AEA: Allen Environmental Archaeology
Redroof, Green Road, Codford St. Peter, WARMINSTER, Wiltshire, BA12 0NW (Tel: 07828 103454)

The environment of a Neolithic palaeochannel and the sediment history of the Torridge at New Road, Bideford, Devon

by Michael J. Allen, Nigel Cameron, Alan J. Clapham and Rob Scaife

TABLES

FIGURES

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Abstract

Geoarchaeological and palaeo-environmental assessment, limited diatom analysis and radiocarbon dating was undertaken from sediments recovered from a 7 meter deep borehole (+0.52 to -6.48m OD) on the foreshore of the River River Torridge, Bideford, off New Road south of Longbridge, Bideford. The sediment sequence was predominantly sands and gravels over sands and silts, the latter containing waterlogged plants, fine woody fragments and dating to the Late Neolithic. Palaeo-environmental information (pollen, diatoms, wood, and waterlogged plants) provided a history of changing environments from a now buried forest/alder carr to more open conditions, and of a change from marine deposition to littoral or sub-littoral deposition. Although boreholes are not the ideal method for recovering archaeological evidence and indicating the presence of human activity, the geoarchaeological and palaeo-environmental record seem to indicate little human disturbance and activity, however fine unidentifiable charcoal fragments were present.

Geoarchaeological and palaeo-environmental assessment was undertaken from sediments recovered from a borehole on margins of the River Torridge below, and in advance of, the construction of the New Road Cantilver Walkway, immediately south of Bideford Longbridge and opposite Tantons Hotel (Figs 1 and A3.2). Geotecnhical boreholes by Frederick Sherrell Ltd, on behalf of Devon County Council (BH19 and BH20) had indicated depths of 9.20m and 11.80m to rock head and comprising predominantly sandy and gravel facies.This report provides the geoarchaeological sequence and information from the assessment of the pollen, waterlogged plant remain and molluscs, with full diatom analysis and radiocarbon dating of the basal waterlogged deposits (unit 3d) forming in a Neolithic alder carr (Allen 2011; 2012).

Location, Topography and Geology

Coring was undertaken on the tidal margins of the River Torridge (SS 4544 2643), through the deep alluvial deposits (9-11m) which overlie shales though which the river Torridge cuts at this point. The location was just south and upstream of Bideford Longbridge off New Road (Fig. 1). Sheet piling to the rockhead by the contractors revealed the profile of the rockhead and indicated apalaeo-valley and former tributary to the Torridge whose course ran beneath Tantons Hotel (Fig. 1). Access to the foreshore was provided via rock armour laid by the developers (Fig. 2).

Archaeological and Palaeo-environmental Background

Alluvial sequences can be long and stratified sediment sequences which have the potential of containing long histories of land-use and environmental change (cf. Needham & Macklin 1992; Howard *et al.* 2003), such as those seen locally in the Taw valley at Barnstaple (Allen *et al.* 2004). Such deposits have the potential to blanket, seal and contain evidence of former human activity that may not necessarily be directly related to the river. Evidence of former activity and of buried land surfaces may be encountered, which provide the opportunity to examine and interpret human activity and use of the area in former different environments.

Geotechical coring undertaken as a part of the development by Frederick Sherrell Ltd, on behalf of Devon County Council, indicated the presence of between *c.* 9m and 11m of alluvium over the rockhead, the majority of which was sand and gravel facies. No stratified peat or organic deposits were present, but in one borehole (B19), a firm green and grey laminated organic sandy clay silt was present just above the shale.

The construction of the cantilever walkway provided the opportunity to examine the long sediment sequences and provide an indication of the development of the Torridge waterway and nature of the prehistoric environment and changing local environments. These data can be related to the potential for human activity. Although Mesolithic artefacts were recorded from the river bed downstream during construction of the Bideford New Bridge in 1985, and several hulks are known to survive along the river, the minimally intrusive work were not aimed at locating archaeological artefacts, but may indicate human evidence via proxy palaeo-environmental data.

Fieldwork Methods

A borehole located within the centre of the possible palaeochannel, as crudely defined by the sheet piling profile (see above and figure 2), was cored, recorded and sediments retrieved. Coring was undertaken on 31st May 2011 by GeoDrive using a Tracked Window Sampling Rig operating a petrol-driven percussion hammer driving a window sampler and windowless sampling tube (Figs 2 and 3) of 80mm diameter under geoarchaeological supervision. Sediments were logged in the field and undisturbed sediments were retrieved in sleeved cores and removed for more detailed recording and subsampling – see borehole record.

Coring was conducted below the developer's rock armour (Fig. 2) to a depth 7m (-6.48m OD) beyond which coring and sediment retrieval was not possible. Coring was difficult where medium and coarse gravels were encountered, and almost beyond the capability of the rig. Where medium and coarse gravels were present these were logged in the field and were largely not recovered in undisturbed cores. The upper 3m were cored and recorded in the field. Sleeved cores were recovered from 3m (-2.48m OD) to 4m (-3.48m OD), and then from 5m (-4.48m OD) to 7m (-6.48m OD). A full record of 7m of sediments were logged and 79 subsamples samples removed for palaeo-environmental assessment and analyses

Sediment record

Sediments recovered in window samples in the field were described and recorded *in situ* following terminology outlined by Hodgson (1976) and sleeved cores were removed to laboratory facilities and cut open. Following careful and judicious cleaning of both faces, full descriptions were be made of moist sediments. Particular attention was be paid to presence of stasis horizons (*in situ* pedogenesis), erosion faces and of anthropogenic activity and artefacts. The sediments were also examined under illuminated magnification. Munsell colours recorded moist in daylight conditions.

Although the shale rock head had not been reached, 0.4m of bedded organic clays were recorded as the basal deposits in the geotechnical cores (Fedrick Sherrell 2003, BH 19 and BH20) over loose sand above the shale, and similar bedded organic deposits were recovered during our and thus it was deemed that the sequence recovered here was nearly a full sequence. The sediment record is given in detail (see borehole record), and the profile summarised below. Overall the sequence can be seen to comprise 3 main units

Unit 1: <u>Sand and gravel facies (0-475cm)</u>: Predominantly medium sands with lenses of medium rounded gravels

Unit 2: <u>Sand, fine gravel and silt facies (476-552cm)</u>: Darker sands and gravels with a silt band

Unit 3: <u>Sands and humic silts (552-700+cm)</u>; sands with fine silt laminations over firm silt with woody fragments

Unit 4: <u>Shale Rockhead:</u> Not reached but by comparison with BH 19 which contained 0.4m of grey laminated clay over 0.7m of loose sand above the shale, it was deemed that most of unit three had been recovered and the sand above the rockhead was likely to be not much further.

Radiocarbon Dating

During the examination for the cores, the sediments were examined under illuminated magnification and examined for suitable waterlogged wood or plant matter. No fine herbaceous (i.e. *Phragmites*) plant mater was observed but short-lived twiggy wood fragments were recovered from unit 3d (local alder carr conditions) at 655.5cm and 665cm (both alder) and 672cm (willow). These woody fragments are in keeping with the pollen and waterlogged plant remain assessment of alder carr, willow and trees locally. In addition woody fragments were recorded in the waterlogged plant remains from unit 3b/c (at 640-655) and unit 3d (655-670cm, 670-685cm and 685-700cm). Although short-lived roundwood fragments are present in the bulk samples they plant remains are less precisely located in the sequences. Charcoal is also present; however it is too small to identify and has washed in so could be residual and will not date the sediment deposition with any certitude.

Of the three suitable fragments recovered, all were alder twigs or short-lived willow wood fragments. One lay at the top of the unit (at 655.5cm, -6.035m OD) and the lowest fragment recovered (at 672cm, -6.20m OD) lay in about the middle of this unit. There was nothing available to date the base of the cored profile, which itself was not the base of the sediments. These two samples were submitted for AMS radiocarbon dating and the results are given in table 1, and as probability distributions in figure 4.

The results indicate a rapidly accumulating deposit in the mid to late second millennium BC, i.e. late Neolithic (Fig. 4).

