PALAEOECOLOGICAL INVESTIGATIONS OF BURIED PEATS AT THE PROPOSED CARDIFF INTERNATIONAL RAILFREIGHT TERMINAL, WENTLOOGE, CARDIFF

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Palaeoecological evidence (pollen, plant macrofossils and diatoms) is described from two peat sequences buried beneath alluvial silts and clays on the Gwent Levels to the southeast of Trowbridge, Cardiff. Radiocarbon dating shows that the peats are of late Holocene age. A negative sea-level tendency, dated to 3750 ± 50 ^{14}C yrs BP (3900-4350 cal BP) marks the transition from tidal saltmarsh to coastal mire, after which an extensive alder carr developed in the near-shore area, while to landward were areas of mixed oak woodland. Alder carr was succeeded by reedswamp from 3400 ± 70 ^{14}C yrs BP (4240-3820 cal BP), while tidal saltmarsh was re-established in the area early in the third millennium BP (2600-2800 ^{14}C yrs BP; 3050-2500 cal BP). There are indications throughout this period of extensive burning, although in the absence of unequivocal evidence in the pollen and plant macrofossil records for anthropogenic activity in the vicinity, it is possible that these could have been natural (eg from lightning strikes) rather than being human-induced.

INTRODUCTION

This paper describes palaeoecological investigations of buried peat sequences in the area to the southeast of Trowbridge, Cardiff (Figure 1A), where the Welsh Development Agency is proposing the development of an International Railfreight Terminal on the south side of the Cardiff-London railway line approximately 6 km east of Cardiff station. The proposed development (centred on NGR ST 239 797) lies on the northern edge of the Wentlooge Level between the Rivers Rhymney and Usk which forms part of the flat alluvial plain lying to the north of the Severn Estuary and known collectively as the Gwent Levels (Figure 1B). The site lies within the back fen on the inland edge of the Levels, at the boundary with the bedrock (Sell 1999), and a little over 1 km from the present-day coastline. As is the case with much of the Gwent Levels, the area is likely to have been a former saltmarsh crossed by tidal creeks during much of the prehistoric period (Rippon 1996), and subsequently drained by a system of reens, sluices and drains for use as farmland (Fulford *et al* 1994). In a number of localities, excavations through the estuarine silts have revealed terrestrial and semi-terrestrial peats which, in turn, overlie further marine or peri-

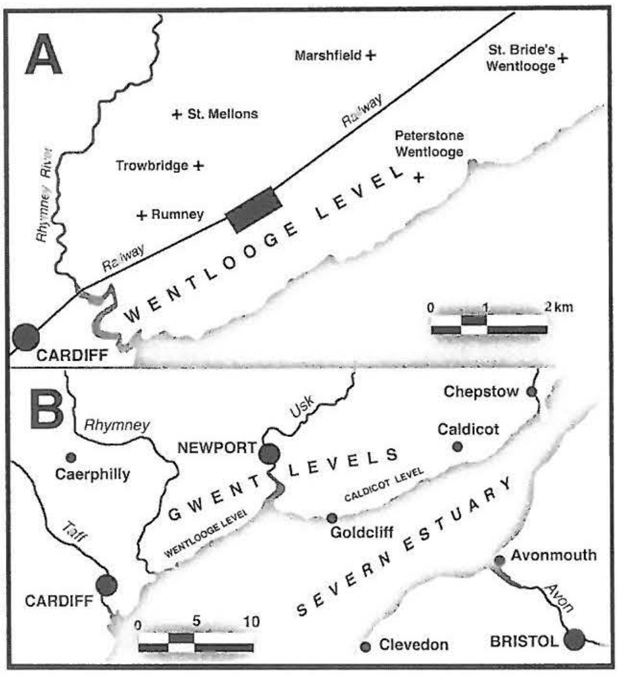

*Figure 1: **A**. The location of the proposed Cardiff Railfreight Terminal on the Wentlooge Levels. **B**. The Gwent Levels showing localities and features mentioned in the text.*

