POLLEN ANALYSIS AND RADIOCARBON DATING OF THE INTERTIDAL PEATS AT CALDICOT PILL

by Robert Scaife

This contribution deals with pollen analysis and radiocarbon dating of peat and sediment sequences occurring on the foreshore of the Bristol Channel at Caldicot Pill. This work formed part of a broader archaeological survey carried out by Cadw prior to the construction works of the Second Severn Crossing. These data have been previously presented in the archaeological report of Godbold and Turner (1993). However, only a few copies were produced for restricted distribution. Now that recently acquired radiocarbon dates are available it was thought desirable to make the results more widely available. This dating evidence also enables issues of sea-level change to be considered in the accompanying paper by Scaife and Long (p. 81). Other aspects of the archaeological evidence from intertidal areas of the Second Severn Crossing, relating particularly to Medieval fishtraps and other wooden structures, are reported in Godbold and Turner (1994).

The Severn Estuary can be regarded as the largest of the drowned river valleys or rias common particularly to South West England. The cause of marine inundation is intricately linked with Holocene changes in relative base levels; that is, a combination of eustatic changes initiated in response to climatic amelioration at the end of the last cold stage (the Devensian) and of local Neotectonic (crustal/geological) movements. The result has been the deposition of sediments and accumulation of peats representing the changing marine, brackish, freshwater and terrestrial environments of the last 10,000 years. Linked with these changes has been the human utilisation of the resource base offered by the predominantly ecotonal character of these environments. This combination of biostratigraphy, lithostratigraphy and archaeology prompted a number of past studies of the sometimes highly visible submerged peat beds which occur on both sides of the Bristol Channel and Severn Estuary region.

The Bristol Channel has had a long history of such studies starting with the first recognition of 'submerged forests' and peat beds exposed only during low tides. Risdon (1811) carried out perhaps the first such investigation relating to the now well studied Mesolithic midden site at Westward Ho!, North Devon. At this site, flint artefacts occurring under what were described as 'The Upper Peats' were found in 'Blue Clay' by Ellis (1866) and Bate (1866) and wooden stakes driven through these deposits (Hall 1870, 1879) marked the first association of archaeology with sediments in the Bristol Channel region. The submerged forest at this site has subsequently been analysed on many occasions (Rogers 1908; Churchill 1965; Rogers 1946; Balaam *et al.* 1987).

The potential of these sedimentary sequences for elucidating the history of sea level change was recognised by Clement Reid. In his seminal works on 'Submerged Forests' (1913) he discussed strata described by Dr. Strahan which were exposed during the excavation of the Barry Dock extension (Glamorgan) in 1895. This study is remarkable in its attention to the characterisation of the sediments, the plant, mollusc and archaeological assemblages (a Neolithic worked flint) and for noting the relationship of the differing lithologies to Ordnance Datum. His earliest conclusions stated:

'Whatever may have been the exact range of the tides in these early days, it seems that the Bristol Channel points to a subsidence in post-glacial times of about 60 feet-or just about the same amount as the Thames, Humber and Mersey'. (Reid 1913, 57)

He goes on to state, in a way which can hardly be bettered as an introduction to the value of such a study of the geology of the intertidal zone, that:

'Before leaving this locality (ie the Bristol Channel) it may be well to enquire what further light it sheds on the movement of submergence , and on its continuous or intermittent character. The succession of the strata above the lowest land-surface, and the nature of their enclosed fossils, suggest long continued but intermittent subsidence'. (Reid 1913, 57-8)

At Swansea, Sir Harry Godwin produced his now classic study (1940). At Westward Ho!, studies by Rogers (1946) and Churchill (1965) carried out the first systematic and detailed survey of sea-level change, intertidal archaeology and environment. Balaam *et al.* (1987) represents one of the more recent multidisciplinary studies of archaeology and environment again focusing on the Mesolithic midden site at Westward Ho!, a site which was being subject to severe erosion necessitating excavation and removal of much of the midden. This study was able to draw on the less detailed data obtained from other sites along the south side of the Bristol Channel at Porlock Weir, Blue Anchor Bay (Kerney 1976) and Minehead. From discussions above it will be evident that Westward Ho! has, in the past, been regarded as the prime Mesolithic site occurring in an intertidal zone (see Balaam *et al.* 1987) in the Bristol Channel region. Recent field work and studies on the north bank of the Bristol Channel and Severn Estuary have shown that Mesolithic activity occurs elsewhere along the intertidal zone and a number of important researches have been produced which illustrate this. At Uskmouth and Magor Pill, Aldhouse-Green *et al.* (1992) have discovered late Mesolithic human and animal footprints in intertidal sediments and have carried out multidisciplinary analyses including stratigraphical, pollen, plant macrofossil, foraminiferal and diatom studies. Radiocarbon assay places the archaeology and organic sediments in an absolute dating framework which allows correlation with other sites noted above. Uskmouth and that of Goldcliff some 4 km to the east (Smith and Morgan 1989) with a nearby Mesolithic site (Bell, p. 132) and particularly the nearby but more inland site at Vurlong Reen, Caldicot (Walker and James 1993) provide the most important comparative data with the environmental study undertaken at the site of the Second Severn Crossing at Caldicot Pill. Peat and associated sediments occurring on the foreshore at Caldicot Pill were sampled for pollen, diatoms and radiocarbon determination during archaeological survey prior to construction of the Second Severn Crossing. A total of 16 archaeological sites were recorded in the area of Caldicot Pill including well preserved timber alignments, hurdle structures and trackways (Godbold and Turner 1993). This contribution presents the results of pollen analysis and radiocarbon dating of two of the foreshore sections examined. Scaife and Long (this volume p. 81) have reassessed the evidence for sea-level change in the light of recently obtained radiocarbon dating of these two stratigraphical sequences.