PALAEO-ENVIRONMENTAL ASSESSMENT and ANALYSES

Sampling

The core was fully sampled for pollen at 10m bandwidths and at 8cm intervals through sandy and gravel facies and reducing to 4cm intervals through fine-grained deposits, and diatoms with samples of 10mm band width at 16cm intervals through sandy and gravel facies and 8cm intervals through the fine-grained deposits (see borehole record). A total of 59 subsamples were taken (Allen 2011). Three pieces of plant matter were taken for radiocarbon dating (see above) two of which were dated. The remainder of sediment retained in the sleeved samples was wholly removed as 14 larger contiguous bulk disturbed samples for processing for waterlogged plant remains and molluscs.

Disturbed bulk samples

Fourteen small (0.45-0.9L) bulk disturbed samples of the cored sediment sequence were removed and processed to recover molluscs (marine, fresh/brackish-water and terrestrial), and waterlogged plant remains and wood. The volume of processed sample was recorded and the samples soaked in warm water and stirred and agitated. Samples were processed by laboratory wash-over flotation and the flots retained on 300µm mesh, and where flots were larger the flots were retained on 300µm and 2mm mesh sieves (see Table 2). These methods are comparable to standard processes for the recovery of shells (Evans 1972), and waterlogged plant remains. The size of the flots (Table 2) provide a crude indication of the presence and volume of waterlogged remains.

Analyses

A programme of pollen, diatom and waterlogged plant remain assessment was conducted, although an full analytical programme was recommended by the authors, only the analysis of three basal diatom samples and the two radiocarbon dates were funded. Nevertheless, the assessment and limited analysis provides an important record of the Neolithic environment and hydrology of the Torridge.

Assessment of Pollen

Rob Scaife (University of Southampton)

A series of 39 pollen sub-samples were taken and 16 were selected for assessment of their sub-fossil pollen and spores content. These would provide useful information on the on-site, local and more regional vegetation and the changing depositional environment. The latter was highlighted as of importance in relation to establishing the freshwater and/or marine origin of the sediments. Pollen was recovered in sufficient quantity from 13 of 16 samples and some preliminary data on the above aspects of the palaeo-environment have been obtained.

Pollen Method

Standard techniques for pollen concentration of the sub-fossil pollen and spores were used on these sub-samples of 1.5 ml. volume (Moore & Webb 1978; Moore *et al*. 1991). A pollen sum (dry land) of between 200 and 300 grains per level was identified and counted for each level. A pollen diagram (Fig. 4) was produced using Tilia and Tilia Graph with percentages calculated as follows:

Sum =	% total dry land pollen (tdlp)
Marsh/aquatic herbs =	% tdlp + sum of marsh/aquatics
Spores =	% tdlp + sum of spores
Misc. =	% tdlp + sum of misc. taxa.

Taxonomy in general follows that of Moore and Webb (1978) modified according to Bennett *et al.* (1994) for pollen types and Stace (1991) for plant descriptions. These procedures were carried out in the Palaeoecology Laboratory of the School of Geography, University of Southampton.

Pollen Data

The pollen assessment is of only 200-300 grains so the interpretation here was not always conclusive and can only be considered tentative and preliminary, until more robust analysis with full pollen counting (of up to 800+ grains) can be undertaken. Because of the predominantly sandy nature of the sediments, pollen was in varying states of preservation and numbers. Of the 16 samples examined, 13 contained sufficient pollen for adequate assessment counts to be obtained and construction of an assessment pollen diagram which provides a basic characterisation of the local vegetation at the time of sediment deposition. There appear to be two local pollen assemblage zones (l.p.a.z.). Details of these are given below.

l.p.a.z.	***Pollen characteristics***
l.p.a.z. 2 Poaceae 3.60 to 5.58m	This zone is delimited by a reduction in trees and shrubs and an expansion of herbs, especially Poaceae. *Quercus* (20%) and *Corylus avellana* type (15%) decline from the base of the zone. *Alnus* values are variable. There is an increase of *Calluna* to consistent but small numbers. Herbs are dominant with an increase of diversity and dominated by Poaceae (to 40%). Cereal pollen is present. Chenopodiaceae (halophyte ?) is more consistent (1-2%). *Ranunculus, Rumex*, Apiaceae, *Plantago lanceolata* and Asteraceae types are also of note. There is a more consistent record of Cyperaceae. Spores of *Pteridium* have an initial peak (20%) followed by a decline to low values. Pre-Quaternary palynomorphs become more consistent.
l.p.a.z. 1 *Quercus-Alnus-Corylus avellana* type 5.58 to 6.82m	Trees and shrubs are dominant. *Quercus* (to 42%), *Alnus* (to 30%) and *Corylus avellana* type (to 55%) are the dominant taxa. There are also occasional *Betula, Pinus, Ilex* and *Fraxinus*. There are fewer herbs than in subsequent l.p.a.z. 2. Poaceae are most important (increasing to *ca.* 30%). Other taxa include *Plantago lanceolata* (1%) and sporadic occurrences of other types. Fen marsh taxa are represented by Cyperaceae at the base of the profile (4%). Spores of *Pteridium aquilinum* (10%), *Polypodium* (9%) and *Dryopteris* type (monolete Pteropsida) (10%) are present

Vegetation and environmental change

The two local pollen assemblage zones correlate with the change in stratigraphy from silts in part humic and laminated (6.55m to 7.00+m) and overlying predominantly medium and coarse sands. Absence of pollen in the lower part of the latter unit and *c.* 4.0 to 5.0m reflects the poor pollen preservation in such coarse material and possibly also the potential for short term/rapid accumulation of such sediments. It is also likely that the sands represent a transgressive or regressive sequence caused by fluctuating relative sea level. There may also be a temporal hiatus at the level separating the pollen zones. The pollen spectra/assemblages can be interpreted in terms of the on-site vegetation and environment and second, the local and more regional terrestrial habitats.

The on site/depositional habitat: Local pollen assemblage zone 1 occurs in the lower grey green silts suggested as being of brackish or marine derivation (Dr. M Allen pers. comm.). There is no firm palynological evidence for this with halophytes such as sea plantain (*Plantago maritima*) and more consistent Chenopodiaceae arriving in l.p.a.z. 2. However, diatoms (see below) show that this is indeed the case. There are similarly few freshwater fen taxa to suggest a mire habitat. It is probable that this was a tidal, estuarine, environment with grasses and sedges growing along the fringes of the river/estuary or growing on an adjacent floodplain. In l.p.a.z. 2 with transition to sands, there is, however, a change towards more saline conditions with occurrence of the halophytes noted (sea plantain and chenopod and orache types). It is likely that this was a transgressive littoral or near sub-littoral wave of sand being deposited in the (or on?) the preceding alluvial zone (barrier bar formation?).

The terrestrial zone: The time-span represented by pollen zone 1 appears to have been predominantly wooded. Oak (*Quercus*) and hazel (*Corylus*) were most important and are the typical dominants of the late-prehistoric period within Southwest England as a whole. Pollen of alder (a tree associated with fen carr, floodplain woodland and along banks) of rivers and streams is not present in sufficient quantity to suggest that it was important in the local region although occasional growth cannot be ruled out. It produces copious quantities of pollen which is wind disseminated and may come far afield. During this earlier zone, there are relatively few herbs represented and this probably reflects the predominantly wooded habitat, at least locally. Small numbers of ribwort plantain (*Plantago lanceolata*) and some of the grass pollen indicate that there was probably some local grassland within this local woodland or alternatively pollen may have derived from more extensive ? pasture at some distance. During this phase (l.p.a.z. 1) there is no evidence of cereal cultivation.

In l.p.a.z. 2 there is some decline (although not major) in the numbers of oak and hazel pollen and an expansion of herb pollen numbers (largely grass pollen) and also diversity of types. Whilst grasses and other taxa of grassland, possibly pasture are most important, there are also some indications of cereal cultivation. It is also interesting to note that a small increase in ling (*Calluna*) indicates the existence of heathland in the region. This represents the expansion of heathland vegetation and soils due to soil degradation/acidification especially on high ground. As pollen numbers are small it is probable that this pollen comes from more regional sources.