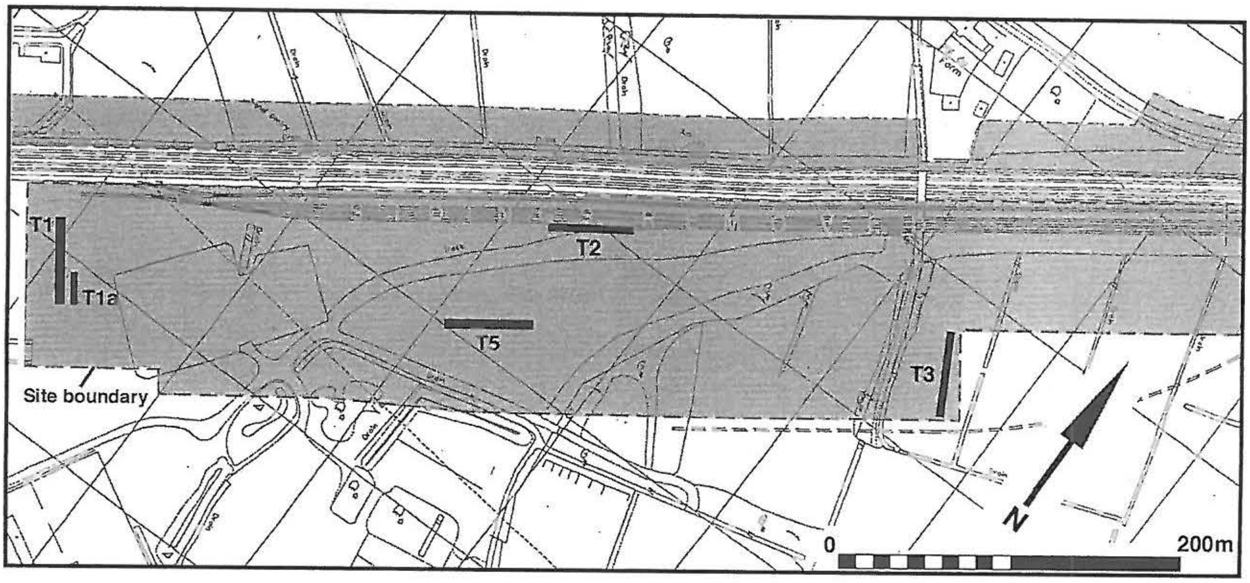

Figure 2: Location of the exploration trenches (T1, T1a, T2, T3 and T5) on the site of the proposed Cardiff Railfreight Terminal.

marine deposits (Allen 2001), and these have provided evidence for environmental change and human activity along the northern foreshore of the Severn Estuary during the later prehistoric period (Smith and Morgan 1989; Scaife 1995; Bell and Neumann 1997; Walker *et al* 1998; Bell *et al* 2000). For example, on the Rumney foreshore, only 1.9 km to the south of the site of the proposed Railfreight Terminal, Allen (1996) reported evidence of Bronze Age and Iron Age activity in the form of a hut circle on the peat radiocarbon-dated at 3080 ± 50 BP and a later occupation scatter dated at 2250 ± 60 BP.

During the course of a field evaluation within the area of the proposed development by the Glamorgan Gwent Archaeological Trust, trial excavations revealed the presence of subsurface peats, interbedded with marine or peri-marine deposits. In contrast to the Caldicot Level to the east, there have been few studies of this type of depositional sequence in the Trowbridge area. Hence, the exposure of these sediments provided the opportunity to obtain a palaeoenvironmental record for this part of the Gwent Levels for the later prehistoric period.

CONTEXT AND STRATIGRAPHY

Four trenches were excavated in the study area, and all revealed peat deposits underlying grey alluvial clays (Figure 2). The thickest peat sequences were exposed in trenches 1a and 3, and these were selected for palaeoecological analyses. In trench 1a (NGR ST 239 797), ash and surface material *c.* 0.70 m deep overlies *c.* 1.4 m of grey silty clay which, in turn, overlies peat at a depth of *c.* 4.00 m OD. The peat, which is 13.5 cm in thickness is underlain by blue-grey alluvial clay. The lower boundary between the peat and clay is therefore at *c.* 3.87 m OD. In trench 3 (NGR ST 243 800), a similar stratigraphy was recorded, but the peat here is 56 cm in thickness. The upper boundary between the peats and the overlying silty clays is at 3.71 m OD, while the base of the peat sequence is at 3.15 m OD. Below the peat unit is a silty clay with organic remains which overlies sterile silty clays. The boundary between these two units is at 3.10 m OD.

A series of vertical monoliths was taken through the peat and silt/clay sequences for pollen and diatom analyses, and bulk samples were also collected for plant macrofossil analysis and for wood identification. The stratigraphy of the sampled sections is shown on the left of the pollen diagrams (Figures 3 and 4, below). One bulk sample from trench 1a was examined for plant macrofossils and wood was identified from five samples, one sample from trench 1a and four samples from trench 3.

LABORATORY METHODS

Pollen analysis

Thirty nine samples from the two exposed sections were analysed in detail for pollen content: thirteen from trench 1a and twenty six from trench 3. These were prepared using standard techniques, namely digestion in 10% NaOH, followed by acetolysis (Moore *et al* 1991). HF treatment was required for samples from the minerogenic horizons. Residues were mounted in safranin-stained glycerine jelly and analysed using a Laborlux microscope at x400 magnification, with critical identifications under oil at x1000. In the majority of levels, the pollen sum was 300 land pollen grains, although in the upper and basal sections of Trench 1a the pollen content was lower and the pollen sums were reduced accordingly. Pollen and spores were identified using the key in Moore *et al* (1991), and categorised after Bennett (1994); nomenclature follows Stace (1991). The pollen diagrams (Figures 3 and 4, below) were drawn using TILIA*GRAPH (Grimm 1991).