Pollen sampling and methodology

Samples for pollen analysis were obtained in conjunction with the archaeological survey of S. Godbold. As a result of this survey it was decided

to sample two of the principal areas in which organic deposits were located (Figure 33).

Context 333-340 is representative of surface peat which is being eroded on the estuary foreshore. The possibility of truncation of the upper surface, and of disturbance and resulting contamination through biological activity, necessitated the location and sampling of organic deposits which are sealed by more recent sediments. Such an area was located at context Oscar 3 (Figure 33) where organic freshwater muds are overlain by marine silts. Monolith samples of 50 cm and 100 cm respectively were taken from slots dug at these two locations.

Stratigraphy: Context 333-340: Transect D1:

0-2 cm
Peat: highly humified, black, containing silt and horizontally bedded monocot. remains (*Phragmites*).
Some faunal channels present.

2-7 cm
Transition from grey silt below to organic above darker grey fine silt with ?clay. Some organic banding present.

7-20 cm
Grey silt and fine sand. Containing ?charcoal specks and some vertical monocot. roots. Horizontally bedded *Phragmites* present at 13 cm and 16 cm.

19-21 cm
Transition; gradual.

21-44 cm
Coarse and medium sand; buff colour containing occasional dark mineral specks and stones (27 cm). Wood and *Phragmites* noted at 35-36 cm.

44-49 cm
Buff sand containing stones to bottom of section.

?-49 cm
Basal gravels; coarse with sand interstices.

Stratigraphy: Oscar 3 profile:

0-7 cm
Grey marine silt and clay; some vertical root penetration. Darker organic lens between 4-5 cm.

7-10 cm
Light grey and brown organic silt. No visible plant structure.

10-32 cm
Organic; brown organic silts and clay; containing freshwater Mollusca. No visible plant structure.

32-51 cm
Grey clay/fine silt. Containing sporadic monocot. remains, rootlets and organic inclusions.

51-57 cm
Lighter brown, more organic; containing rounded pebbles to 2-3 cm (incl. white quartzite).

57-82 cm
Dark grey silt and clay with occasional black organic fragments (eg.57-58 cm).

100-82 cm Pale grey slightly browner silt (ie. more organic than above).

The above monoliths were extracted, sealed and transported to the laboratory where they were sampled for pollen and diatom studies (see Cameron in Godbold and Turner 1993 for results of the latter).

Pollen procedure

Samples of 1ml volume were prepared from a sampling interval ranging from 4 cm to 2 cm intervals in profile Oscar 3 and at a closer interval (1 cm) in the peats of context 333-340. Extreme care was taken to avoid areas of biological

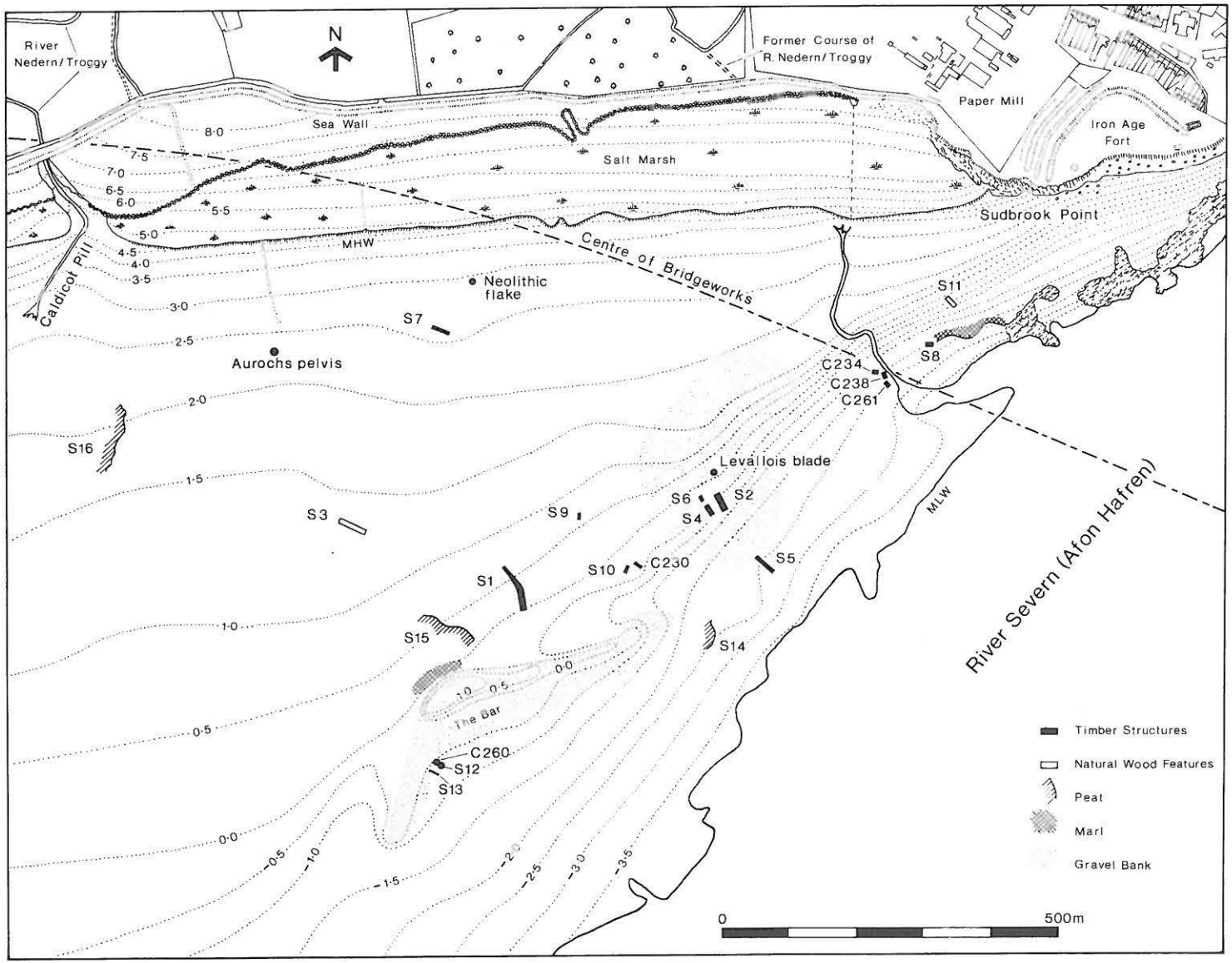

Figure 33. Second Severn Crossing survey area: showing location of pollen sites and archaeological contexts.

