrian woodland colonisation (Betula and Pinus). This transition occurred at c.10,000 bp.

- GIW: 5
220-182 cm Characterised by sharply increasing Betula to a maximum (80%) but with Pinus rising steadily to 40% and exceeding Betula at the top of the zone. Juniperus is evident at the base and correlates with GIW:4. Thermophiles are sporadically recorded: Corylus, Quercus, Alnus, Sorbus type and Salix. NAP percentages are high but decline from the base of

Figure 2 Gatcombe Withy Bed : pollen diagram; trees and shrubs

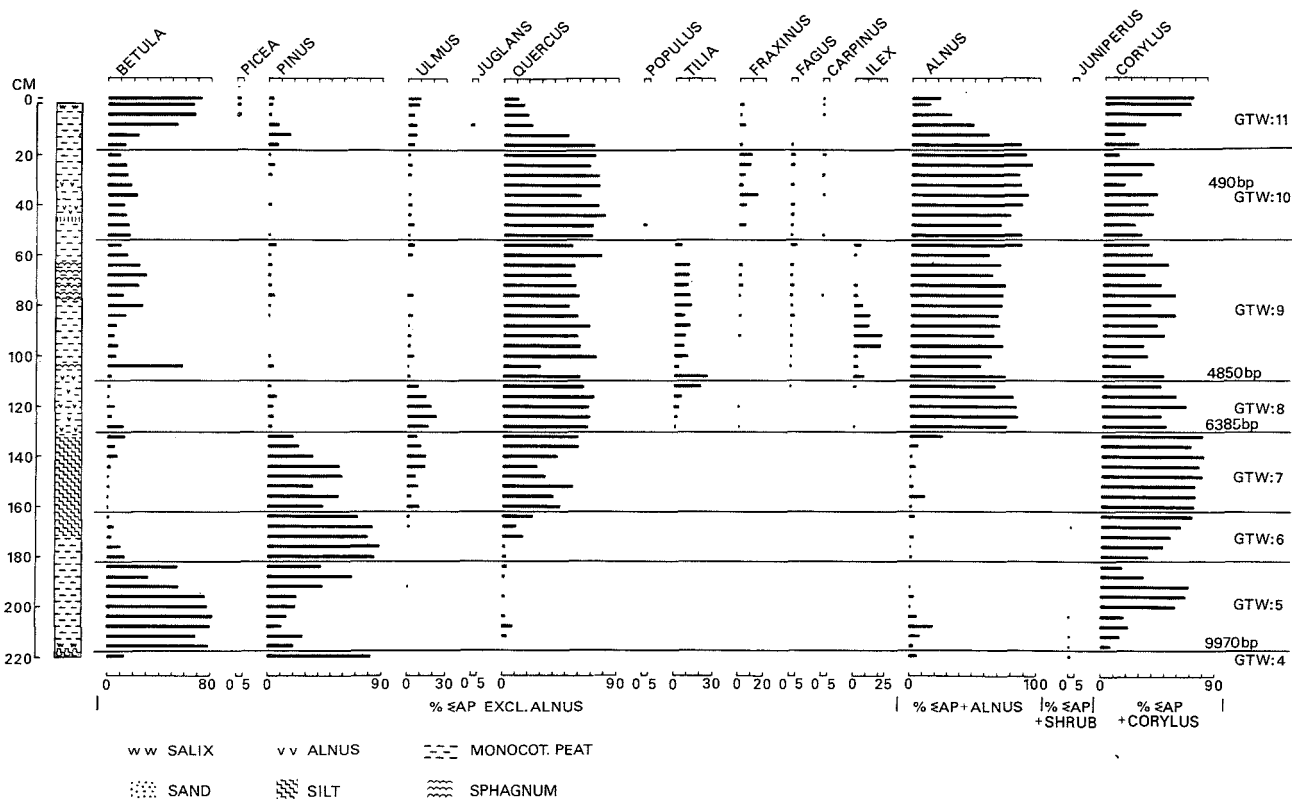
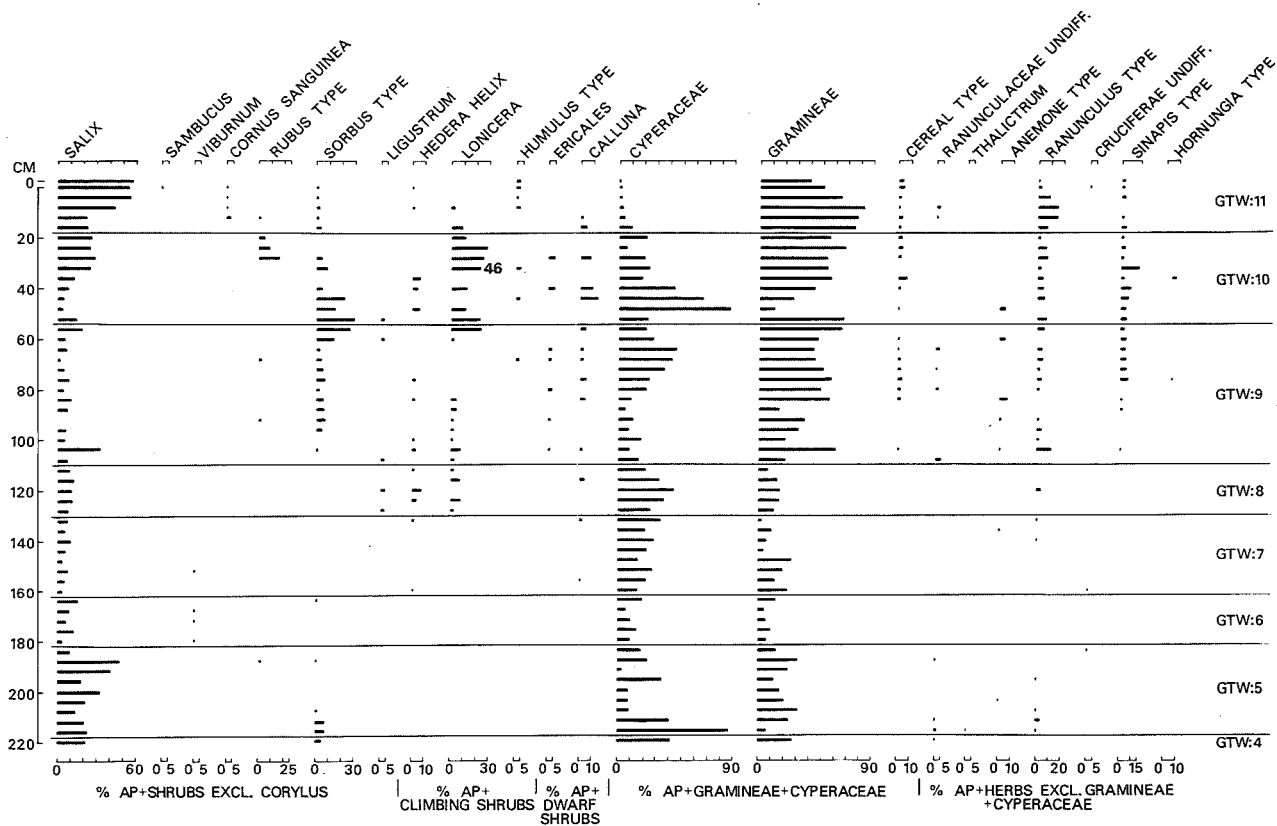


Figure 3 Gatcombe Withy Bed: pollen diagram; shrubs, climbing shrubs, dwarf shrubs and herbs



the zone; Gramineae, Cyperaceae, Filipendula (65%) are dominant with a diverse range of taxa present.