Plant macrofossil analysis

The bulk sample from trench 1a (016) was sub-sampled and then sieved through a stack of sieves. The subsample was 250 ml and the finest sieve used was 250 microns. The sample was sorted and identified using a Wild M5 stereo microscope.

Trench	**1a**
Sample number	**016**
Sample size (ml)	**250**
Taxa	
Suaeda maritima (L.) Dumort	1
Rumex sp.	1
Eupatorium cannabinum L.	16
Eupatorium cannabinum L. frags	c. 200
Typha spp.	c. 150
Monocot. remains	+
Insect remains	+

Table 1: Plant macrofossil remains from Wentlooge Railfreight Terminal

Trench	**3**	**3**	**3**	**3**	**1a**
Sample number	**002**	**005**	**006**	**007**	**013**
Taxa					
Alnus glutinosa (L.)	1	3	1	1	5
Salix spp.	9	-	1	-	-
Total	10	3	2	1	5

Table 2: Wood identifications from Wentlooge Railfreight Terminal.

Identification was by comparison with modern reference material and standard texts including Berggren (1969, 1981) and Schoch *et al* (1988). Although the samples were examined principally for plant remains, other remains were also noted. The results are presented in Table 1.

Wood identification

Wood was identified from 5 samples (see above) by examination of transverse, radial longitudinal and tangential longitudinal sections using a Leitz microscope. Identification criteria used followed Schweingruber (1978). The results are given in Table 2.

Charcoal analysis

No quantitative estimate of charcoal abundance was made, but a qualitative record of charcoal presence was assembled during the pollen counting and sieving. The results are considered briefly below.

Diatom analysis

Diatom counts were carried out to assessment level on ten sediment sub-samples. Diatom preparation followed standard techniques: the oxidation of organic sediment, removal of carbonate and some clay, concentration of diatom valves and washing with distilled water. Two coverslips, each of a differing concentration of the cleaned solution, were prepared from each sample

Lab Sample Number	1	2	3	4	5	6	7	8	9	10
Trench	3	3	3	3	3	3	1A	1A	1A	1A
Top Depth (cm)	0	4	8	70	74	76	4	8	28	32
Bottom Depth (cm)	1	5	9	71	75	77	5	9	29	33
DIATOMS & SALINITY PREFERENCE										
Polyhalobous										
Cymatosira belgica Grun. in Van Heurck 1881		1								
Paralia sulcata (Ehrenb.) Cleve 1873	5	6	11				4	19		
Podosira stelligera (J.W. Bail.) Mann 1907	2	2	4	2			2		1	
Rhaphoneis sp.	1 f		1				2			
Rhaphoneis amphiceros (Ehrenb.) Ehrenb. 1844		1								
Rhaphoneis surirella (Ehrenb.)Grun.in Van Heurck 1881		2	1					2		
Trachyneis aspera (Ehrenb.) Cleve 1894			1							
Polyhalobous to Mesohalobous										
Actinoptychus undulatus (J.W. Bail.) Ralfs in Pritch. 1861			1							
Diploneis cf. *smithii* (Breb. ex W. Sm.) Cleve 1894							1	2		
Pseudopodosira westii (W. Sm.) Sheshuk.-Poretzsk.1964	2			5	2	3	1	1	2	4
Thalassiosira decipiens (Grun.) E. Jorg. 1905			1					2		
Mesohalobous										
Caloneis westii (W. Sm.) Hendey 1964		2	1				2	2		
Diploneis didyma (Ehrenb.) Cleve 1894	1									
Diploneis interrupta (Kutz.) Cleve 1894			2							
Navicula digitoradiata (Greg.) Ralfs in Pritch. 1861		1	5				1	6		
Navicula peregrina (Ehrenb.) Kutz. 1844		17	9	2 cf			3	12		
Nitzschia hungarica Grun. 1862		1								
Nitzschia navicularis (Breb.) Grun.	8			1			8	3		
Nitzschia punctata (W. Smith) Grunow 1878			1							
Stauroneis cf. *amphioxys* Greg.								3		
Mesohalobous to Halophilous										
Nitzschia tryblionella Hantzsch in Rabenh. 1860		2								
Halophilous										
Navicula cincta (Ehrenb.) Ralfs in Pritch. 1861										

Table 3: Diatom assessment counts from Wentlooge Rail Freight Terminal: f – fragments; cf. – compare with the species (continued next page).