disturbance, that is, largely the channels of burrowing marine worms and molluscs. Standard procedures were used for extracting and concentrating the sub-fossil pollen and spores (Moore *et al.* 1991). Micromesh (10μ) sieving was also used to assist in the removal of the clay fraction. Absolute pollen frequencies have been calculated using the addition of known numbers of 'exotic' (Stockmarr *Lycopodium* tablets) grains to a measured sample volume. Pollen counting was carried out using an Olympus biological research microscope with phase contrast facility at magnifications of x400 and x1000. The pollen sum (count) varied according to the character of the sediment. Highest arboreal pollen frequency (APF) occurred in the freshwater organic and peat horizons. In marine silts and especially the lower horizons of monolith 333-340, APF values were markedly lower and the pollen sum was of necessity reduced. In the case of context 333-340, pollen was not present below 10 cm possibly due to higher alkalinity. Thus, the APF values of the former attain a maximum of 200-440,000 grains per ml. in the organic material but only 3000 grains per ml. in the lower, marine sediments.

In the pollen diagrams, pollen has been calculated as a percentage of dry land taxa where this can be determined. Marsh/swamp taxa are as a percentage of this total as are spores of ferns. In the inorganic sediments, large numbers of pre-Quaternary spores were recovered. These have been calculated separately as a percentage of the pollen sum (dry-land taxa). The pollen data are presented in diagram form and were plotted using *Tilia* Graph in the Quaternary Environmental Change Research Centre, Department of Geography, University of Southampton.

Vegetation and environment of the Caldicot Pill sediments

Two pollen sequences have been analysed. These profiles exhibit stratigraphical changes noted above and palynological variations which have been assigned pollen zones. These zones are CP1 for Oscar 3 and CP2 for context 333-340. These pollen zones are characterised below. It should be noted that the relative percentages and proportions of pollen taxa described in this section do not necessarily infer the absolute dominance of a taxon since (as for example in the case of *Pinus*), pollen production, dispersal and taphonomic factors may have an overwhelming importance in the interpretation of the pollen spectra.

OSCAR 3 : (Figure 34)

CP1:1 98-84 cm: Basal zone broadly corresponding with the basal lithostratigraphic unit recognised. Dominated by *Quercus, Pinus, Alnus, Corylus* and Gramineae. The zone is characterised by higher values of *Alnus* and Gramineae than in subsequent zones. Arboreal pollen are dominated by *Quercus* (av. 28%), *Pinus* (to 15%) and *Alnus* (to 18%), with *Ulmus* and *Tilia* and sporadic occurrences of *Fraxinus* and *Betula.* Shrubs comprise predominantly *Corylus* type (12%). Herb diversity is low with Gramineae (45% at base of profile). *Chenopodium* type and Cyperaceae (24%) are the principal taxa. Spores of ferns are *Pteridium aquilinum,* (10%), *Dryopteris* type (to 11%) and *Polypodium*. Pre-Quaternary/derived spores are abundant.

CP1:2 84-50 cm: Characterised by increases in *Ulmus* (to 8%), *Betula* , *Corylus* type and *Chenopodium* type. *Quercus, Pinus* and *Ulmus* are the dominant AP taxa with relatively low