This zone is representative of the early Flandrian period, from the decline of Juniperus after its initial maximum (GTW:4) and dated at 9970+80bp. A sequence of rapidly changing vegetational events took place associated with temperature amelioration and plant migration rates. On drier surrounds Juniperus, Sorbus, Alnus, Betula, Pinus and Corylus are evident whilst the mire shows expansion of Salix carr and associated tall herbs. The result was the overall afforestation and stabilisation of previously soliflucted and disturbed ground.

GTW: 6
182-162 cm

Delimited by high Pinus and Corylus values but with the introduction of Quercus and Ulmus. Betula declines further whilst Pinus increases to maximum values (88%) and subsequently declines. Corylus increases from 16% to 72%. NAP totals are low. Stratigraphically this zone embraces the change from peats to silts of low organic content.

This zone shows the maximum extension of Pinus forest being dominant in all but the valley mire communities. Synonymous with this is the ousting of Betula in its pioneer role. More competitive deciduous taxa-Quercus and Ulmus-start to increase in importance.

GTW: 7
162-130 cm

Changing dominance of arboreal taxa is evident with the expansion of Quercus, Ulmus and Corylus over Pinus. Pinus declines throughout the zone (from 82%-20%). Ulmus and Quercus expand to values of 14% and 60% respectively. Corylus expands in a second peak. NAP taxa are few but include autochthonous Cyperaceae (34%) and Gramineae (26%).

Pinus becomes subordinate to the increasing dominance of deciduous trees, initially Quercus, followed shortly after by Ulmus. High Corylus percentages show the prevalence of hazel as pure stands or as an understorey to the above. A period of dryness is indicated at the top of the zone by the drying out of the silts (see above).

GTW: 8
130-110 cm

Stratigraphically, the beginning of this zone corresponds with a change from silts to highly humified peat dated here at 6384+50bp (SRR-1339). Alnus, increasing sharply to maximum values of 84% and Quercus (68%) are statistically the dominant taxa. Ulmus attains its maximum values (23%). Pinus declines sharply at the base of the zone. Of significance is the incoming of Tilia increasing from 1%-20% by the end of the zone.

This zone is representative of the climatic and vegetational optimum of the Flandrian (Flandrian II). At least in the area of Gatcombe, climax deciduous woodland occurred, possibly broken by natural or Mesolithic created glades. The dominant/co-dominant arboreal taxa present were Alnus, Quercus, Ulmus, Tilia and Corylus. Suggestion of polyclimax has been made (see below) on areas with different ecotypes on differing edaphic, lithological, ground water and topographical conditions. From c.7000 bp the valley mire became one of Alder Carr which has remained with modification to the present day.

GIW: 9
110-54 cm

The lower zone boundary has been delimited by the decline of Ulmus from 15-20% to <1% and which has been dated at 4850 (SRR-1338). Expansion of other AP types occurs (Ilex, Fraxinus, Sorbus type and Fagus) along with the introduction or re-establishment of a diverse NAP flora which includes cereal type, ruderals and segetals. Two main sub-zones have been delimited in which four phases of anthropogenic changes/activity are apparent.

SZ:I, Phase i, 108-112cm; the primary Ulmus decline takes place. Phase ii, 104cm; a sharp rise in Betula and herb totals including cereal and Plantago lanceolata occurs.

SZ:II, Phase iii, 100-88cm; relatively few herbs. Phase iv, 86-54cm; herbaceous totals increase sharply and AP totals decline sharply from 76cm.

The primary Ulmus decline, Cl4 dated at 4850 ± 50bp (SRR-1338) indicates the incoming of the Neolithic with all the connotations attached to the cause of this widespread palynological phenomenon. A period of agriculture took place after the Ulmus decline including a 'landnam type' clearance in which arable crops were grown (phase ii). This period has been studied in detail using a 2mm contiguous sampling interval (see below). In phase iii little cultivation occurred but later Neolithic forest regeneration took place. Pastoral agriculture with woodland foraging may have occurred in this secondary forest. Sub-Zone II marks the initial Bronze Age activity at c.3300bp with extended forest clearance and arable agriculture and settlement on both valley sides adjacent to the mire. The mire throughout the period spanned by this zone remained Alnetum but with episodic Sphagnum growth consequent upon increased valley side inwash from the acid Lower Greensand lithology. Tilia woodland remained as pure stands on well drained soils. Fraxinus and Fagus expanded, possibly filling gaps left by the removal of Ulmus. Ilex, Sorbus/Crataegus and Corylus responded to the relative openness of the landscape.

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GIW: 10
54-18 cm

The lower zone boundary is delimited by the decline of Tilia and Ilex and subsequent absence. Quercus (6-80%), Alnus (85%) and Betula (16%) remain the dominant tree types. Pinus becomes continuous from 28cm upwards. Three periods of anthropogenic disturbance are indicated 56-52cm (phase v); 40cm (phase vi) and 28cm (phase vii).

The removal of Tilia and Ilex (phase v) indicates extensive and important changes in the vegetation environment of the Gatcombe region. A similar impact has been noted at Borthwood Farm (see below) and Bohemia Bog (SZ 513833) where Cl4 dating has placed this event at c.1000-1200 bc. Although not necessarily synchronous, later Bronze Age woodland clearance for agriculture is postulated. The mire shows a response to the clearance with change from carr woodland to an acidophilous fen community containing Sphagnum, Narthecium and Drosera. In phase vi, soil deterioration is illustrated by ericaceous communities in some areas. The upper clearance horizon (phase vii), dated from a cut alder stake, is apparently the first direct influence by man on the mire evidenced by the thinning out and use of Alnus as coppice and promotion of Salix withy.

GIW:11

Betula, Pinus, Ulmus, Corylus and Salix increase sharply. This upper zone is representative of the last 300 years of agricultural enclosure (Ulmus procera) and the planting of 'exotic' Pinus and Picea.