Lab Sample Number	1	2	3	4	5	6	7	8	9	10
Trench	3	3	3	3	3	3	1A	1A	1A	1A
Top Depth (cm)	0	4	8	70	74	76	4	8	28	32
Bottom Depth (cm)	1	5	9	71	75	77	5	9	29	33
DIATOMS & SALINITY PREFERENCE										
Halophilous to Oligohalobous Indifferent										
Rhoicosphenia curvata (Kutz.) Grun. 1860		1								
Oligohalobous Indifferent										
Fragilaria pinnata Ehrenb. 1843								1		
Hantzschia amphioxys Ehrenb. (Grun.)								1		
Navicula rhynchocephala Kutz. 1844		1								
Pinnularia major (Kutz.) W. Sm. 1853		1	1							
Unknown Salinity Preference										
Amphora sp.								2		
Caloneis sp.		1 cf	1							
Diploneis sp.								1		
Gomphonema sp.								1		
Navicula sp.		1 f	1				1			
Nitzschia sp.			1					1		
Pinnularia sp.		1								
Unknown centric sp. (probably marine)	2					1				
Unknown Naviculaceae	2	2			1 f				1	
Unknown pennate sp.							1			

Table 3 (continued): Diatom assessment counts from Wentlooge Rail Freight Terminal: f – fragments; cf. – compare with the species.

and fixed in a mountant of suitable refractive index for diatoms (Naphrax). For samples where there were low concentrations of diatoms a second set of coverslips and slides was prepared to check for the presence of valves or fragments. Slides were scanned at a magnification of x400 and counted at x1000 under phase contrast illumination. Several diatom floras and taxonomic publications were consulted to assist with diatom identification, including Hendey (1964) and Hustedt (1930-1966). Diatom species' salinity preferences were classified using the halobian groups of Hustedt (1953; 1957, 199) summarised below:

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 valves and fragments were present in all ten samples and the results are shown in Table 3. The principal source used for diatom ecological data was Denys (1992).

Sample depth (cm)	Laboratory number	$\delta^{13}C$ (‰)	Uncalibrated ^{14}C date	Calibrated age range (2σ; 95% probability)
Trench 1a (011)				
10.5-11.5	Beta-157362	-27.5	2770 ± 70 BP	3050-2760 BP 1100-800 BC
23-24	Beta-157363	-27.3	3400 ± 70 BP	3840-3470 BP 1890-1520 BC
Trench 3 (003/004)				
9-10	Beta-157208	-29.4	2610 ± 60 BP	2800-2710 BP 2580-2510 BP 850-760 BC 640-560 BC
30.5-32	Beta-157209	-27.9	2660 ± 60 BP	2870-2730 BP 920-870 BC
58-60	Beta-157210	-25.0	3670 ± 80 BP	4240-3820 BP 2290-1870 BC
69-70	Beta-157361	-27.8	3750 ± 70 BP	4350-4330 BP 4300-3900 BP 2400-2380 BC 2360-1950 BC

Table 4: Radiocarbon dates from Wentlooge Railfreight Terminal.

RADIOCARBON DATING

Samples for radiocarbon dating were taken from six horizons, four from trench 3 (003/4) and two from trench 1a (011). In both profiles, the upper contacts between the peats and the grey silty clays were dated, while in trench 1a a date was obtained on the lower peat/silt contact. In trench 3, three further horizons were sampled for dating: the thin silty clay band within the peats at 30-32 cm, the transition from organic-rich peat to silty peat at 59-60 cm, and the base of the silty clays with organic fragments at 69-70 cm. The dated horizons are shown in Figures 3 and 4. The conventional radiocarbon ages, after correction for isotopic fractionation, were calibrated to calendar years using the INTCAL98 radiocarbon age calibration (Stuiver *et al* 1998), details of which are presented in Table 4.

RESULTS

Pollen analysis

There are a number of similarities between the two pollen diagrams (Figures 3 and 4), but also several distinct differences. Both show a significant increase in *Alnus glutinosa* pollen during the initial phase of peat accumulation, followed by a progressive decline (more abrupt in trench 3) in alder and an expansion of Poaceae. *Quercus* is a major component of the pollen spectra in both profiles, while *Corylus avellana* is also strongly represented. *Pinus* is present in small quantities in the basal silt/clay horizons, but becomes increasingly sporadic thereafter, and a similar trend is evident in the record for *Tilia. Ulmus* is also present, but seldom in more than trace quantities. *Salix* expands significantly in the middle and upper part of the trench 3 profile, while *Betula* also registers strongly immediately before the upper peat-clay transition. *Fraxinus* appears in the middle of the peat sequence, and is present in low but consistent quantities thereafter. In the trench 1a profile, by contrast, although *Salix*, *Betula* and *Fraxinus* are recorded in the middle and upper levels of the sequence, their representation is much more subdued, and it may be that the pollen signal from these three genera is being masked by, in particular, Poaceae. In both trenches, the lower and upper silt-clay deposits contain pollen taxa characteristic of saltmarsh and