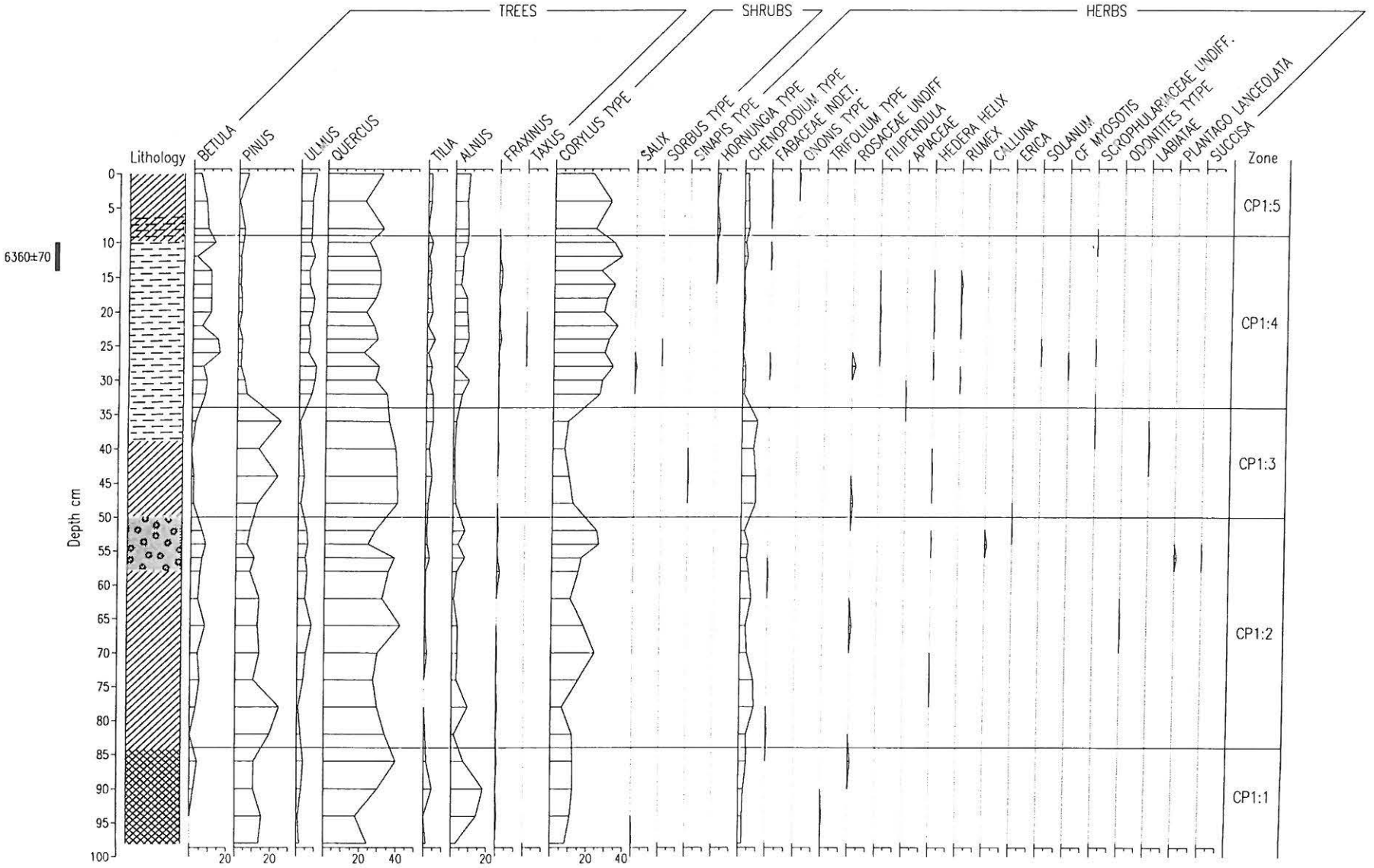

Figure 34a. Caldicot Pill: Oscar 3 pollen diagram (for continuation see Figure 34b).

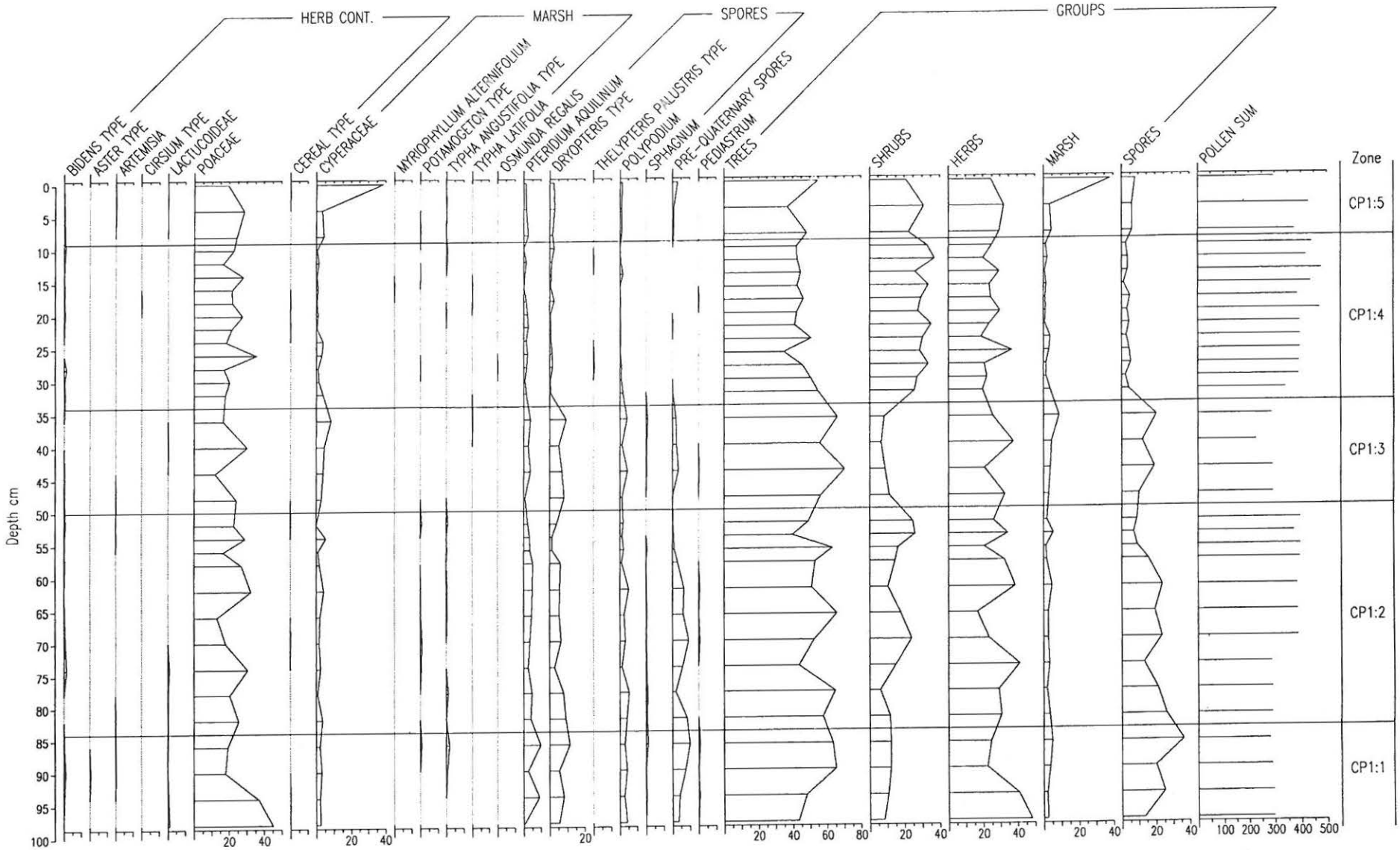

Figure 34b. Caldicot Pill: Oscar 3 pollen diagram (continued from Figure 34a).