Age of the sediments and comparison with other local data

Pollen data from Westward Ho! and sites at nearby Barnstaple offer local comparison whilst there are numerous other sites in Devon at further distance. The inter-tidal peat at Westward Ho! are of middle Holocene (Atlantic Age; i.e. *c.* 6000-4000 cal BC) and the pollen data (Balaam *et al*. 1987) differ from those reported on here. Dominance of woodland at Westward Ho! included lime (*Tilia*) and elm (*Ulmus*) which along with other tree types are diagnostic for this period. Diagnostically, lime pollen (*Tilia*) is not present at any quantity at New Road, Bideford and is suggests that this part of the site is of later date than that at Westward Ho! , as shown by the radiocarbon dates (Table 1). Lime and oak are not present together at New Road suggesting that this site is of a later date. The sites of Barnstaple Bay (Allen *et al.* 2004) and Barnstaple Western bypass (Scaife 2006) are also of later age, Romano-British and Iron Age to Saxon respectively. Pollen from Barnstaple Bay (Scaife in Allen *et al*. 2006) shows a predominantly open agricultural landscape at this time. However, Western By-pass has evidence of Iron Age woodland which diminishes from the start of the Romano-British phase and into the later periods. The woodland was of similar oak-hazel character with alder as discussed here. Little Pill Farm, Sticklepath (Scaife 2007) shows a similar depletion of woodland from the Romano-British period.

Pollen zone 1 has been dated to the later Neolithic (and the vegegetion compares well with the regional history), but based on these comparisons pollen zone 2 is assumed on the basis of the assessed pollen of very late-prehistoric but more probably early historic (i.e. Romano-British and later). However, pollen is not a dating technique and absolute dates are clearly needed to affirm this.

Conclusions

The following principal points have been made in this pollen assessment study.

- Pollen is very variably preserved due to the coarse sandy character of the sediments and possible rapid deposition of some parts of the stratigraphy.
- Two local pollen assemblage zones have been recognised with a possible hiatus between the two.
- The lower later Neolithic pollen zone 1 is dominated by trees and shrubs with oak, hazel and alder being most important (with very little lime).
- The upper zone is delimited by a reduction of trees and shrubs and a marked increase in herbs dominated by grasses but, with a more diverse range of taxa than in the preceding zone.
- Zone 1 has no evidence of arable agriculture but tentative evidence of grassland with ribwort plantain from possible localised woodland clearance. However, this pollen element may also have travelled from more extensive pastoral areas at distance.

- Zone 2 whilst clearly showing importance of grassland and also has some evidence of cereal cultivation.
- Overall there are few palynological indications of brackish or marine conditions. Where these do occur they comprise largely pollen of Chenopodiaceae (goosefoots, oraches and samphire) and occasional sea plantain. These are present mostly in the upper, zone 2.
- Dating of the full sediment sequence has not been possible. Zone 1 is late Neolithic date. There may be a hiatus between the zones, and the age of the upper unit is not clear but is possibly late Prehistoric to early historic, based on comparison with pollen data from nearby Barnstaple.

Diatom Analysis

Nigel Cameron (University College, London)

A large suite of samples were taken, and initially eight samples between 5.32m and 6.94m were assessed by Dr. R.G. Scaife to examine the diatom content and potential for establishing the marine, brackish or freshwater affinity of the depositional environment (Scaife in Allen 2011). Diatom frustules were present in seven of the eight samples assessed. However, in these often coarse and sandy sediments, preservation of diatoms is extremely variable. Furthermore, as expected, the finer grained and siltier sediments below *c.* 6.5m contained a greater number and diversity of diatom frustules than the upper, sandier sediments. The diatom assemblages comprised taxa of tidal environments and these occurred throughout the profile (Table 3). No freshwater taxa were observed (Scaife in Allen 2011). This diatom assessment identified that additional analysis would be useful in order to fully characterise the depositional environment of the sediments, especially as the pollen data were not conclusive (Allen 2011).

Three further samples from the dark green grey silt identified in the lower part of the sequence below *c.* 6.5 m were analysis to aid in the reconstruct water quality and the aquatic environment.

Methods

Diatom preparation, counting and analysis followed standard techniques (Battarbee *et al.* 2001). Diatom floras and taxonomic publications were consulted to assist with diatom identification; these include Hendey (1964), Werff & Huls (1957-1974), Hartley *et al.* (1996), Kremmer & Lange-Bertalot (1986-1991) and Witkowski *et al.* (2000). Diatom species' salinity preferences are discussed in part using the classification data in Denys (1992), Vos & de Wolf (1988, 1993) and the halobian groups of Hustedt (1953, 1957: 199), these salinity groups are summarised as follows:

1. Polyhalobian: >30 g l^{-1}
2. Mesohalobian: 0.2-30 g l^{-1}
3. Oligohalobian - Halophilous: optimum in slightly brackish water
4. Oligohalobian - Indifferent: optimum in freshwater but tolerant of slightly brackish water
5. Halophobous: exclusively freshwater

6. Unknown: taxa of unknown salinity preference.

Diatom data were plotted using the ‘C2’ program (Juggins 2003).

Results and Discussion

Slides were prepared and analysed for diatoms from 3 levels from the laminated humic silts, unit 3d (698cm, 686cm, and 670cm). The results of diatom percentage counting are shown in Figures 6 and 7 which present diatom species and summary halobian group diagrams respectively.

The diatom assemblages of all three samples are dominated by marine taxa; polyhalobous diatoms comprise 81%, 83% and 86% of the total diatoms (Fig. 7). Polyhalobous to mesohalobous taxa comprise 4% to 5% of the total, and mesohalobous diatoms 7% to 10% (Fig. 6). Freshwater (oligohalobous indifferent) and halophilous diatoms are absent from the bottom sample (698 cm) and comprise less than 1% of the total diatoms at 686 cm and 670 cm. There are no significant changes in diatom halobian group (Fig. 7) and diatom species (Fig. 6) composition between the samples. The three samples therefore represent similar, fully tidal depositional environments.

The most common diatom in the three samples is the planktonic coastal species *Paralia sulcata* which comprises from 58% to 65% of the total diatoms. Other common polyhalobous taxa are the planktonic diatom *Podosira stelligera*, semi-planktonic diatoms such as *Cymatosira belgica*, *Rhaphoneis surirella* and *Rhaphoneis amphiceros*. Benthic marine taxa such as *Trachyneis aspera* are present in smaller numbers. The dominance of open water taxa and relatively small numbers of non-plankton suggests that the site of deposition was in relatively deep tidal water. Polyhalobous to mesohalobous diatoms also include planktonic diatoms such as *Actinoptychus undulatus* and *Pseudopodosira westii,* whilst attached marine brackish species such as *Cocconeis scutellum* are relatively rare. Again the most common mesohalobous taxon is a planktonic diatom *Cyclotella striata.* However, a number of benthic mesohalobous taxa are present in low numbers, for example *Diploneis aestuari, Diploneis didyma, Diploneis interrupta, Nitzschia navicularis* and *Nitzschia punctata*. The very small, combined, halophilous and oligohalobous indifferent diatom component is comprised of robust, aerophilous taxa including *Navicula cincta* fo. *minuta, Pinnularia major* and *Eunotia pectinalis*. These desiccation-tolerant, aerophilous diatoms are likely to be allochthonous and probably represent the inwash of terrestrial material. Overall then the three diatom assemblages represent fully tidal conditions; coastal habitats where the diatom assemblages are dominated by marine planktonic diatoms with a smaller component of benthic or epiphytic taxa and a very small component or absence of (aerophilous) halophilous and freshwater taxa.

Conclusions

1. Diatoms are present in the three samples in relatively low numbers and the quality of preservation is poor with only moderately high diatom species diversity.

2. Analysis shows that the three diatom assemblages represent fully tidal conditions. The diatom taxa represent coastal habitats where the diatom assemblages are dominated by marine planktonic diatoms and in particular *Paralia sulcata*. There are smaller components of marine and brackish-marine benthic or epiphytic taxa. In two samples there are very small components of allochthonous, aerophilous halophilous and freshwater taxa. Freshwater and halophilous diatoms are absent from the bottom sample (698 cm).
3. The poor preservation and relatively low numbers of diatoms from the three sediment samples in the New Road sequence can be attributed to taphonomic processes. This may be the result of silica dissolution caused by factors such as high sediment alkalinity, very high acidity, the under-saturation of sediment pore water with dissolved silica, cycles of prolonged drying and rehydration, exposure of sediment to the air, or physical damage to diatom valves from abrasion or wave action (e.g. Flower 1993; Ryves *et al.* 2001).