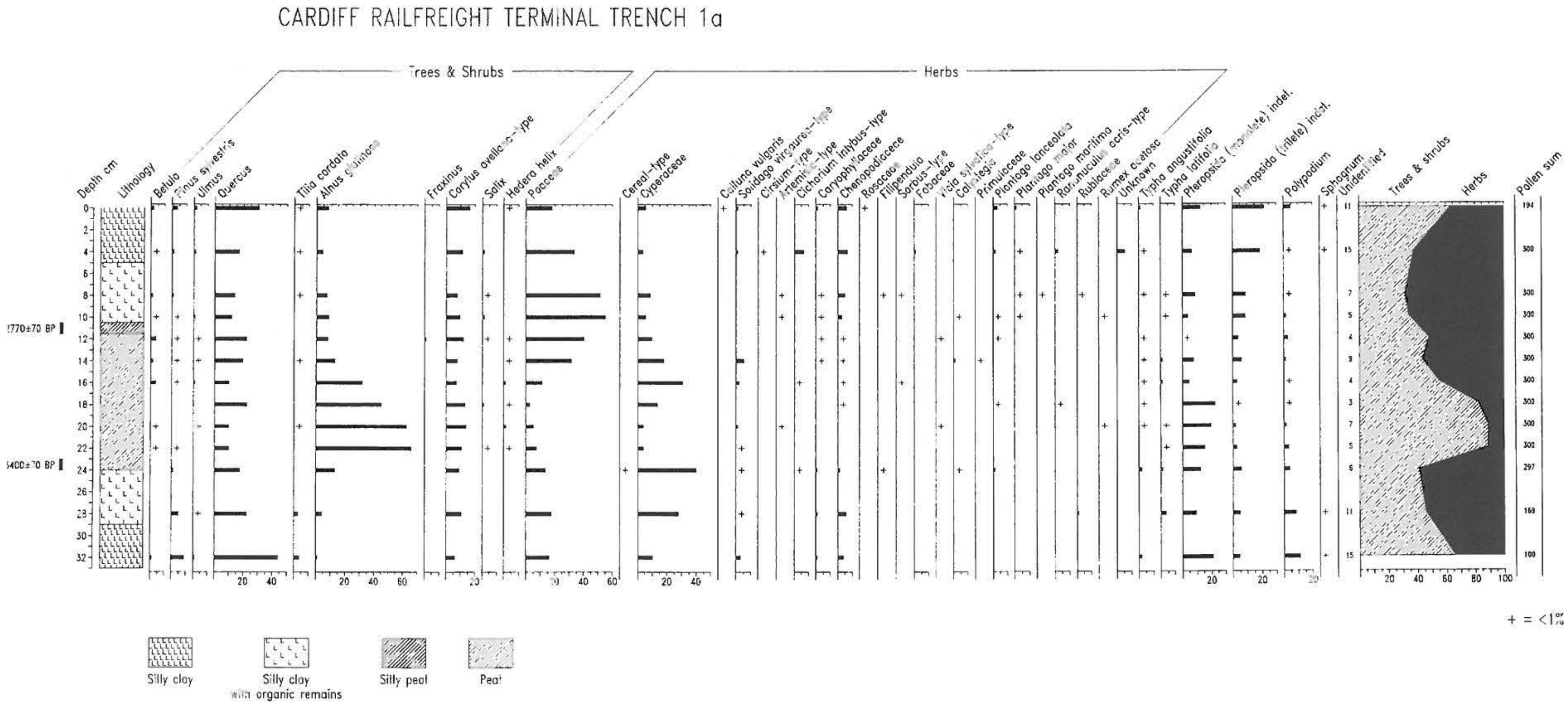

Figure 3: Percentage pollen diagram from Trench 1a.