values of *Betula, Tilia* and *Fraxinus* present. *Corylus* values increase to a maximum of 25% in a peak between 50-60 cm. This peak, and a lesser increase in *Alnus,* corresponds with a horizon of increased organic content which contained stones to 2 cm size. Herbs continue to be dominated by Gramineae (to 31%) with *Chenopodium* (8%), values of the latter reaching a peak at 74 cm. Spores remain dominated by *Pteridium, Dryopteris* type and *Polypodium* also with large numbers of derived pre-Quaternary spores which decline to low values between 50-60 cm corresponding with this more organic stratigraphical phase. This may be regarded as a pollen assemblage sub-zone.

CP1:3 50-34 cm: There is a relative/percentage decline in pollen of *Betula* (1%), *Ulmus* (max. 3%) and *Corylus* type (av.9%) to lowest values in this sequence. Correspondingly, there is an increase in *Pinus* (25%), *Tilia* (4%), *Chenopodium* (9%) and Cyperaceae (8%). *Quercus* remains the dominant arboreal taxon (40%) with *Pinus* (23%). Apart from the increased importance of *Chenopodium* type and Cyperaceae, herbaceous taxa remain constant from the preceding zone.

CP1:4 34-10 cm: This zone is lithologically diagnostic comprising an organic freshwater mud containing some freshwater molluscs. A radiocarbon measurement was made on the upper 4 cm of this sedimentary unit (10-14 cm) which produced an assay of 6360±70 BP (Beta-79887). Palynologically the zone is characterised by marked expansions of *Ulmus* (9%), *Alnus* (8%), and especially *Corylus* (to 35%). There are also minor expansions/increases in *Betula* and *Fraxinus.* In contrast *Pinus* and *Chenopodium* values decline markedly. Arboreal pollen remains dominated by *Quercus* (30%) with *Ulmus* (9%), *Alnus* (8%) and *Corylus type* (37%), *Tilia* (4%), *Fraxinus* (1%) and sporadic occurrences of *Taxus* and *Salix* are of note. With decline of *Chenopodium* type pollen, Gramineae is the dominant herb (to 28%). Overall there is a notable decline in spores of ferns (*Pteridium, Dryopteris* type and *Polypodium*) and of derived pre-Quaternary spores which are absent throughout.

CP1:5 10-0 cm: Stratigraphical change to marine silts from the organic mud of the preceding zone. The zone is characterised by increased percentage of *Chenopodium* type (3%), Cyperaceae (39% in the upper level) Cruciferae/*Hornungia* type and the re-introduction of derived pre-Quaternary spores.

CONTEXT 333-340 (Figure 35)

Pollen preservation in this shorter profile differed very markedly from that in the Oscar 3 profile where pollen (above) was recovered from 100 cm of sediment. In this 50 cm profile, pollen was only recovered from the upper 10 cm. Absolute pollen frequencies attain values from 155-441,000 grains per ml; that is, in the peat which outcrops on the foreshore surface. This declines to very low values below 10 cm to a point which made pollen counting impractical. This marked variation in pollen preservation may be due to differing palaeodepositional environments. During pollen extraction marked differences in pH values of the inorganic sediments were noted and some samples were highly calcareous.

Three pollen assemblage zones have been recognised in this short sequence. These are characterised as follows:

CP2:1 10-5 cm: Stratigraphically this pollen zone occurs in the first part of the sedimentary transition between the grey silts/fine sand and the upper humified peat (see stratigraphy above). Absolute pollen frequencies are low.