Assessment of the Waterlogged Plant Remains

Alan J. Clapham and Michael J. Allen

Fourteen small bulk samples of between 0.45L and 0.9L taken from the sleeved cores (Table 2). The samples were processed by wash-over flotation and assessed by Alan Clapham. Assessment aimed at establishing the presence and nature of waterlogged plant remains present, and to indicate the general character of the palaeo-environments.

Of the 14 bulk subsamples removed from the cores 12 produced waterlogged flots (Table 2) and were rapidly scanned under low magnification (Table 4) and nomenclature follows Stace (1997). All but one of the waterlogged flots were from the lower sequence (500-700cm i.e. unit 3. Apart from the waterlogged plants recorded in table 4, other data is summarised in table 5.

The plant assemblages overall suggest a submerged forest and the presence of alder and ash suggest alder carr. This is supported by the presence of wetland species, but the vegetation in the upper sequence (i.e. unit 1i at 360-380cm) appears to become more open. The majority of the samples indicate a marine influence indicated by annual sea-blite (*Suaeda maritima*)and sea arrow grass (*Triglochin maritimum*) i.e. unit 2 (500-520cm and 520-540cm); unit 3b (600-620cm, 620-640cm); unit 3b/c (640-655cm) and unit 3d (670-685cm). Reducing conditions as evidenced by pyritisation is present thought unit 3; i.e. unit 3a/b (550-575cm), unit 3b/c (640-655cm) and unit 3d (670-685cm, 685-700cm).

Mollusca

Michael J. Allen

Few molluscs were recovered from the bulk samples and all were marine shells. They included mussel (*Mytilus edulis)* unit 1e and cf. *Scobicularia plana* from laminated humic silts (units 3c and 3d).

DISCUSSION

The sediment sequence

The basal recovered sediment sequence (unit 3c-d) was bedded fine-grained humic silts with some and sand indicating gentle accumulation with some sand washed in from the littoral.

Unit 1	Sands and Gravels	+0.52m to -4.13m OD	Littoral
Unit 2	Dark Sand	-4.13m to -5.00m OD	Sand and silt bands
Unit 3a	Silt Band	-5.00m to -5.02m OD	littoral
Unit 3b-c	Sand with silts	-5.02m to -6.03m OD	riverine + littoral
Unit 3d	Silt	-6.03m to -7.00+m OD	littoral to littoral +riverine

The Torridge

It is clear that in the later Neolithic at about -6.43m OD fully tidal conditions were present represented by sand recorded above the shale (not present in the analysed core). As freshwater from the Torridge, rather than sediment from the sea, became a factor in deposition, a series of humic silts were deposited. These were river-edge and sub-aqueous near-edge deposits deposited by both freshwater input from inland, but also subject to fully tidal ingress. This change occurs in the later Neolithic period. By the assumed later prehistoric the presence of sand driven from the coastal margin increases. Deposit coarsen up profile, and after deposition of over 1.5m of predominantly silts, this gives way to medium sands and gravels, then a huge depth (5m) of river and tidal gravels

The palaeo-environmental evidence

The lower silts dating to mid to later second millennium BC, the later Neolithic, were deposited in estuarine deposits and fully tidal conditions with coastal habitats. Initially the sequence is wholly marine, but a freshwater presence is indicated from 686cm (i.e. -6.34m OD). The surrounding land was colonised with alder carr, hazel and a herbaceous (grasses and sedges) understory growing along an estuary floodplain or fringes of a river/estuary. The higher drier grounds on the interfluves supported open oak and hazel woodland. This is followed by harsher sedimentation and sands and gravels washed in from the littoral zone which corresponds to more open conditions (as suggested by both pollen and waterlogged plants) with open grassy floodplain and channel/estuary margins The interfluves show signs of acidification and degradation with the appearance of heathland which may be a consequence of deforestation and tillage. Indeed cereal pollen is present in very low numbers throughout this phase.

Site environmental history

Overall there is a simple change from marine and brackish conditions of an estuary fringed with alder carr, grasses and sedges in the Late Neolithic (2470-2580 cal BC to 2630-2870 cal BC) which is replaced by littoral sand washed up the estuary or river into a more open landscape. Woodland had been cleared from the interfluves, acidification and degradation of these soils lead to localised development of heathland, while the floodplain was more open and the estuary charged with sands and gravels

Evidence of human activity

There is no direct evidence of human activity in the form of artefacts from the boreholes. Fine unidentifiable charcoal washed into the basal later Neolithic laminated humic silts (units3c and 3d, see table 5) may suggest human activity within the floodplain catchment, but could represent natural causes such as wildfires or lightning strikes. Woodland clearance probably occurred on the drier interfluves and Torridge valley sides rather than on the floodplain where Bideford is located today. By the Romano-British period at least and the presence of cereal cultivation occurred, and gain probably restricted the drier valley sides. There is little record in the sediments cored of much impact or activity in the post Neolithic to later prehistoric periods.

The most important information here is the of a much sediments relating to gentler, freshwater silt and marine deposition in the Neolithic and the present of freshwater alder and willow carr fringing the river. This is a period when fin inwashed of charcoal suggest human activity on the interfluves and drier land.

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References

Allen, M.J. 2011. New Road, Bideford Devon: Torridge Foreshore Coring (NGR SS 4544 2643) *Geoarchaeological and Palaeo-environmental Assessment and Analyses.* Unpubl Assessment report for ACD Archaeology, report AEA 141.3.1, dated 27th July 2012

Allen, M.J. 2011. New Road, Bideford Devon: Torridge Foreshore Coring (NGR SS 4544 2643) *Geoarchaeological and Palaeo-environmental Assessment.* Unpubl Assessment report for ACD Archaeology, report AEA 141.2.2, dated 9th September 2011

Allen, M.J., Moore, C. & Scaife, R.G. 2004. The geoarchaeology of the alluvium in the Taw Valley west of Barnstaple. *Proceedings of the Devon Archaeological Society* 62, 41-51

Anderson, R. 2005. An annotated list of the non-marine Mollusca of Britain and Ireland, *Journal of Conchology* 38 (6), 607-637

Balaam, N.D., Bell, M.G., David, A.E.U., Levitan, B, Macphail, R.I., Robinson, M. & Scaife, R.G. 1987. Prehistoric and Romano-British sites at Westward Ho!, Devon: archaeological and palaeoenvironmental surveys 1983 and 1984. In N.D. Balaam, B.

Levitan, & V. Straker, (eds), Studies in Palaeoeconomy and Environment in Southwest England, .pp. 163-259. Oxford: British Archaeological Reports 181

Battarbee, R.W., Jones, V.J., Flower, R.J., Cameron, N.G., Bennion, H.B., Carvalho, L. & Juggins, S. 2001. Diatoms. In (J.P. Smol and H.J.B. Birks eds.), Tracking Environmental Change Using Lake Sediments Volume 3: Terrestrial, Algal, and Siliceous Indicators, 155-202. Dordrecht: Kluwer Academic Publishers

Barnett, C., Scaife, R.G. & Cooke, N. 2007. Iron Age to Saxon landscape and landuse change in the Taw Valley: evidence from an infilled river channel at little Pill Farm, Sticklepath Hill, near Barnstaple, *Proceedings of the Devon Archaeological Society* 65, 15-34

Bennett, K.D., Whittington, G. & Edwards, K.J. 1994 Recent plant nomenclatural changes and pollen morphology in the British Isles. *Quaternary Newsletter* 73, 1-6

Cappers, R.T.J., Bekker R.M. & Jans, J.E.A. 2006. *Digital Seed Atlas of the Netherlands.* Groningen Archaeological Series 4. Groningen: Barkhuis

Denys, L. 1992. *A check list of the diatoms in the Holocene deposits of the Western Belgian Coastal Plain with a survey of their apparent ecological requirements: I. Introduction, ecological code and complete list.* Service Geologique de Belgique. Professional Paper No. 246, 41

Evans, J.G. 1972. *Land Snails in Archaeology.* London: Seminar Press

Frederick Sherrell Ltd. 2003. Bideford Long Bridge Borehole Records (Unpubl. logs for Devon County Council)

Flower, R.J. 1993. Diatom preservation: experiments and observations on dissolution and breakage in modern and fossil material. *Hydrobiologia* 269/270, 473-484

Hartley, B., H.G. Barber, J.R. Carter & P.A. Sims. 1996. *An Atlas of British Diatoms.* Bristol: Biopress Limited

Hendey, N.I. 1964 An Introductory Account of the Smaller Algae of British Coastal Waters. Part V. Bacillariophyceae (Diatoms). Ministry of Agriculture Fisheries and Food, Series IV. pp. 317.