THE EASTERN YAR SYSTEM

The eastern Yar river system rises at Godshill; (Moore Farm SZ 535820). Initially the stream flows generally northeastwards and parallel to the downlands. It undergoes a right angle shift flowing through the Brading Gap after which it flows northwards entering the sea at Brading Harbour (SZ 630887) (Small 1970). Numerous and deep areas of fen peat occur as at Newchurch (c.10 metres) along the length of this river and in its smaller tributary valleys. Unfortunately, much of this peat is devoid of pollen due to the effects of alkaline groundwater from the chalklands and/or recent anthropogenic pressures (drainage etc. noted above). Pollen has been recovered from a number of areas along this river system (fig. 1). These include Moor Farm, Godshill dating to Boreal or earlier; Redway Farm (SZ 536847) drained but with Atlantic peats (currently being analysed), adjacent to Sandown Water Works (SZ 588849) and Bembridge/Brading Harbour. Two peat sequences in the northward flowing tributary of Scratchells Brook at Ninham Farm (SZ 569825) and Borthwood Farm (SZ 578849) have been studied in more detail (Scaife 1980). The latter is used here as an example of such sequences occurring along the Eastern Yar.

BORTHWOOD FARM

The area (NGR SZ 52578849) lies approximately 2km west of Sandown and abuts the area of Sandown airport to the south and Sandown Golf course to the east. To the south and west lies the area of Borthwood copse consisting of 23 ha of deciduous woodland (NT). The chalk downland ridge lies 1.5-2km to the north. A core of 6m depth was obtained from this extensive lowland area.

Stratigraphy

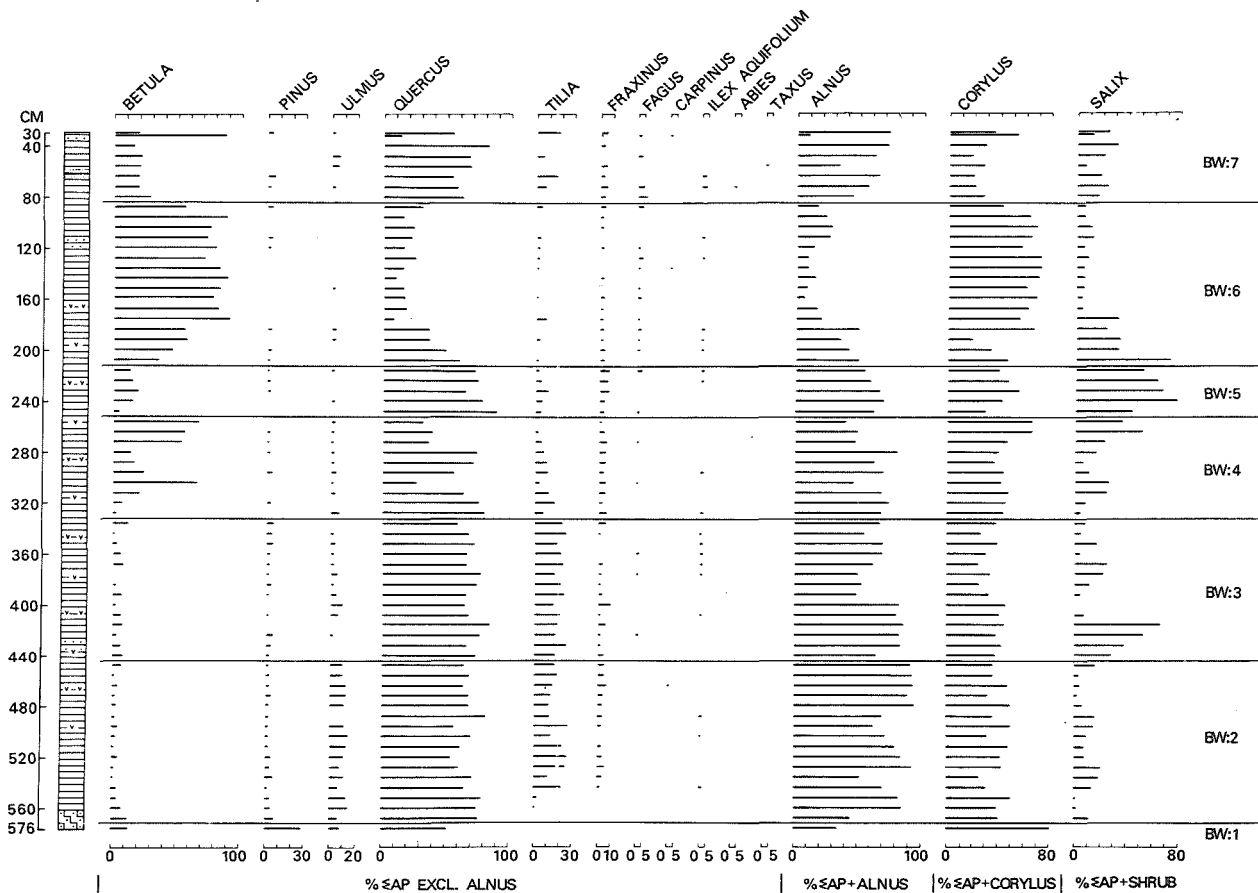
The basal 30cm comprise grey silt. Overlying these are 560cm of homogeneous brown fen and fen carr peats. Wood (Alnus) remains occur frequently throughout. Bryophyte/Sphagnum peat is largely absent in any quantity. Because of the surface drainage of the mire, the upper 30cm of peats are highly oxidised and disturbed and were not therefore sampled.

Pollen analysis

A sampling interval of 8cm and pollen sum of 600 grains (excluding Alnus, spores and aquatic taxa) were used for the analysis of 576cm of core obtained. The results of the analysis (figs. 4 & 5) are calculated as a percentage of arboreal pollen plus the group of which the taxon forms a part. Seven biostratigraphical pollen assemblage zones have been delimited and are as follows:

- BW: 1 Basal zone delimited by high Pinus (27%) and Corylus frequencies with moderately high Quercus (52%) and Ulmus (8%). The domination of Pinus, Quercus and Corylus is indicative of a late Boreal date for these initial sediments. On the assumption that the rise of Alnus is broadly synchronous across the Isle of Wight, this horizon has been dated at 6385±50 bp at the base of Gatcombe GIW:7 (fig. 2) with which it corresponds.
- BW: 2 AP dominates. Pinus declines sharply. Quercus (76%), Ulmus (10%), Tilia (26%) and Alnus (78%) are the principal AP types. Alnus and Tilia are especially important with sharply increasing values (to 9% and 26% respectively). Relatively high frequencies of other thermophiles include Ilex (1.5%), Fraxinus (5.7%), Hedera (15%), Lonicera and Viscum. This zone is interpreted as the Atlantic (F II) period stating at c.7000bp and indicated by the importance of and massive increases in thermophilous taxa. High values of Tilia are indicative of dominant or at least co-dominant communities of lime on the adjacent greensand and/or chalk scarps. The valley mire community shows a typical Alnetum with an understorey of herbaceous fen taxa.