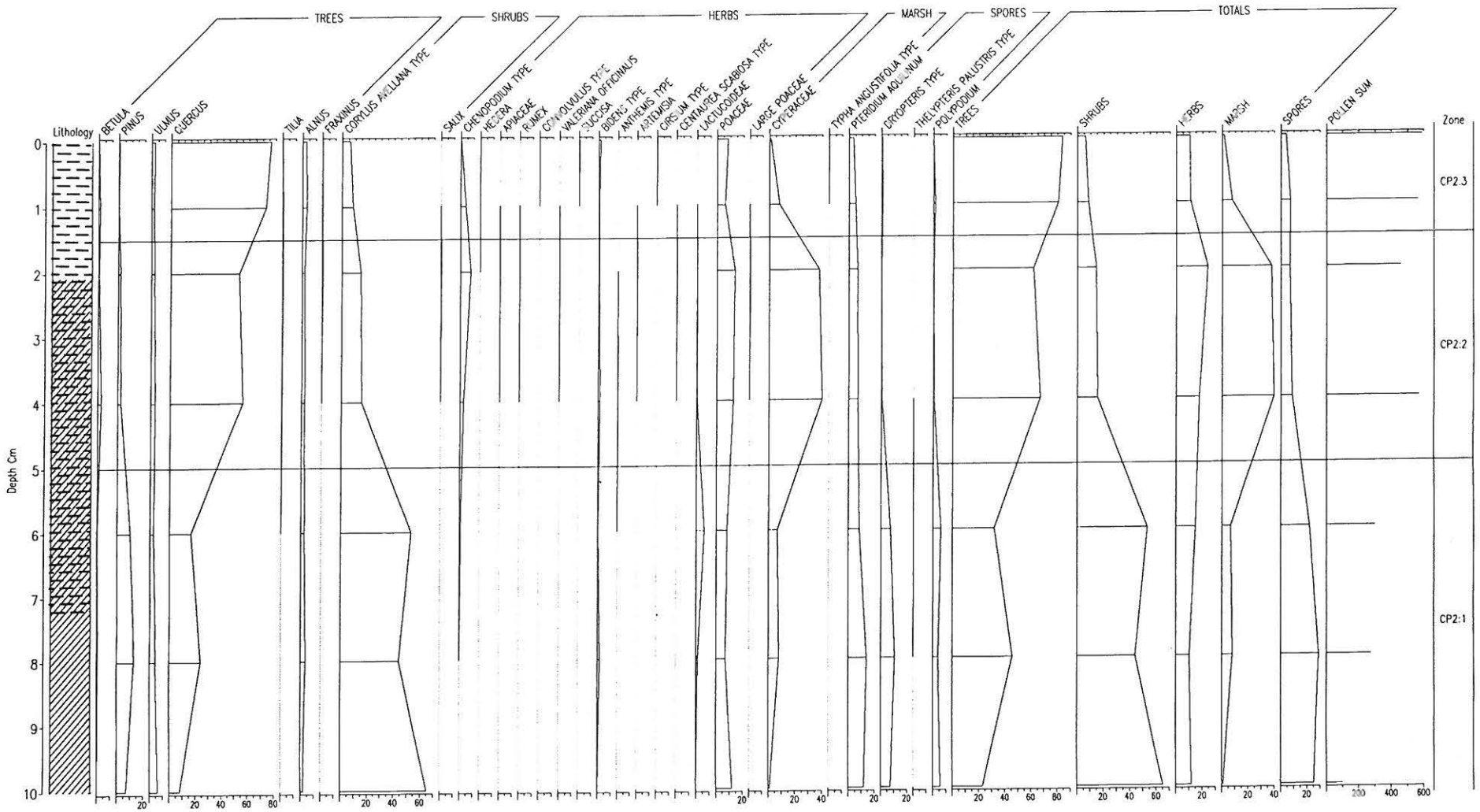

Figure 35. Caldicot Pill: pollen diagrams from context 333-340.

Palynologically the zone is characterised by dominance of *Corylus* type (to 65%) and higher values of *Pinus* (13%) than in subsequent horizons. *Betula, Ulmus* and *Alnus* are present (<6%). Pollen of herbs is sparse and with little taxonomic diversity. Gramineae (to 12%), Cyperaceae (9%) and Liguliflorae (to 6%) are the principal taxa. Spores of ferns are important with *Pteridium aquilinum* (20%), *Dryopteris* type (15%) and *Polypodium* (8%).

CP2:2 5-1.5 cm: This pollen assemblage zone (2 levels) occurs in the upper part of the sedimentary transition from grey ?marine sediment below to humified peat above. Absolute pollen frequencies attain 441,000 grains per ml. This zone is characterised by increasing percentages of *Quercus*, a marked peak of Cyperaceae (66%) and reductions in *Pinus* and in spores of *Dryopteris* type and *Polypodium*. Arboreal pollen is dominated by *Quercus* with small numbers of *Betula, Ulmus* and *Alnus*. *Pteridium* remains important from the preceding zone and is dominant. Excluding Cyperaceae, herbs are few and with little taxonomic diversity; Gramineae (13%), *Chenopodium* type (3%).

CP2:3 1.5-0 cm: This uppermost pollen zone of the unit correlates with the change to dark highly humified fen peat. A radiocarbon assay of 6660±80 BP (Beta-79886) was obtained from the top 1cm of this peat. *Quercus* reaches its highest values and is the dominant arboreal taxon (76%). Also present are low percentages of *Betula, Pinus, Ulmus, Tilia* and *Fraxinus*, all at less than 5% TP. *Corylus* type declines to 6% at the top of the zone/diagram. Herbs show some increase in diversity but remain subordinate to arboreal and shrub pollen. Cyperaceae declines markedly from the preceding zone.

The changing vegetation environment

Of the two pollen profiles, Oscar 3 provides a longer temporal sequence. As noted above, this is due to the poorer preservation in context 333-340. Both show a transition from marine to freshwater or brackish reed swamp environment. The two sequences provide information on the local variations in vegetation and depositional environment and supply evidence of the complexity of the local depositional environment.

Pollen spectra from alluvial and marine sediments may present a number of interpretative problems. Taphonomically, alluvial and marine sediments may contain pollen which is predominantly allochthonous and derived from one or more environments away from the depositional site. Furthermore, pollen may be reworked within the alluvial and marine sediments themselves. This can result from erosion of sediments which may also give hiatuses in the depositional sequence. These factors are in addition to the 'normal' factors of differential pollen production and dispersion which have to be considered in the interpretation of more typical pollen analyses of peat mires and inland lake sediments. Superimposed on these, there may also be considerable quantities of pollen derived from halophytic plants such as Chenopodiaceae (*Atriplex, Chenopodium* and *Salicornia* spp.)

The vegetational and depositional environment

The 1 m of sediments of section Oscar 3 have been studied in conjunction with diatom analysis (Cameron in Godbold and Turner 1993). Along with pollen analysis, these illustrate a progressive change from marine, salt marsh conditions through to freshwater and fen environments and subsequently a return to the marine conditions which

pertain today. Changes in the lithostratigraphy may indicate that there have been changes in the sedimentary input from marine and riverine sources and that there may also be depositional hiatuses present.