CARDIFF RAILFREIGHT TERMINAL TRENCH 3

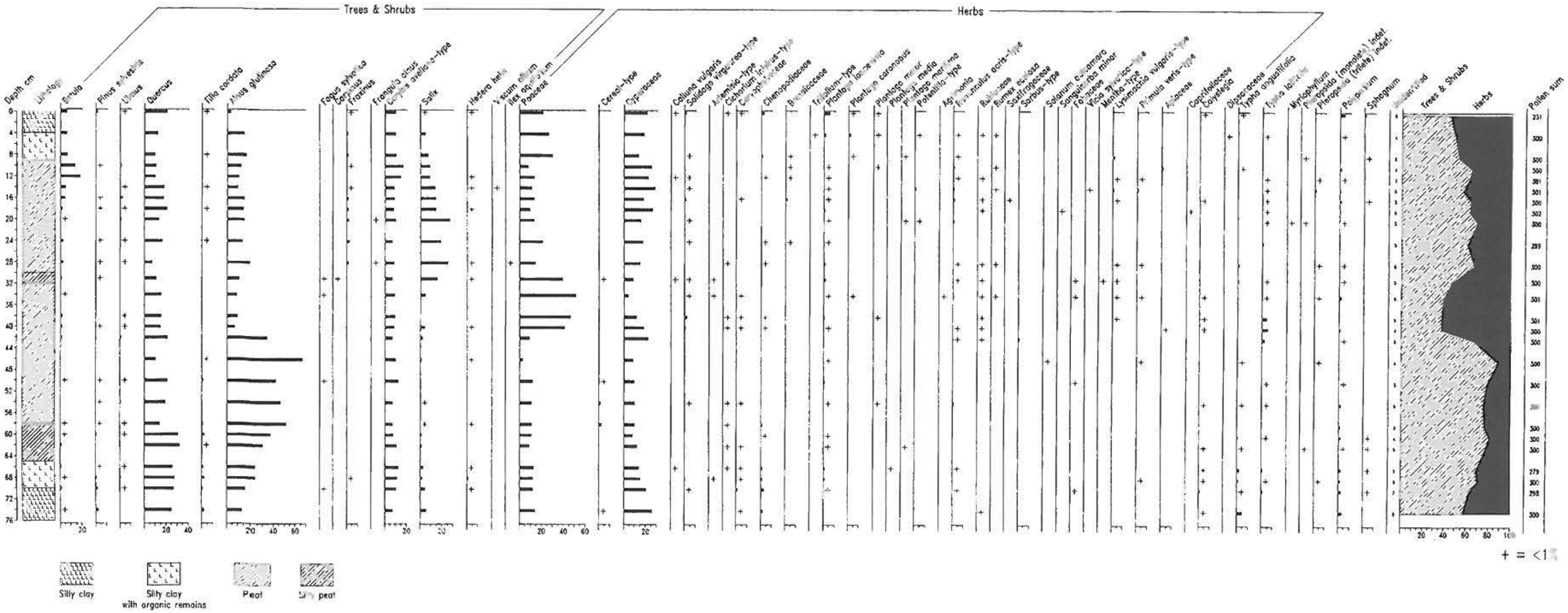

Figure 4: Percentage pollen diagram from Trench 3.

nearshore communities (eg Chenopodiaceae, *Plantago coronopus, P. maritima*).

In terms of vegetational/environmental history, the two diagrams clearly reflect the transition from a saltmarsh to semi-terrestrial or terrestrial peats during a period of falling sea level (a 'marine regression', or 'negative sea-level tendency' *sensu* Shennan (1987)). This was followed by the development initially of alder carr, which gradually gave way to a mire dominated by grasses, sedges, and local stands of willow. The reasons for this transition from carr to open fen which, in trench 3, may also be reflected in the increase in *Typha latifolia*, cannot be determined on present evidence. It could, however, be indicative of local water-table changes or episodic flooding, perhaps associated with a relative rise in sea-level, which had an adverse effect on the arboreal elements of the mire communities. On the regional scale, the high counts for *Quercus* and the consistent presence of *Corylus* points to a landscape of mixed woodland, dominated by oak, with stands of hazel, and possibly also birch in more open situations. Lime was also a woodland component, particular in the earlier part of the sequence, while ash became established locally later on. The upper part of the profile reflects the inundation of the mire by rising sea level (a 'marine transgression', or 'positive sea-level tendency'), and the re-establishment of saltmarsh, or inter-tidal conditions. The sequence contrasts with that found at the East Moors site, some 4.8 km to the southwest, where higher arboreal values (particularly of *Tilia*) were recorded, and which presumably dates from an earlier woodland phase (Hyde 1936).

There is little direct evidence in the pollen record of human activity. Some large grass pollens (cereal-type) were recorded in the profile from trench 3, and in one level from trench 1a, but as many cereal grains are almost indistinguishable from pollens of some wild grasses (especially coastal grasses, such as *Leymus arenarius* or *Ammophila arenaria*), this evidence alone is too slight to be taken as a firm indication of local arable farming. *Plantago lanceolata*, a widely recognised weed from grazed pastures (Behre 1986), occurs in the pollen records, and in both profiles increases significantly in the upper levels. However, this species is also present in entirely natural coastal herbaceous communities, and hence while the presence of *P. lanceolata* could be indicative of local pastoral activity, the evidence is by no means unequivocal. On the other hand, the recovery of animal bone and identification of foot-print tracks of domesticates from sites dating to the middle-late Bronze Age both on the Wentlooge Level (Allen 1996; Yates *et al* 2002) and on the Caldicot Level (Locock *et al* 2000; Bell 2002) does suggest pastoral activity in the region as a whole. There is also the possibility that the decline in *Alnus* may be due, at least in part, to anthropogenic clearance, but as there is no complementary decline in pollen of other woodland taxa (eg *Quercus*), the fall in alder values may reflect natural processes within and around the mire ecosystem, rather than human activities.