Figure 4. Borthwood Bog: pollen diagram; trees and shrubs



BORTHWOOD FARM

The area (NGR SZ 52578849) lies approximately 2km west of Sandown and abuts the area of Sandown airport to the south and Sandown Golf course to the east. To the south and west lies the area of Borthwood copse consisting of 23 ha of deciduous woodland (NT). The chalk downland ridge lies 1.5-2km to the north. A core of 6m depth was obtained from this extensive lowland area.

Stratigraphy

The basal 30cm comprise grey silt. Overlying these are 560cm of homogeneous brown fen and fen carr peats. Wood (Alnus) remains occur frequently throughout. Bryophyte/Sphagnum peat is largely absent in any quantity. Because of the surface drainage of the mire, the upper 30cm of peats are highly oxidised and disturbed and were not therefore sampled.

Pollen analysis

A sampling interval of 8cm and pollen sum of 600 grains (excluding Alnus, spores and aquatic taxa) were used for the analysis of 576cm of core obtained. The results of the analysis (figs. 4 & 5) are calculated as a percentage of arboreal pollen plus the group of which the taxon forms a part. Seven biostratigraphical pollen assemblage zones have been delimited and are as follows:

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 rise of Alnus is broadly synchronous across the Isle
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 at the base of Gatcombe GIW:7 (fig. 2) with which it
 corresponds.
- BW: 2 AP dominates. Pinus declines sharply. Quercus
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 the principal AP types. Alnus and Tilia are
 especially important with sharply increasing values
 (to 9.5% and 26% respectively). Relatively high
 frequencies of other thermophiles include
 Ilex (1.5%), Fraxinus (5.7%), Hedera (15%), Lonicera
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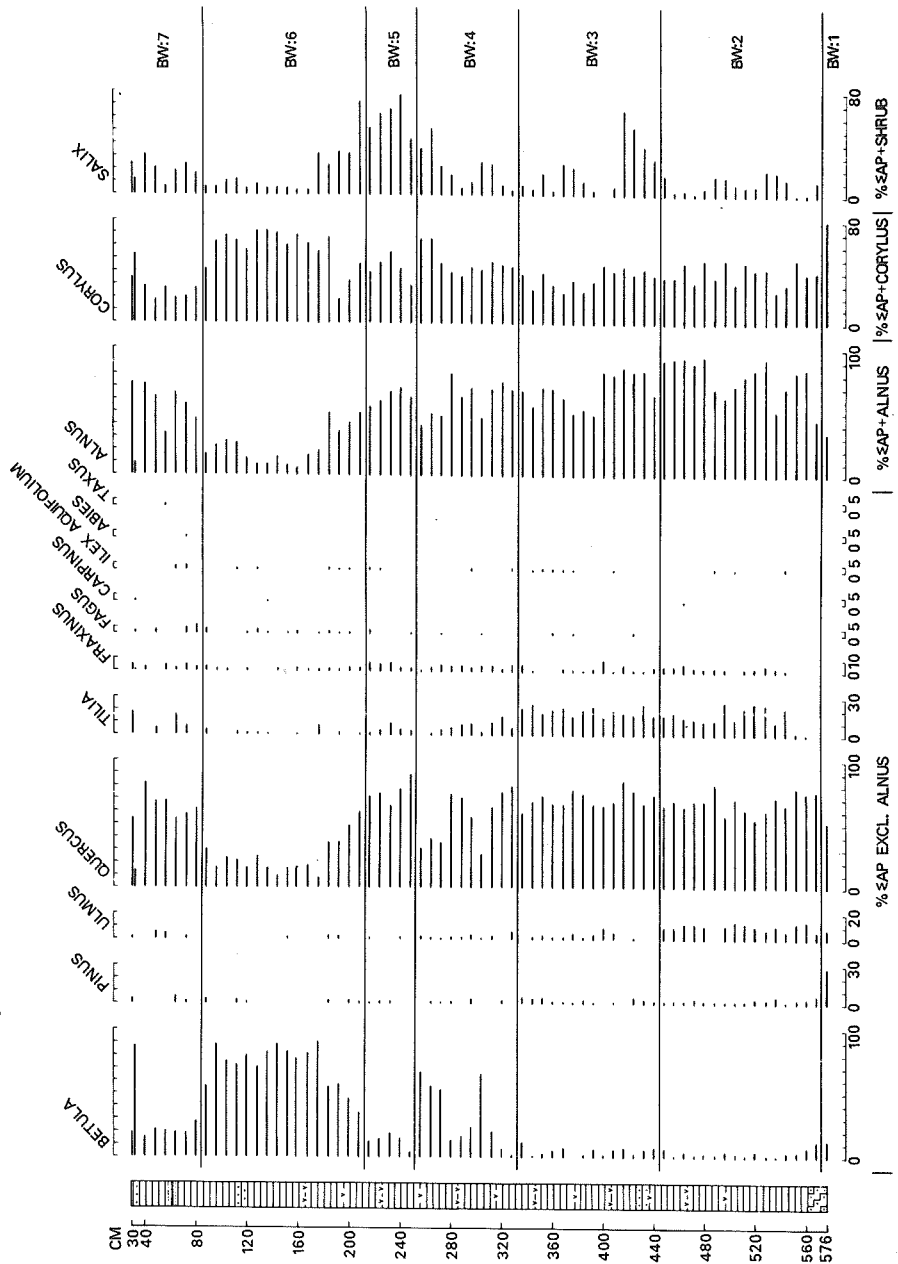
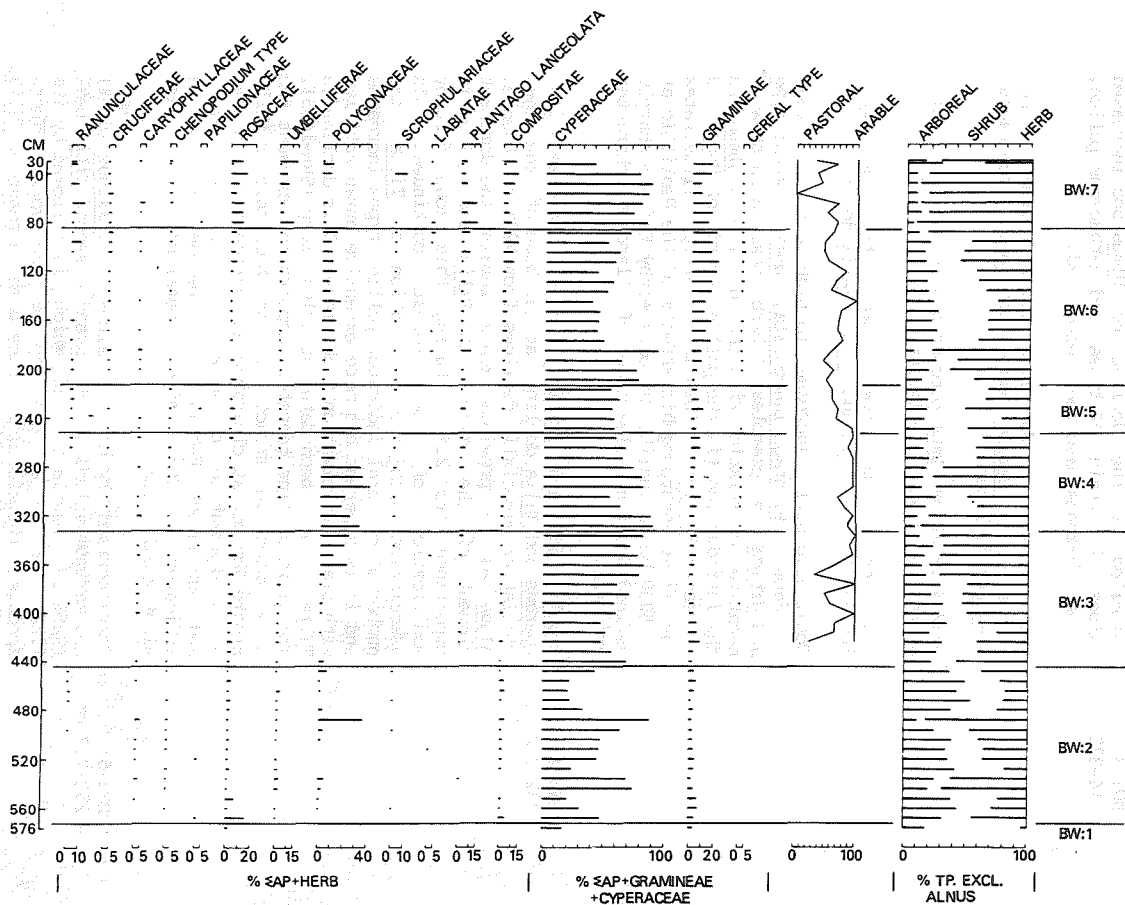