Radiocarbon dates not available in the original presentation (Scaife in Godbold and Turner 1993) have now been obtained for the organic horizons in both sections described above. Comparison can thus be made with other dated sedimentary sequences in this region such as Goldcliff (Smith and Morgan 1989), Uskmouth (Aldhouse-Green *et al.* 1992) and especially at Vurlong Reen, Caldicot (Walker and James 1993). In addition to dates obtained for the peat and organic mud, two dates have also been obtained from wood relating to the latter stages of peat developing in fen carr. Wood from site 3, the submerged forest, produced an assay of 5760±70 BP (Beta-54827) and *Alnus* root growing in an ice wedge cast in the substrate has been dated at 6040±70BP (Beta-54829). These dates are comparable with wood peat dates of 5810±80 BP (OxA-2628) at Uskmouth (Aldhouse-Green *et al.* 1992) and at Goldcliff of 5850±80 BP (CAR-658). The organic peat deposits of context 333-340 and freshwater muds of Oscar 3 (above) date to the mid-Holocene (Atlantic; Godwin pollen zone VIIa) with radiocarbon dates of 6660±80 BP (Beta-79886) and 63360±70 BP (Beta-79887) (uncorrected) respectively. Marine sediments underlying these organic deposits thus pre-date this phase and are referable to the early Atlantic or perhaps Boreal periods.

As suspected in earlier work (Scaife in Godbold and Turner 1993), the organic horizons studied here are comparable with the dated timbers of the submerged forest. The latter are, however, slightly younger in age and represent the final stages of fen carr woodland prior to marine inundation. It appears, therefore, that the major spread of organic deposits at, or near, low water mark at Caldicot Pill are comparable with the 'Lower peats' described at Uskmouth. Barham (pers. comm.), examining the stratigraphical relationship of the peat and sediments, has suggested that two distinct organic sequences may be present at Caldicot Pill. It is possible that a second organic sequence occurring nearer the foreshore may be contemporaneous with the 'Upper peat' at Uskmouth.

Pollen zone CP1:1, the earliest data available, reflects the broad textural differences of these sediments compared with the overlying zone. Pollen spectra in this zone provide evidence of deciduous and possibly coniferous woodland. *Quercus*, and *Ulmus* are dominant but with elements of *Tilia* and *Fraxinus* also present. The latter are frequently under-represented in pollen spectra because of their lesser pollen production and entomophily (Andersen 1970,1973). Therefore, these taxa may be regarded as of greater importance than their absolute numbers would suggest. This arboreal assemblage provides evidence of mixed deciduous woodland comprising of these taxa with *Corylus* understorey growing on adjacent land areas close to the coastline or in the fluvial catchments of rivers discharging into this estuary. The high absolute values of fern spores are typical of fluvially derived sediments (Peck 1973) where sediments eroded from river catchments may have orders of magnitude greater spore content. A small number of freshwater aquatic (*Potamogeton*, *Myriophyllum alternifolium*) and marginal aquatics (*Typha angustifolia/Sparganium* type) and the algae *Pediastrum* are also possibly derived from fluvial input from freshwater sources. Relatively high percentage values of *Alnus*, although not high enough to suggest local dominance on the site, may be referable to growth in carr woodland similarly in river valleys discharging into the estuary or from growth along the

wetter foreshore or in lagoonal situations.

Sedimentologically and from diatom studies (Cameron in Godbold and Turner 1993), it is clear that the variable grey clays lying below the organic muds of pollen assemblage zone CP2:1 are of marine origin and the environment of deposition may be envisaged as one of estuarine salt marshes. This is reflected by the presence of *Chenopodium* type in this and subsequent zones. It must, however, be noted that pollen morphologically, *Chenopodium* type contains all taxa of the Chenopodiaceae including terrestrial taxa and it is only by interdisciplinary analyses that this pollen taxon may be referred to the salt marsh environment. Other taxa typical of this habitat are largely absent with no Plumbaginaceae (*Armeria* and *Limonium*) and Cruciferae. However, the continuous but relatively low values of *Aster* type (probably *Aster tripolium*) and Gramineae are representatives of halophytic communities. The category of large Gramineae (>45μ) are similarly typical of some halophytic grasses (eg. *Elymus* spp.).

Pinus forms an important constituent of the arboreal assemblage in pollen assemblage zones CP1:1-3 and CP2:1. This is probably over-represented because of its great pollen production and anemophily and also from its generally recognised over-representation in marine sediments due to its buoyancy. *Pinus* may, however, have been a constituent of the flora although due to long distance transport capability this may have been at some distance. The presence of *Pinus* during the early and middle Holocene (Flandrian chronozones I and II) of south and central Wales has been discussed at a number of sites (Walker 1982). The data here, are commensurate since the presence of *Tilia* to the base of the sequence suggests an Atlantic date (Flandrian chronozone II date) for CP:1. *Tilia* of this age is also seen in the work of Walker and James (1993) at Vurlong Reen on the landward (north) side of Caldicot.

Variations in the stratigraphy and colour of the pre-organic sediments and varying degrees of organic content reflect differing phases of sediment inwash and stabilisation of the salt marsh environment by halophytic vegetation communities. As noted above, transition between litho-stratigraphic units may represent hiatuses of indeterminable temporal extent. Conversely phases of accelerated sedimentation may also be present here, as evidenced by coarser material deposited during high energy regimes. For example, Oscar 3, 51-57 cm contains more organic debris and larger stones/pebbles. This is accompanied palynologically by higher APF values of *Corylus* type, *Alnus* and possibly Gramineae and Cyperaceae. This may be interpreted as either a phase of stabilisation and colonisation by woodland or due to a period of higher fluvial discharge from inland which contained allochthonous organics and sediment. The latter is corroborated by the continued preponderance of marine diatoms (Cameron pers. comm.). This pollen zone assemblage (CP1:2.i) contains higher percentages of organic material caused by soil erosion and transport of soils from the river(s) catchment(s) containing the pollen taxa noted above.