Charcoal was found in varying amounts throughout both of the profiles. In trench 1a, relatively large quantities were observed on the pollen slides between levels 0 and 15 cm, and a substantial quantity was noted in the sievings from level 12-13 cm. Charcoal was also abundant on the pollen slides from 28-33 cm. In trench 3, the most abundant micro-charcoal particles were found on the pollen slides from 38-43 cm and 60-67 cm. Hence, in both profiles, charcoal is present prior to the rise in *Alnus* (and perhaps also a slight decline in *Quercus*) and immediately after the alder decline. Although these data must be interpreted with caution, and any conclusions must be tentative, the occurrence of charcoal in relative abundance at comparable positions in the two profiles does point to episodes of burning. Whether this was anthropogenic or natural (eg lightning fires) cannot be determined on present evidence.

Plant macrofossil analysis

The sample was dominated by monocotyledonous stems and roots, largely *Phragmites communis*. *Eupatorium cannabinum* seeds were abundant and hemp agrimony may form a tall herb fen community with *Phragmites* (NVC S25 *Phragmites australis-Eupatorium cannabinum*). In open water it sometimes grades into *Phragmites australis* swamp and on drier ground may be a transition to *Salix cinerea-Betula pubescens-Phragmites australis* woodland or *Alnus* *glutinosa-Carex paniculata* woodland (Rodwell 1995, 240), which from the pollen and wood evidence might be the case here. *Typha* spp. seeds were also abundant and are typical of fen and swamp vegetation communities. The other taxa recorded are *Rumex* sp., which similarly can be found in fen or swamp, and *Suaeda maritima* which can occur in reed swamp but is frequently found in salt marsh. The presence of the latter may therefore hint at a slightly brackish influence. The results tend to confirm that the high Poaceae pollen values in the diagram from trench 1a are likely to be attributable to *Phragmites* and it is probable that the *Solidago virgaurea* type pollen is at least partially derived from *Eupatorium cannabinum.*

Wood identification

Alnus glutinosa was identified in samples from both trench 1a and trench 3, whilst *Salix* sp. was also recognised in trench 3. Both are typical of carr woodland. The wood identifications are in close agreement with the pollen records, with alder well represented in the pollen record from trench 1a and both alder and willow frequent in the record from trench 3.

Diatom analysis

The three diatom samples from the lower silty clay in trench 3 have low or very low diatom concentrations and poor diatom preservation. The two lower samples from 76-77 cm and 74-75 cm each contain a few valves of the polyhalobous to mesohalobous (marine-brackish) species *Pseudopodosira westii* along with poorly-preserved remains of unidentifiable diatom taxa. *Pseudopodosira westii* is a planktonic, marine-brackish diatom, which may begin its lifecycle in benthic habitats. The presence of this coastal diatom indicates that the environment was tidal. However, the survival of only this heavily silicified species is also a reflection of the preferential preservation of a robust diatom. Preservation in the uppermost sample from the basal silty clays is also poor, with low valve concentrations and low species diversity. *Pseudopodosira westii* is once again most common, but there are also valves of the marine planktonic species *Podosira stelligera*, the brackish water, benthic diatom *Nitzschia navicularis*, and fragments likely to be those of another brackish water, benthic species, *Navicula peregrina*. The presence of both marine and brackish species suggests that there is a trend of decreasing salinity compared with the basal samples from the sequence.

Diatoms are well preserved or moderately well preserved in the three samples from the upper silty clay in the sequence from trench 3. A brackish-marine diatom flora dominates the lower samples from nearest to the clay-peat contact (8-9 cm, 4-5 cm). They have a high proportion of brackish (mesohalobous and halophilous) diatoms and also have traces of freshwater taxa, although in the latter case *Pinnularia major* may represent a semi-terrestrial species that has been washed into the sedimentary environment. These two samples also contain significant numbers of planktonic marine diatoms such as *Paralia sulcata* and *Podosira stelligera* showing that there was contact with the estuary. However, most notable were the relatively high numbers of mesohalobous, benthic diatoms such as *Navicula peregrina, Navicula digitoradiata, Caloneis westii* and *Navicula cincta.* These diatoms are typical of the mud-surface, epipelic algal community in brackish water and probably represent an autochthonous component of the diatom assemblage. The diatom assemblage from 0-1 cm, in contrast to the lower samples of the upper silty clay, is a marine-brackish one. From the skeleton diatom count, halophilous and freshwater taxa appear to be absent whilst the mesohalobous taxa that are present are associated with the upper end of the brackish salinity range. These mesohalobes are the benthic, probably epipelic, diatoms *Nitzschia navicularis* and *Diploneis didyma.* The marine species include *Paralia sulcata, Podosira stelligera* and *Pseudopodosira westii.* The impression gained is one of increasing salinity from the upper peat-clay contact towards the top of this sequence.