Figure 4 Borthwood Bog: pollen diagram; trees and shrubs

Figure 5 Borthwood Bog: pollen diagram; selected pollen types



BW: 3
444-332 cm

Delimited by the decline of Ulmus and increased values of certain AP types and herbaceous pollen. Three sub-zones have been recognised:

SZ:1 444-412 cm No Ulmus pollen present. Minor increases in Betula with high Salix percentages. Fraxinus declines.

SZ:2 412-364 cm Ulmus percentages increase and Salix starts to become more important.

SZ:3 364-332 cm. Low values of Fraxinus. Pinus increases with Tilia and Ilex. Salix declines.

Total herb pollen increase to high values of 90%TP at 368cm. Plantago lanceolata, Rumex, Cereal type and Urtica are examples of herb taxa which show a negative correlation with the decline in Ulmus and the introduction (in the pollen record) of Fagus and increased Fraxinus. This zone therefore illustrates the first anthropogenic effects of the Neolithic at c. 5000 bp but unlike Gatcombe Withy Bed, no sharply defined Neolithic clearances of 'landnam' character are seen.

BW: 4
332-252 cm

Betula (65%) and Fraxinus (to 4%) increase whilst Quercus and Tilia decline at the base of the zone. The latter especially declines from >20% to absence. Alnus as in previous zones remains the dominant element of the mire with Salix increasing in importance (to 21%). During this zone further modification of the forest continues. In association with the depredation of Tilia, the number of cultural indicator pollen types increases and it is apparent that more extensive human activity with arable cultivation took place. This decline in Tilia has here been dated at 4010 ± 110bp (SRR-1435). The Tilia decline therefore appears to represent the more extensive impact of Late-Neolithic or Early Bronze Age forest clearance and agriculture in some areas adjacent to the mire. Clearance of downland and subsequent Betula scrub regeneration may be indicated. The mire remained a damp Alnetum/Salicetum.

BW: 5
252-212 cm

Characterised by higher values of Fraxinus (9.5%) and maximum values of Salix and a second Tilia peak (9.5%). The latter of which is followed by its final decline at the top of the zone. There appears, therefore, to have been a phase of Tilia clearance. This has been dated at 3280 ± 80bp (SRR-1434) and represents Bronze Age activities at a time corresponding closely to the earliest archaeological evidence from the Island. This may be correlated with the extensive downland barrow cemeteries on Ashey and Brading Downs immediately to the north.

BW: 6 Characterised by dominant peaks of Betula (80-90%) and Corylus type and a major reduction in Salix and some Fraxinus. Fagus is more frequent (3%). The main features are the dominance of Betula and Corylus and the decline in Alnus and Salix. Fen mire herb taxa increase markedly. This illustrates a change in the local status of the mire from Alnetum/Salicetum to Sphagno-Caricetum. This openness perhaps resulted in an expansion of the pollen catchment and consequent input from downland Corylus and Betula scrub. The zone does, however, show a period of forest clearance at 3280+-80bp. In response to this, Corylus and Betula regeneration took place. At the same time a marked change in the mire status is apparent with previously dominant Alnus and Salix carr being largely replaced by wetter fen. It is difficult to ascertain whether this change was initiated by coppicing of the Salix, or from higher water table and surface run-off resulting from valley side clearance.

BW: 7 Characterised by a marked decline in Betula and Corylus frequencies with the expansion of Quercus, Tilia, Fraxinus, Alnus, Salix and Fagus. NAP values are due to the dominant Cyperaceae values and an increase in cultural pollen types. The highest levels of this diagram do not represent the present day due to the extensive drainage and disturbance of the uppermost levels. It is clear that these levels pre-date the expansion of exotic Pinus and Ulmus hedgerows planted in the post 18th Century. It does, however, illustrate the expansion of woodland, that is possibly Borthwood copse adjacent to the mire, and mixed agricultural activities. Expansion of Salix took place possibly from the promotion of Withy (coppice) beds.

THE WESTERN YAR

The western Yar is a small stream which runs from Freshwater Gate (SZ 347857) to Yarmouth, a distance of 4km. This small stream flows through a broad belt of alluvium with intercalated peats and marine silts (Osborne White 1921). Coastal erosion of the south west coast of the Island has truncated the points where southward flowing tributaries of this formerly more extensive river system occurred. As a consequence of this, there is now a belt of peat and alluvium which meanders parallel to the coast between Chilton Chine (SZ 407823) and Compton Bay/Shippards Chine (SZ 378841). In places these sediments outcrop in the cliff section where they are subject to much lateral change in their exposure due to mass movement in the underlying Wealden clays and marls. It is in these peats that the infamous 'Noah's Nuts' occur. These are the numerous well preserved hazel nuts which are found in the gravels and peats of Atlantic date and in association with a wide range of other plant macrofossils (see Osborne White 1921, 171 for Thomas Webster's 1856 description of the stratigraphy). Early pollen and

plant macrofossil analysis was carried out by Clifford (1936) from peats associated with a Mesolithic hearth exposed in the cliff section at Brook Bay. His early pollen analysis is commensurate with the late Mesolithic date of the flint artefacts recovered from various points along the section. Recent pollen analysis (Scaife unpublished) shows a typical Atlantic (Flandrian II) spectrum for these peats, being dominated by Quercus, Corylus and Tilia and which accords well with the plant macrofossil data of Clifford.