Subsequently (pollen assemblage zone CP1:3) there is a return to grey marine sediments in which there is a decrease in the amounts of deciduous tree pollen taxa. *Pinus*, however, increases which again indicates higher representation through marine buoyancy influence/effects. *Chenopodium* type is similarly attributed to this and indicative of the salt marsh conditions which prevailed at this site. This phase correlates with sediments immediately underlying pollen assemblage zone CP2:3 and from which the transitional zone CP2:3

into CP2:2 occurs (context 333-340). During this phase there is the start of progressive colonisation by reed swamp evidenced by interbedded *Phragmites* in sediments of pollen assemblage zones CP1:3, CP2:1.

The two pollen sequences examined show variations in the local wetland ecology (pollen assemblage zones CP1:4, CP2:2/3). This ranges from a freshwater community at site Oscar 3 which laid down organic muds, similarly evidenced by the diatom study of Cameron (in Godbold and Turner 1993), and the presence of freshwater molluscs (*Planorbis* and *Lymnaea*) to a drier reed swamp (*Phragmites* and Cyperaceae) with possibly very local/on-site growth of *Quercus* and *Corylus* woodland at context 233-240. In the former, however, the pollen spectra of the freshwater muds show woodland comprising dominant *Quercus* and *Corylus* but with increased importance of *Betula, Ulmus, Tilia* and *Alnus* over preceding zones. This is perhaps a reflection of two taphonomic factors. Firstly, it is likely that the airborne pollen rain to this more open freshwater habitat may have been from greater distances and from better drained soils/areas more compatible with growth of these taxa. *Tilia* and *Fraxinus* especially, require well drained soils and may thus be regarded as elements of the woodland growing away from the low lying mire areas. Furthermore, both taxa are under-represented in pollen spectra through their entomophily and small pollen production further suggesting that these were important constituents of the woodland flora. Secondly, the freshwater sediments may contain a substantial proportion of allochthonous pollen grains transported fluvially from inland catchments with a possible time-lag in their production and final deposition in the sediments. This will also have resulted in an admixture of the 'terrestrial' pollen types and those taxa growing close to the freshwater pool. The process is similar to the preceding zone of marine deposition of sediments containing pollen derived from river systems flowing into the Severn Estuary. In this latter case, however, there also occurs pollen of salt marsh halophytes.

In the drier, peat-forming environment of context 233-240, there occurred a significant local vegetation succession. Pollen zones CP2:1 to CP2:3 illustrate a progressive change from marine salt marsh through (*Phragmites*) reed swamp to sedge fen and ultimately dominant oak woodland. Such changes must be viewed spatially as well as temporally with dynamic/colonising vegetation producing asynchroneity in the fossil pollen and plant macro record. Multiple pollen profiles would be needed to illustrate such progressive colonisation, but it is likely that transition from marine salt marsh to freshwater fen carr occurred diachronously depending on local topography and water table. The single profile (333-340) exhibits one geographical point on this colonisation of the progressively exposed area of the foreshore. Although marine conditions existed in CP2:1, *Corylus* formed an important constituent of the flora and it is possible that this represents a phase of hazel scrub colonisation of areas nearby subsequent to removal of marine influence. In CP2:2, Cyperaceae reflect damp to wet but less marine conditions at the site. Continued reduction of the base levels and establishment of woodland resulted in the dominant *Quercus* woodland with a hazel understorey; although percentages of the latter are reduced in the upper zone CP2:3, this may reflect reduced flowering in shaded woodland conditions.

The conclusion is that on removal of marine influence during the early to middle of Flandrian chronozone II, the region of Caldicot Pill underwent a series of vegetation changes resulting in a range of freshwater and peat forming habitats. These changes were

likely to have been asynchronous depending on local topographical conditions but resulted in freshwater aquatic, marginal aquatic vegetation and damp oak/hazel fen carr woodland. Radiocarbon assay of the organic lake muds and fen carr peats places these developments firmly in the Atlantic period/Chronozone II period. This variation is further evidenced when compared with similarly dated sequences along the Bristol Channel/Severn Estuary which also show evidence at this time of alder and willow carr woodland in similar contexts (eg. Minehead). The last stage of damp oak woodland development produced the typical 'submerged forests' comprising oak root stools and trunks which were killed as a result of marine inundation at *c.* 5760 BP.

Archaeological implications of the vegetation sequences

It will be apparent from the above discussion of the vegetation and radiocarbon dating that we are here dealing with a time span embracing the earlier and middle Holocene; that is the later part of Flandrian chronozone I and chronozone II (late Boreal and Atlantic). This therefore embodies the later Mesolithic period. The distribution and abundance of Mesolithic sites in coastal locations attest to the traditional view that the coastal zone and hinterland afforded an ideal environment for the hunting and gathering subsistence of this culture. The Severn Estuary typifies this with a diverse range of near terrestrial woodland, freshwater, marine and ecotonal habitats suited to utilisation of a varied resource base including hunting, fishing and exploitation of wild plants. As might be expected from such ephemeral exploitation of the environment, there is no evidence in this study for the impact of such activities on/in the environment. This study, does, however, provide an insight into environment and the diverse ecotypes available in the Mesolithic.

The date of final marine inundation of *c.* 5760 BP at Caldicot Pill precedes the generally accepted first appearance of the Neolithic and associated economy of domesticated plants and animals and the 'typical' *Ulmus* decline at *c.* 5000 BP. Consequently, there is no pollen evidence in the sites analysed here for this period. However, studies of peats at higher levels OD at Stoop Hill, Caldicot (Walker *et al.* 1991) and Vurlong Reen (Walker and James 1993) found at a higher level Ordnance Datum appear to be of later date and do contain archaeological and environmental evidnce for later prehistoric environment and occupation of this region.

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