Hodgson, J.M. 1976. *Soil Survey Field Handbook.* Harpenden: Soil Survey Technical Monograph 5

Howard, A.J., Macklin, M.G. & Passmore, D.G (eds), 2003. *Alluvial Archaeology in Europe*. Rotterdam: Balkemma

Hustedt, F. 1953. Die Systematik der Diatomeen in ihren Beziehungen zur Geologie und Okologie nebst einer Revision des Halobien-systems. *Sv. Bot. Tidskr.*, 47: 509-519

Hustedt, F. 1957. Die Diatomeenflora des Fluss-systems der Weser im Gebiet der Hansestadt Bremen. *Ab. naturw. Ver. Bremen* 34, 181-440

Juggins. S. 2003. C2 User guide. Software for ecological and palaeoecological data analysis and visualisation. Newcastle upon Tyne: University of Newcastle

Krammer, K. & Lange-Bertalot, H. 1986-1991. *Bacillariophyceae.* Stuttgard: Gustav Fisher Verlag

Moore, P.D. 1977. Ancient distribution of lime trees in Britain. *Nature* 268, 13-14

Moore, P.D. & Webb, J.A. 1978. *An Illustrated Guide to Pollen Analysis*. London: Hodder and Stoughton

Moore, P.D., Webb, J.A. & Collinson, M.E. 1991 . *Pollen Analysis* Second edn. Oxford: Blackwell Scientific

Needham, S. & Macklin, M.G. (eds), 1992. *Alluvial Archaeology in Britain.* Oxford: Oxbow Books, 91-23

Ryves, D.B., Juggins, S., Fritz, S.C. & Battarbee, R.W. 2001. Experimental diatom dissolution and the quantification of microfossil preservation in sediments. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 172, 99-113

Scaife, R.G. 2007. Pollen, pp. 23-26. In C. Barnett, R.G. Scaife & N. Cooke, Iron Age to Saxon landscape and landuse change in the Taw Valley: evidence from an infilled river channel at little Pill Farm, Sticklepath Hill, near Barnstaple, *Proceedings of the Devon Archaeological Society* 65, 15-34

Stace, C. 1991. *New flora of the British Isles*. Cambridge: Cambridge University Press

Stace, C. 1997. *New Flora of the British Isles.* Cambridge: Cambridge University Press, (2nd Edn.)

Vos, P.C. & de Wolf, H. 1988. Methodological aspects of palaeoecological diatom research in coastal areas of the Netherlands. *Geologie en Mijnbouw* 67, 31-40

Vos, P.C. & de Wolf, H. 1993. Diatoms as a tool for reconstructing sedimentary environments in coastal wetlands; methodological aspects. *Hydrobiologia* 269/270, 285-296

Werff, A. Van Der & Huls, H. 1957-1974 *Diatomeenflora van Nederland*, 10 volumes

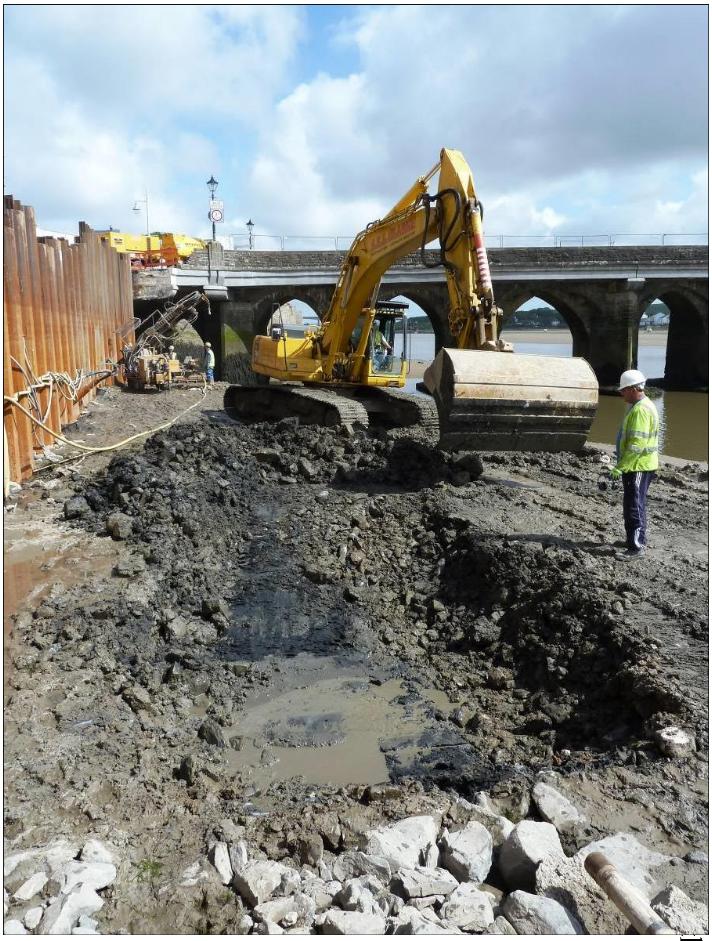
Witkowski, A., Lange-Bertalot, H. & Metzeltin, D. 2000. *Diatom Flora of Marine Coasts I.* Iconographia Diatomologica. Annotated Diatom Micrographs Ed. by H. Lange-Bertalot Vol. 7. Königstein, Germany : A.R.G. Gantner Verlag. Koeltz Scientific Books