At Freshwater Gate in the western Yar proper (SZ 347859) peat sequences exposed (1984 during building) at some metres depth underlying marine silts and Phragmites clay (Phragmites being the contemporary vegetation) have yielded pollen indicating a post-forest clearance and agricultural environment. These have not yet been dated. At the north western end of this river system close to its outlet at Yarmouth, more continuous deposits have been studied by Dr R Devoy (this volume).

A SUMMARY OF VEGETATIONAL DEVELOPMENT

THE LATE-DEVENSIAN

Sediments and peats of late-Devensian and early Flandrian date have been studied at two sites; Catcombe Withy Bed and Munsley peat bed (Scaife 1980, 1982). Space does not permit inclusion of full pollen diagrams from these sites due to their great herbaceous diversity. Throughout the pollen assemblage zones designated from the Late-Devensian at two sites (MUN: 1-4; GW:1-4), the pollen spectra are dominated by high values of herbaceous types. This is one of the most interesting features of the late-Devensian flora and reflects the diversity of micro-environments, which in turn created a high degree of inter-species and community competition. The Isle of Wight evidence suggests that in the Younger Dryas (Zone III) there was a much more open herbeceous vegetation than has been inferred for sites in southern and South East England in the past. It is suggested that tree Betula was only locally present and that the Pinus and Betula present is derived from longer distance transport. Overall similarity of the Pinus pollen curves and an increase immediately prior to 10,000 bp is indicative of the increasing proximity of pine. In spite of the difficulties of differentiating plant communities from the pollen evidence, it has been possible to outline some of the characteristic plant communities which were present. These include;

- i) Shrub communities; dominated by Juniperus and/or dwarf shrub, ericaceous spp. (Calluna, Erica, Empetrum but also possibly including Betula nana and Hippophae rhamnoides).
- ii) Short turf helianthemum communities; containing many of the taxa characteristic of Late Devensian pollen assemblages (Dryas, Helianthemum, Ameria 'A' and 'B' line, Plantago spp. and Botrychium).

iii) Tall herb communities; this group similarly includes many late-Devensian indicator types (Thalictrum, Sanquisorba officinalis, Filipendula, Polygonum bistorta type, Polemonium caeruleum, Valeriana, Scabiosa, Succisa). Trollius europaeus is of special note.

iv) Disturbed soil communities; disturbed soil habitats are reflected by the following taxa-Chenopodium type, Polygonum aviculare, Plantago major and Artemisia spp.

v) Fen and Mire; plant macrofossils show that the valley floors supported a sedge mire with Sphagnum and Cyperaceae being abundant. Spring flushes and reed swamps on wetter areas are also indicated; Caltha type, Menyanthes, Typha/Sparganium, Iris, Selaginella and Equisetum.

vi) Aquatic habitats; infrequent pollen of aquatic taxa indicate that there were few open water areas at least in the sites at present analysed.

The openness of the vegetation suggests that the zone III was even harsher than has often been postulated. This view is commensurate with evidence from Coleopteran assemblages in Britain, which suggests rapidly declining temperatures in Zone III. It is likely that here the widely accepted Betula woodland of the Allerød (Windermere interstadial -Z II) may have been killed off by extreme conditions in Zone III.

EARLY FLANDRIAN VEGETATION SUCCESSION

Early Flandrian changes in the Isle of Wight (and Southern Britain as a whole) are more straightforward if they are viewed in relation to the evidence of Zone III openness. At Gatcombe, a stratigraphical change from sandy silts of Lower Greensand and loessic derivation to humified peats occur at 9970±50bp (SRR-1433). This is associated with a dominant expansion of Betula and Salix indicating that valley side stabilisation by pioneer woodland took place. A characteristic maximum of Juniperus is clearly seen as a transition (zones GIW:4; MUN:4) and response to temperature amelioration. Although Betula shows the greatest expansion in the early Flandrian (FI-a), short lived but important occurrences of other heliophilous shrub/tree taxa occurred (Sorbus and Alnus). Pinus values increase in the immediate post Juniperus phase and showing its real growth in the region. Initially it played a subordinate role to Betula but expanded along with the early increase in Betula and only became dominant in the Boreal period. From 9970±50bp (SRR-1433) a continuous pollen record of Quercus and Alnus occurs. It is difficult to ascertain whether there was localised growth of Quercus at this early date, but it is more likely that the pollen recorded reflects long distance transportation. It is clear that Quercus and Ulmus became dominant forest elements in the middle and late Boreal (FIB-c) and this is illustrated by the consistently high pollen values of Quercus (to 60% AP) and Ulmus (10-15% AP) in zones MUN:7 at Munsley Peat Bed and GIW:7. Similarly and characteristically, Corylus became a dominant

element. In the Isle of Wight a relatively early date for its local growth is apparent, with a double maxima spanning the early Boreal (GIW:5) and late Boreal periods (GIW:7). It is interesting to note that despite the southerly position of the Isle of Wight, there is an absence of *Tilia* and *Fraxinus* in the pollen record prior to c.6400 bp and it is only in the subsequent Atlantic (FII) that consistent records occur.

MID FLANDRIAN FOREST

The period of Mid-Holocene climatic and vegetation optimum is represented at a number of Isle of Wight localities and has been delimited by the CL4 dates from Gatcombe Withy Bed at the beginning of zone GIW:8 (6325 \pm 50bp SRR-1339) and base of GIW:9 (4850 \pm 40bp SRR-1338) which are palynologically broadly comparable with Borthwood BW: 2 and peat deposits at Brook Bay and Redway Farm. These zones are dominated by *Alnus*, *Tilia*, *Quercus* and *Ulmus* and correlate with the hypsithermal Atlantic period (Godwin's pollen zone VIIa) being one of climax deciduous woodland. There is a formidable representation of *Tilia*, *Ilex*, *Alnus*, *Hedera*, *Lonicera* and *Viscum* as thermophilous indicators. Recent authors (Godwin 1975, Scaife 1980) now view the vegetation as a polyclimax rather than the overall Quercetum mixtum often visualised. Locally variable edaphic, topographic and geological factors determined the character of the dominant vegetation type. Because of the lithological and topographical diversity noted above as playing an important role in the late Devensian environment conditions, it is possible to recognise different community types in the pollen spectra representing this period. (i) Wetlands exhibit rapid expansion of alder carr fen communities due to climatic and/or eustatic changes. (ii) On base rich soils, *Tilia* (*T. cordata*) was dominant or co-dominant. This is shown by high pollen frequencies of this normally underrepresented taxon with up to 30%AP at Borthwood, Gatcombe and Brook Bay. At Gatcombe Withy Bed there is strong evidence that *Ilex* was an important element within *Tilia* woodland until the later prehistoric period. (iii) Meadow/gleyed soils probably supported a mixed deciduous forest allied to the Quercetum mixtum often described as dominant throughout the country, that is comprising *Quercus*, *Ulmus*, *Fraxinus* and *Corylus* because of their less demanding soil requirements than *Tilia* which is more suited to base rich soils. (iv) Sandy-low base status soils of the areas of Tertiary Bagshot sands. At present these areas have typical podzolic soils supporting *Calluna* dominated heathland communities. Because of their distance from those pollen sites analysed and because at present there are no known peat deposits adjacent to them (many existed in the last century with acidophilous peat communities which are now destroyed), it has been difficult to ascertain the dominant vegetation of these areas. However, it is tentatively suggested that *Pinus* may have been present on at least small areas to the north of the chalk downland ridge. This argument is based upon the consistent values of 6-8%AP found throughout and which declines contemporaneously with *Ulmus* at c.5000bp (see Gatcombe Withy bed fig. 2). Such localised presence has recently similarly been postulated in the Dorset region (Haskins 1978, Cameron and Scaife forthcoming).

(v) The chalklands of the island present a similar problem with the absence of pollen preserving peats and soils of this date in close proximity to the chalk. Whilst some workers have postulated *Quercus* forest with *Corylus* understorey (Thorley 1971, 1981) *Tilia* dominance seems more plausible if its widespread importance in the pollen record is considered.

ANTHROPOGENIC INFLUENCES ON THE VEGETATION

Although archaeologically the Mesolithic (c.10,000-5300bp) is well represented on the Isle of Wight, having a strong coastal and riverine distribution pattern, direct palynological evidence for vegetation modification is absent in those profiles so far investigated. The Neolithic (c.5300-3500bp) is of great interest in the pollen records of Gatcombe Withy Bed, Borthwood Farm and Bohemia Bog. The initial Neolithic impact has been investigated at Gatcombe by contiguous 2mm sampling of peats spanning the Primary *Ulmus* decline and a subsequent 'landnam' type clearance. The use of such close sampling has revealed the detail of agricultural practices which could not otherwise have been highlighted at more usual sampling intervals.

Five main phases of anthropogenic activity are recognised (figs. 6,7). (i) The pre-*Ulmus* decline. There is some evidence for minor openings of the forest prior to the *Ulmus* decline at 4850±45bp (SRR-1338). Even though *Plantago lanceolata* and other herbs of clearance are found, these cannot be specifically related to anthropogenic glades or herbivore disturbance. (ii) The *Ulmus* decline. This is strongly associated with the expansion of herbs and ruderals characteristic of human occupation and agriculture. Establishment of cereal cropping is evidenced by the first cereal pollen (zone SZ:2) occurring concurrently with declining *Ulmus* percentages. It is thought that this initial activity occurred adjacent to the mire and thus within what must have been a relatively small pollen catchment considering the closed nature of the Alnetum. It is postulated (Scaife 1980, and forthcoming) that this was a phase of woodland based pastoralism and restricted cereal cultivation in small woodland glades. (iii) The cultivation of (ii) (SZ:2) becomes increasingly important and a period of greater impact on the forest and extended cultivation occurred. This is illustrated by a marked expansion of herbaceous pollen in SZ:3 (37%TP) with many 'cultural herbs' making their first appearance. From the pollen totals, clearing in part of some of the adjacent valley sides is evidenced. The absence of any major single reduction in AP types may, however, indicate that this was still of relatively small spatial extent. Of special interest is the 'stepped' appearance of the pollen curves for Gramineae and Cereal type alternating with *Plantago lanceolata*. This phenomenon has been interpreted (Scaife 1980 and forthcoming) as due to arable and pastoral crop rotation within the same forest clearing and in close proximity to the sample site. (iv) Sub-zone IV has close affinities with the typical 'landnam' clearances discussed for other sites in Britain and Ireland. The timing and length of this event are enigmatic since C14 dating produced anomalous dates due to contamination of samples used (Scaife 1980,