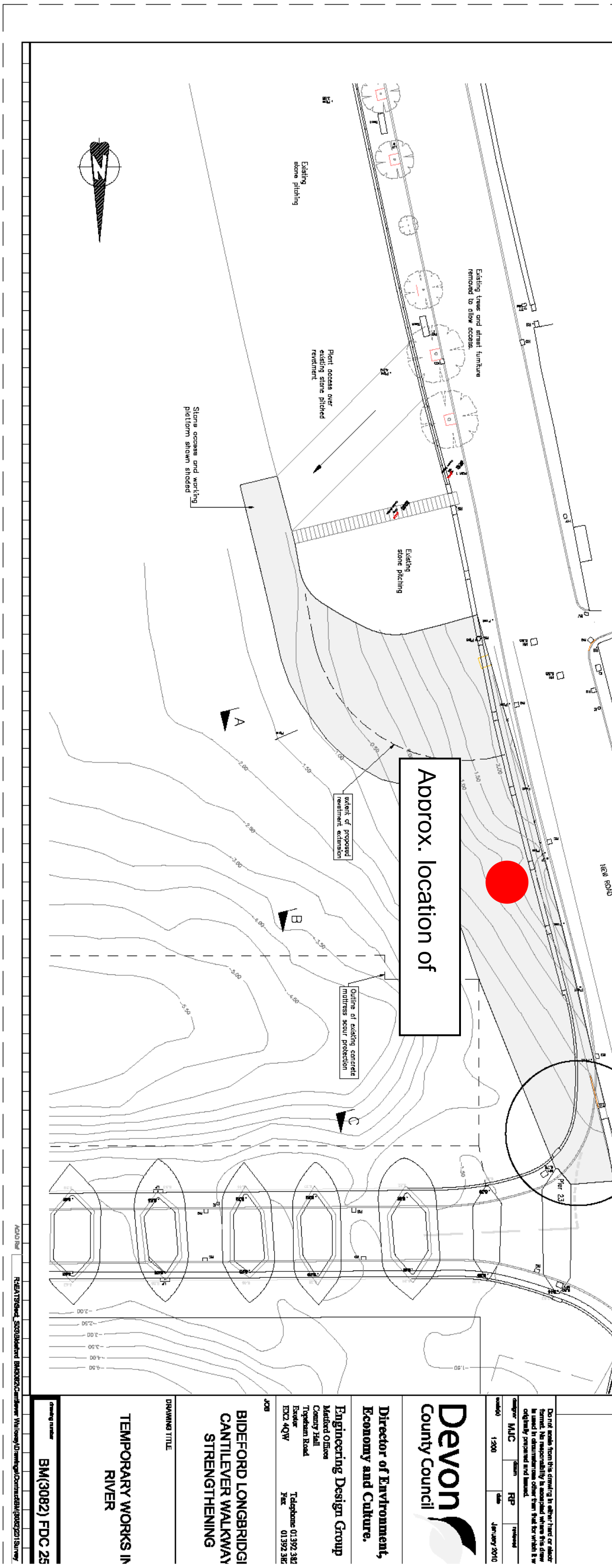
BOREHOLE RECORD

Depth cm	OD top of unit	pollen	Unit	samples: pollen	samples: diatoms	Bulk: Plants snail	Lithology	Summary description
-110-0	+1.62							Rock armour laid for construction and removed by machine
0-150	+0.52		1a	Not retrieved in sleeved core – logged in field, no samples			Beach Sand over Gravel/pebbles	Very dark grey soft moist sand
150-200			1b					Gravel in a loose yellowish brown sand matrix,
200-275			1c					Coarse gravel in sand matrix
275-300			1d					Small flint gravel in loose mixed dark yellowish brown (10YR 4/4) and dark grey (10YR 4/1)medium and coarse sand matrix,
300-310								
310-329			1e					As above with rare small mussel (*M. edulis*) frags
329-338			1f					Transition - mixed
338-349			1g			338-360		Firm moist yellowish brown (10YR 5/4) medium sand with rare medium stones, homogeneous, sharp boundary
349-354			1h					Dark grey (10YR 4/1-2), sand-free silt band, sharp boundary
354-400		Pollen zone 2	1i	360 376		360-380 380-400		As above i.e. Firm moist yellowish brown (10YR 5/4) medium sand with rare medium stones, weakly laminated / bedded 1-3mm defined by Fe staining and occasional light yellow sand inwashes, banding / laminations becoming less distinct below 385cm, and becoming more stony – common medium gravels
400-440				Not retrieved in sleeved core – logged in field, no samples				
440-456			1j					Compact wet yellowish brown fine and medium sand
465-475			1k					Large and medium gravels in yellowish brown sand matrix
475-500	-4.23		2				Sand	
500-552				516 532	532	500-520 520-540 540-550		Firm moist yellowish brown (10YR 5/4) to dark yellowish brown (10YR 4/4) medium sand with rare medium stones, with common small and rare medium gravel / stones, abrupt boundary Silt band at 530-532
552-554	-5.00		3a	552		550-575	Humic silt	Very dark grey (10YR 2/1) firm soft sand-free silt band, abrupt boundary
554-651	-5.02	Pollen zone 1	3b	556 628 642	588 604 642	575-600 600-620 620-640 640-655	Laminated silts and sand	Very dark grey (G1 3/3), becoming dark greenish grey (G1 3/1) homogenous stone-free medium sand 625-630 fine silt lamination, becoming coarser after 630cm
651-655	-5.99		3c	654				As above, but with fine 1-2mm laminations of humic matter
655-700	-6.03		3d	662 666 670 682	**670** 674 682 **686** 694 **698**	655-670 670-685 685-700	Humic laminated silts	Dark greenish grey G1 3/1) firm silt, with few to common fine stones 687-690 sand lens @ 655.5 alder twig fragment [4002±20 BP] @ 665 alder wood twig fragment @ 672 willow woody fragment (decayed) [4144±20 BP]
700+	-6.48							

Only assessed samples with remains listed (samples underlined fully analysed)

FIGURES





he area of cantilever walkway reparation

Figure 2. Excavation of the rock armour to facilitate access to the foreshore deposits; note top of sheet piling indicating the presence of a possible palaeochannel perpendicular to the Torridge and running under Tantons Hotel (photo: M.J. Allen)

Figure 3. Setting up the percussion coring rig on the Torridge foreshore. Note: the coring rig is set up in the excavated trench (photo: M.J. Allen)

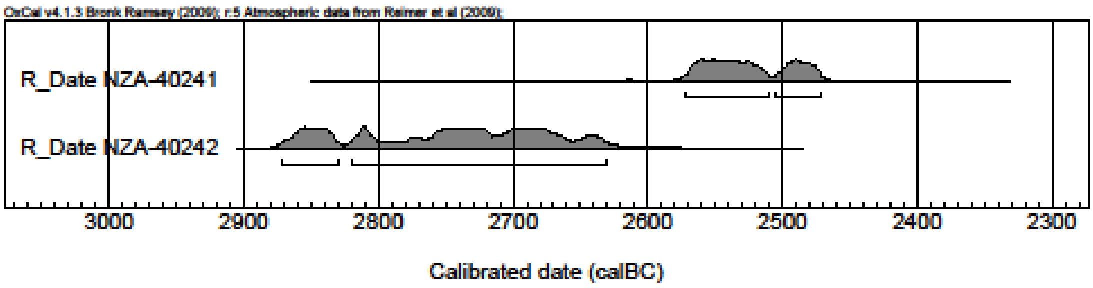


Figure 4. Radiocarbon distributions from samples at 655.5cm (-6.035m) and 672cm (-6.20m)