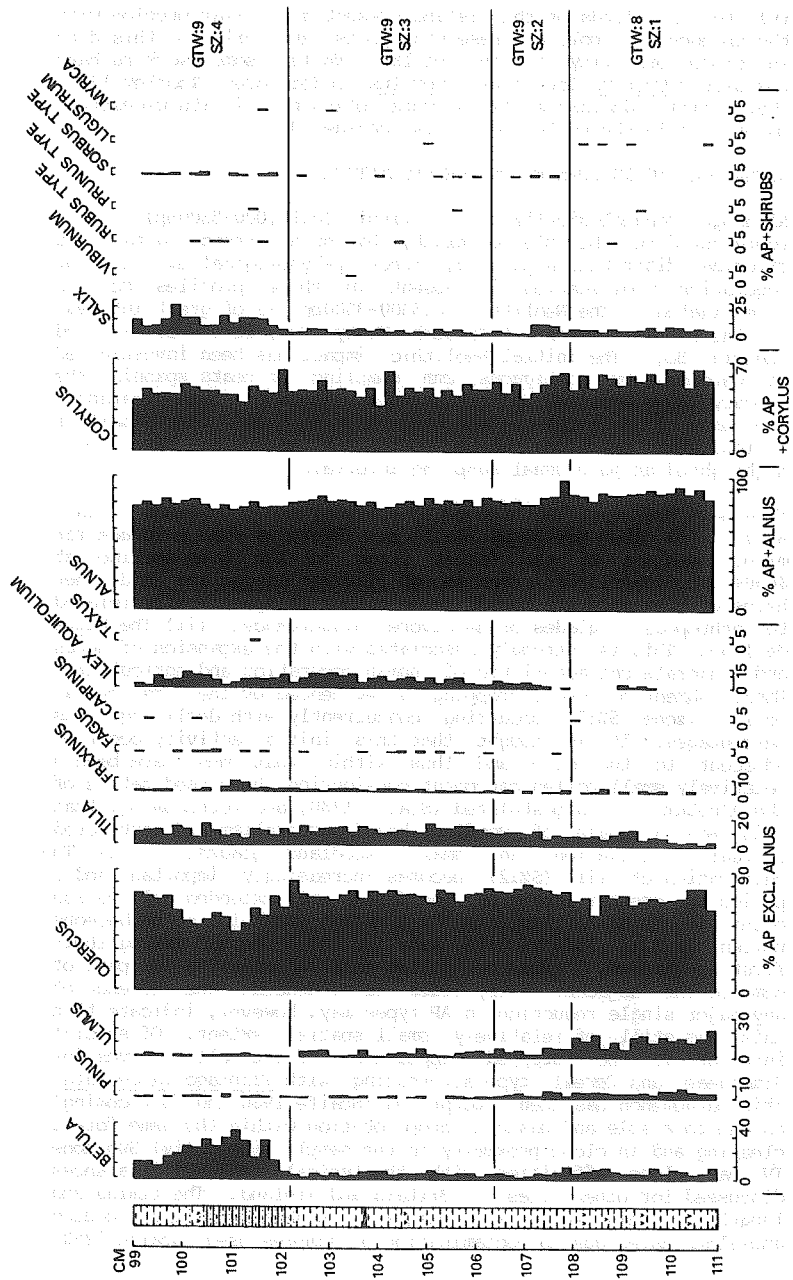
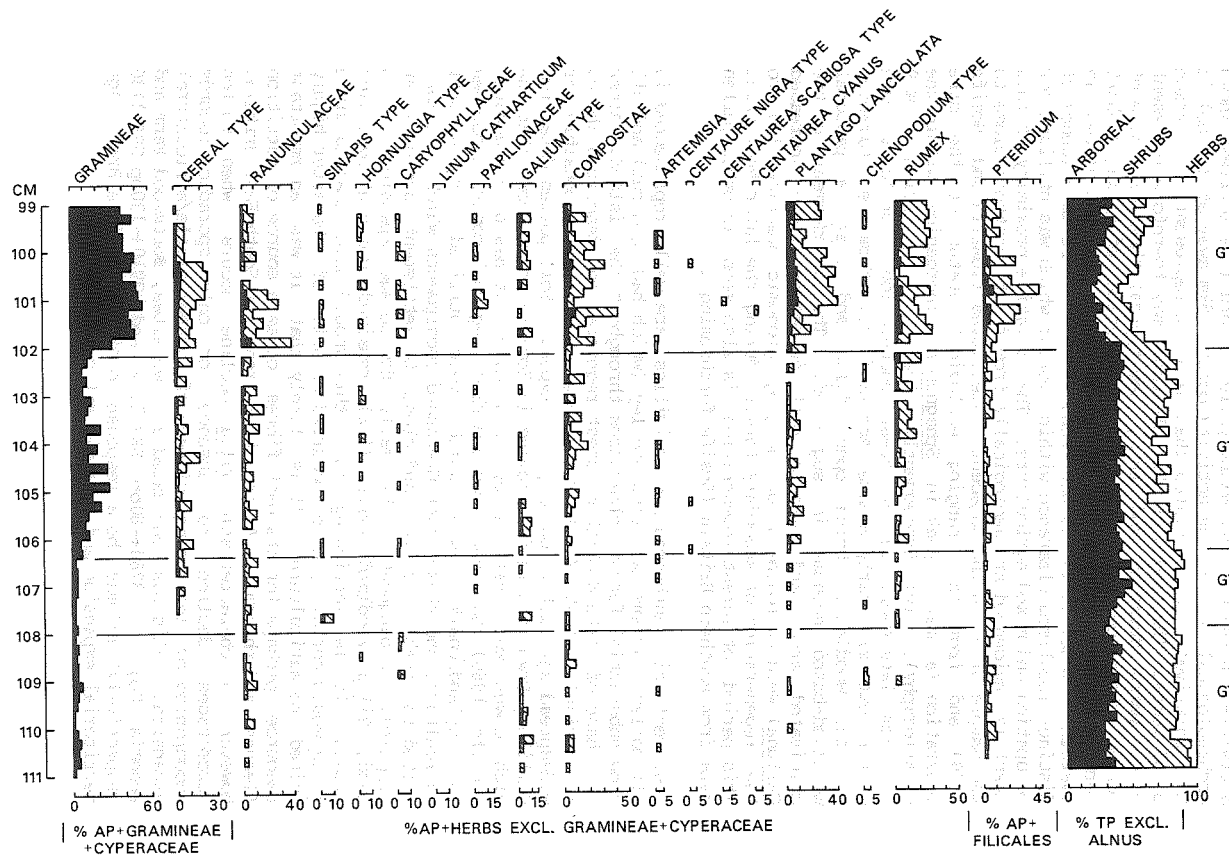


Figure 6 Gatcombe Withered Bed: pollen diagram 3; trees and shrubs

Figure 7 Gatcombe Withy Bed : pollen diagram; selected pollen types



33-38). From approximate calculations of peat accumulation from the Ulmus decline (4850±45 bp) and the evidence of Bronze Age activities in the Gatcombe Withy pollen record (the earliest known archaeological Bronze Age activity occurs 5km away at 3560bp) it may tentatively be postulated that each cm represents an average of 65 years. The length of the clearance may therefore represent c.200 years duration and thus, the typical threefold phase of forest clearance, agriculture and regeneration of a single short term shifting cultivation of 25-30 years as postulated in Iversen's model (1949) is not seen. Instead there is evidence of distinct localised clearance within forest which was utilised for occupation and mixed agriculture. The relative proximity of this event is evidenced archaeologically from flint scatters close to the sample site on the adjacent interfluvies (Tomalin and Scaife 1979) and from the changing ecological status of the mire vegetation (a marked peak in Sphagnum and inorganics within the stratigraphy). (v) Subsequently, there is a period (GTW:9 100-86cm; late Neolithic) of forest regeneration prior to evidence of more extensive early Bronze Age land use. From the character of the woodland, being open Tilia and Ilex, a pastoral woodland-based economy is suggested. The abandonment of the cultivated area and perhaps soil depletion (note increased Calluna) weed encroachment or changing agronomic practices led to the regeneration of secondary forest during the later Neolithic. This period of forest regeneration is also seen in other pollen data from southern Britain (Scaife forthcoming).

Post Neolithic anthropogenic activities are well represented in all pollen diagrams excepting Munsley (which had been cut) and all show substantial forest clearances throughout the island. After the phase of late Neolithic forest regeneration described above, the arrival of Beaker/Early Bronze Age economy was responsible for widespread agriculture on many soil types. Soil pollen data from Gallibury Down (Scaife forthcoming in Tomalin) have shown that the high downs were pasture by this date. It has been suggested (Scaife 1980) that there was a marked regional contrast between the upland/chalk downs which were utilised for pastoral agriculture, and those Lower Greensand escarpments which were more suited to arable activity and close to settlement and/or water supplies. Subsequent to this early Bronze Age expansion of open land, Tilia woodland (with Ilex) remained dominant over wide areas. It is intriguing that this should have remained since Tilia would certainly have occurred on soils of character highly suited to agriculture. It is likely that it was an important resource perhaps for its bast fibres or as a source of nutrition (leaves and phloem). As in other areas of South East Britain, however, a characteristic Tilia decline occurs when pollen percentages decline to absence or only sporadic records accompanied by increasing evidence of further arable/agricultural expansion. This has been dated at two sites, Borthwood Farm and Bohemia Bog (at 3280±80bp SRR-1434 and 2910±130bp SRR-1436 respectively) and may be a response to middle or late Bronze Age territorial expansion and agricultural consolidation.

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