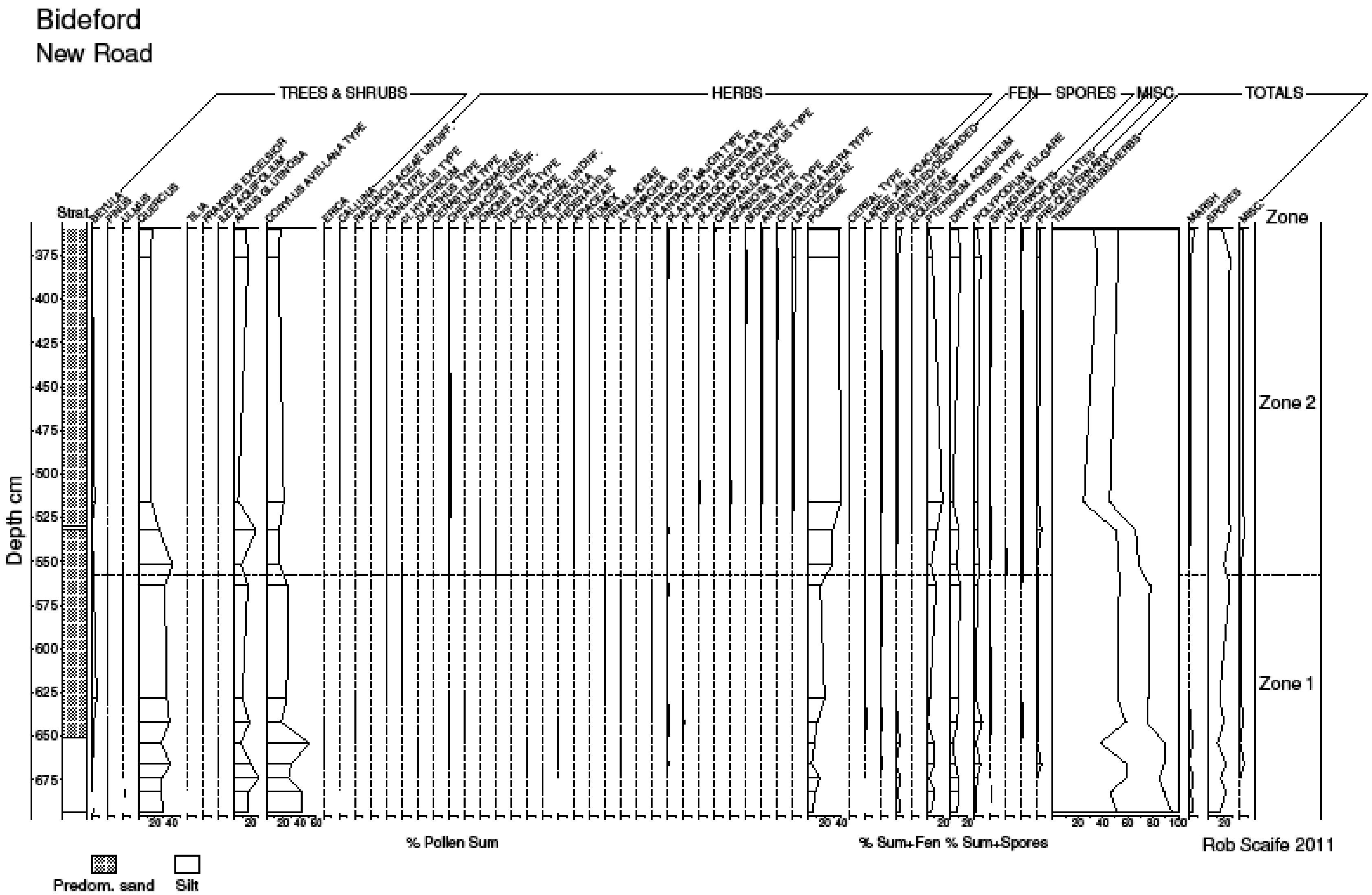


Figure 5. Pollen assessment diagram; Torridge Foreshore, New Road, Bideford

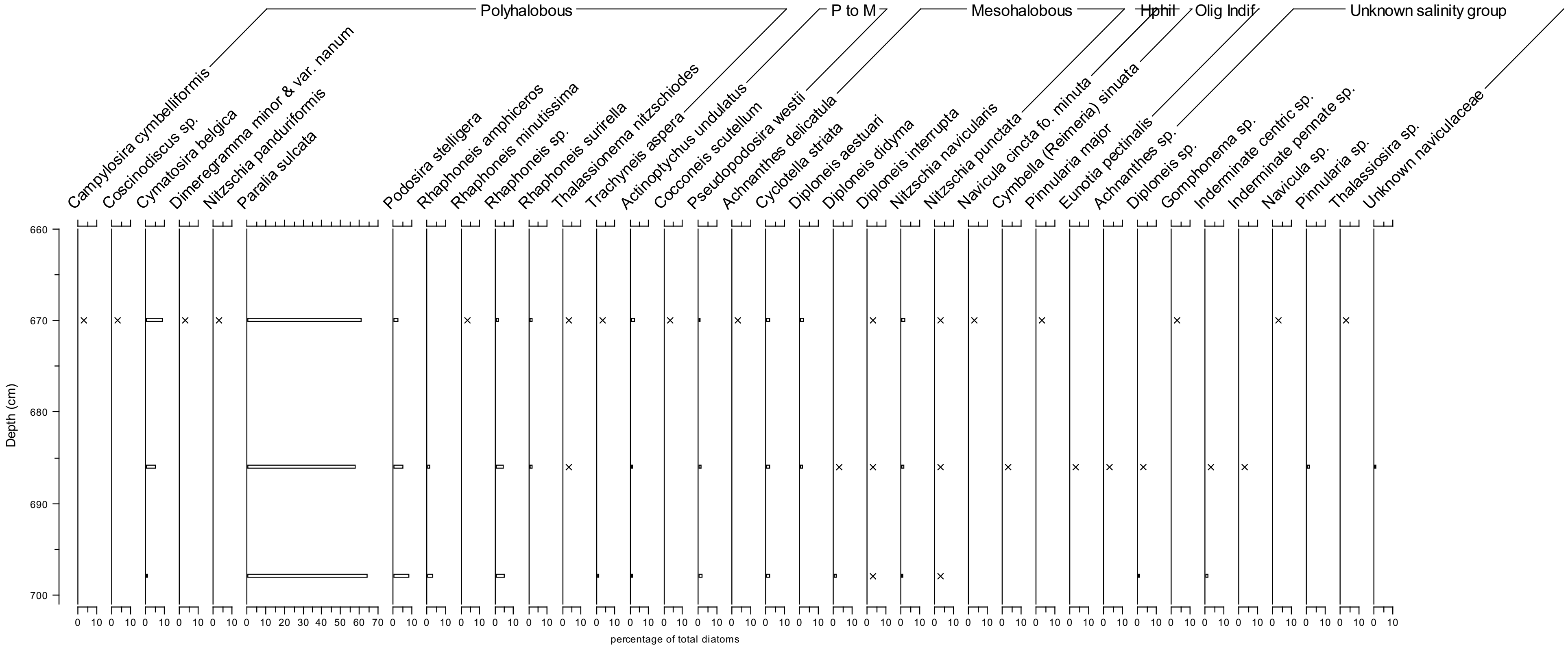


Figure 6. Relative abundance of diatom species present

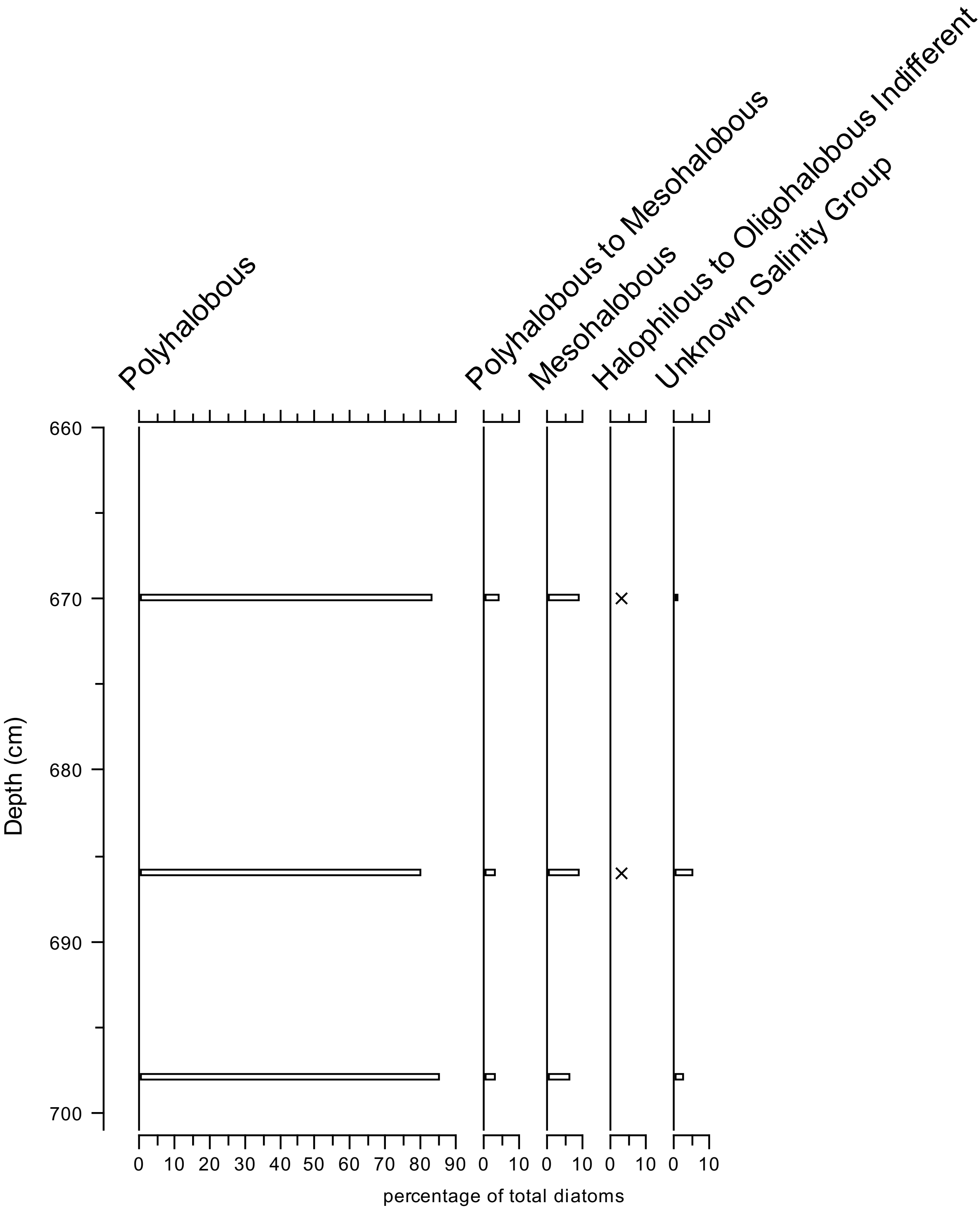


Figure 7. Summary diatom halobian group diagram

TABLES

depth	*OD*	*material*	*Lab no*	*Result BP*	*δC[13]*	*Calibrated result (cal BC)*
655.5cm	-6.035m	Alder (*Alnus*) roundwood twig	NZA-40241	4002±20	-27.0	2470-2580
672cm	-6.20m	Alder (*Alnus*) wood frag	NZA-40242	4144±20	-27.2	2630-2880

Table 1. Radiocarbon results and calibrated dates

depth	***deposit***	***unit***	***Qty processed***		***Residue***	***Flot volume***	
			Wt (g)	***Vol (ml)***	***>2mm Wt / %***	***>300μm***	***>2mm***
338-360cm	Firm yellowish brown sand	1g-h-i	740	600	63 / 8.5	-	-
360-380cm		1i	1009	700	126 / 12.5	2ml	-
380-400cm		1i	1119	825	4 / 0.5	-	-
500-520cm	Yellowish brown sand and gravel	2	1022	800	154 / 0.4	5ml	-
520-540cm			890	700	74 / 8.3	5ml	-
540-550cm			561	500	6 / 1.1	15ml	-
550-575cm	Silt, and fine sand with silt laminations	3a - b	1099	850	3 / 0.3	3ml	-
575-600cm		3b	1166	900	19 / 1.6	10ml	1ml
600-620cm			612	550	42 / 6.9	3ml	-
620-640cm			687	535	0 / 0	10ml	2ml
640-655cm		3b - c	679	600	2 /0.3	20ml	15ml
655-670cm	Stone-free silt with woody fragments	3d	752	450	26 / 3.5	20ml	30ml
670-685cm			680	510	0 / 0	5ml	5ml
685-700cm			596	500	13 / 2.2	20ml	15ml

Table 2. Processed samples, sample details, processed volumes and flot fractions

Depth (m)	***Presence ~ (trace); 5 = abundant***	***Taxa noted***	***unit***	***Sediment summary***
5.32	~	Single centric fragment	3a	Firm medium sand
5.88	0		3b	Very dark grey - dark greenish grey medium sand with silt laminations
6.04	~	*Nitzschia* cf. *compressa* Centric-cf. *Melosira* sp.		
6.28	2	*Fragillaria* sp. *Paralia sulcata* (**) *Cocconeis* fragment *Actinoptychus senarius* *Rhaphoneis amphiceros*		
6.42	~	Centric fragment		
6.74	1	*Paralia/Melosira* sp. cf *Actinocyclus* *Paralia sulcata*	3d	Dark greenish grey silt, with wood fragments
6.82	2	cf *Actinocyclus fragment* *Actinoptychus senarius* *Paralia/Melosira* sp. *Paralia sulcata* *Rhaphoneis amphiceros* *Thalassiosira sp.* *Pseudopodosira stelligera* *Cocconeis scutellum*		
6.94	~ - 1	*Paralia sulcata* *Pseudopodosira stelligera* *Actinoptychus senarius* *Cocconeis* sp.		

Table 3. Bideford, New Road, observed diatom content from assessment (Scaife)

Latin name	Common name	Habitat	360-380 cm	500-520 cm	520-540 cm	540-550 cm	550-575 cm	575-600 cm	600-620 cm	620-640 cm	640-655 cm	655-670 cm	670-685 cm	685-700 cm
		Sedimentary Unit	1i		2		3a/b		3b		3b/c		3d	
Taxus baccata leaf fragment	yew	C									+			
Ranunculus acris/repens/bulbosus	buttercup	CD	+	+							+		+	
Ranunculus sceleratus	celery-leaved buttercup	E									+		+	
Ranunculus flammula	lesser spearwort	E		+			+			+				
Ranunculus sbgen Batrachium	crowfoot	E					+							
Betula sp	silver birch	C			+					+	+			
Alnus glutinosa (cones)	alder	CE									+			
Alnus glutinosa (bracts)	alder	CE									+		+	
Alnus glutinosa (scales)	alder	CE						+						
Alnus glutinosa (fruits)	alder	CE	+					+	+	+	+	++	+	
Alnus glutinosa fruit (fragment)	alder	CE		+										
Alnus glutinosa (catkin fragment)	alder	CE	+	+					+	+	+			+
Corylus avellana shell fragment	hazelnut	C											+	
Chenopodium album	fat hen	AB		++										
Salicornia sp (seed)	glasswort	G			+								+	
Suaeda maritima	annual sea-blite	G		+					+	+	++		++	
Stellaria media	common chickweed	AB	+											
Rumex acetosella	Sheep's sorrel	ABD		+										
Viola sp	violet	DF		+			+							+
*Rubu*s sect Glandulosus	bramble	CD		+			+				+		+	
Crataegus monogyna	hawthorn	C									+			
Ilex aquifolium	holly	C					+			+	+			
Mentha aquatica	water mint	E											+	
Fraxinus excelsior	ash	C									+			
Sambucus nigra	elderberry	BC		+										
Cirsium sp	thistle	ABDE											+	
Chrysanthemum segetum	corn marigold	AB	+											
Eupatorium cannabinum	hemp-agrimony	E								+				
Triglochin maritimum	sea arrowgrass	G									+			
Juncus sp	rush	DE		+	+						+			
Scirpus sylvaticus	wood club-rush	CE								+				
Carex spp (2-sided)	sedge	CDE									+			
Carex spp (3-sided)	sedge	CDE						+				+		
unidentified moss fragments				+	+	+	+	+		++	++	+	+	+
unidentified thorn											+			
unidentified leaf fragments					+	+	+	+++	+	+++	+		+	+++
unidentified bark fragments				+							++	++	+	
unidentified wood fragments				++		+	+	+	+	+	++	++	++	+
unidentified bud				+				+	+	++	+	+	++	
unidentified budscales			+	++	+	+		+	+	+++	+		+++	+
unidentified fruit fragments											+			
unidentified fungal fragments	fungus		+	+					+	+				
unidentified anther			+								+			+

Table 4. Waterlogged plant remains from Torridge Foreshore, Bideford

Depth cm	***OD top of unit***	***Unit***	***Bulk***	***Marine***	***No marine***	***pyritised***	***Identifiable wood***	***charcoal***	***Summary description***
338-349	-2.86	1g	338-360	-	-	-	-	-	Medium sand
349-354	-2.97	1h		-	-	-	-	-	Dark grey sand-free silt band
354-400	-3.02	1i		-	-	-	-	-	Bedded Medium sand some gravel
			360-380	-	-	-	-	✓	
			380-400	-	-	-	-	-	
400-440				-	-	-	-	-	
440-456	-3.88	1j		-	-	-	-	-	Fine and medium sand
465-475	-4.13	1k		-	-	-	-	-	gravels and sand
475-500	-4.23	2		-	-	-	-	-	Firm medium sand
500-552			500-520	✓	-	-	-	-	
			520-540	✓	-	-	-	-	
			540-550	-	-	-	-	-	
552-554	-5.00	3a	550-575	-	-	✓	-	-	Very dark grey silt band
554-651	-5.02	3b	575-600		-	-	-	-	Very dark grey - dark greenish grey medium sand with silt laminations
			600-620	✓	-	-	-	-	
			620-640	✓	-	-	-	✓	
651-655	-5.99	3c	640-655	✓	-	✓	✓	✓	As above, but with fine 1-2mm humic laminations
655-700	-6.03	3d	655-670	-	✓		✓	✓	Dark greenish grey silt, with wood fragments
			670-685	✓		✓	✓	✓	
			685-700	-	✓	✓	✓	-	
700+	-6.48			-	-	-	-	-	

Table 5. Summary of waterlogged elements from the bulk samples

APPENDIX 1:
CLOSURE OF NEW ROAD AS A CRIME SCENE – 31st May 2011

Figure A3.1. Closure of New Road as a crime scene 31 May 2011 (photo: M.J. Allen)

Figure A3.2. Tantons Hotel, New Road. Note the three fire engines (arrowed) outside Tantons Hotel – the approximate coring location is marked with a red circle (photo: M.J. Allen)