Four samples were assessed from trench 1a, two from the silty clay below a band of peat and two from the silty clay above the peat. The samples from below the peat at 32-33 cm and 28-29 cm have poor diatom preservation, very low diatom concentrations and low species diversity. Both contain the marine-brackish species *Pseudopodosira westii.* A single valve of the marine species *Podosira stelligera* was found in the sample from 28-29 cm. Like the lower two samples from the basal silty clay of trench 3 the survival of these species reflects the robust nature of their valves. However, their presence also indicates that the sedimentary environment was tidal.

The two samples from the upper silty clay in trench 1a at 8-9 cm and 4-5 cm have a good, and moderate to poor quality of preservation respectively. Valve concentrations and diversity at 8-9 cm are relatively high, whilst at 4-5 cm diatom concentrations and species numbers are moderate to low. Like the sample from immediately above the upper peat-clay contact in trench 3, the sample from 8-9 cm in trench 1a contains traces of freshwater taxa. These are *Fragilaria pinnata*, and the aerophilous species *Hantzschia amphioxys*, which may represent periodic drying out of the habitat or the inwash of terrestrial material. Similar to the basal part of the upper clay in trench 3, benthic, brackish water species are common and they are likely to originate from epipelic (mud-surface) habitats. These species include *Navicula peregrina, Navicula digitoradiata, Caloneis westii, Nitzschia navicularis* and *Stauroneis* cf. *amphioxys*. The most common single species in the skeleton count is the marine planktonic diatom *Paralia sulcata* and there are a number of other marine and marine-brackish (polyhalobous, and polyhalobous to mesohalobous) diatoms indicating that tidal conditions were prevalent. The uppermost sample from this sequence (4-5 cm) does not contain freshwater diatoms and the assemblage appears to be from an environment of slightly higher salinity than the assemblage from 8-9 cm. The estuarine, benthic species *Nitzschia navicularis* is most common along with the marine species *Paralia sulcata*. Diatoms of the marine genus *Rhaphoneis* are also present and there are marine-brackish diatoms. Other mesohalobous, benthic species, similar to those at 8-9 cm are also present. These species, which are probably from the epipelic community, include *Navicula peregrina, Navicula digitoradiata* and *Caloneis westii*.

Chronology

The six radiocarbon age determinations date the time of peat accumulation to the late Holocene (later prehistoric) period. If the dates are correct, the peats formed over a time interval of around 1100 ^{14}C yrs between *c.* 3700 and 2600 ^{14}C yrs BP. The date for the onset of peat accumulation in trench 1a is 3400 ± 70 BP (Beta-157363), which calibrates to 3840-3470 cal BP (1890-1520 cal BC). In trench 3, two dates were obtained from the lower part of the sequence: 3750 ± 70 BP (Beta-157361) from the base of the silty organic clays, and 3670 ± 80 BP (Beta-157210) from just below the contact between the silty clays and the overlying peats (see Figure 4). The calibrated age ranges for these dates are 4350-3900 cal BP (2400-1950 cal BC) and 4240-3820 (2290-1870 cal BC respectively. An interpolated age, based on the two radiocarbon dates, places the boundary between the lower silty clays with organic remains and the overlying silty peat at *c.* 3710 ^{14}C yrs BP. Although Beta-157363 (trench 1a) and Beta-157210 (trench 3) are statistically indistinguishable (the standard errors overlap by 30 years at 2σ and the calibrated ranges overlap by 20 years), the fact that the date of 3670 ± 80 BP from trench 3 is from a horizon some 5 cm above the stratigraphic contact between the silty peat and underlying clay with organic fragments suggests that the onset of peat accumulation occurred earlier at that site (possibly by at least 100 years) by comparison with trench 1a.

The radiocarbon dates on the upper peat/silt-clay horizon are closer in age: 2770 ± 70 ^{14}C yrs BP (Beta-157362) in trench 1a and 2610 ± 60 ^{14}C (Beta-157208) in trench 3. The calibrated age ranges are 3050-2760 cal BP (1100-800 cal BC) for trench 1a, and 2800-2510 cal BP (850-560 cal BC) for trench 3. Hence, while the dates are statistically significantly different (at 2σ) in terms of their *measured* radiocarbon age, with the date from trench 3 being the younger, the *calibrated* age ranges do, in fact, overlap by 40 cal yrs BP (50 cal yrs BC). This means that, at the 95% level of probability, the calibrated ages are statistically indistinguishable. The date on the thin silt band at 30-32 cm in trench 3 (2660 ± 60 BP) which falls between these two age determinations is also clearly inseparable, a point that is returned to below.

The radiocarbon dates provide some indication of rates of peat accumulation in the two profiles. If the upper and lower dates from trenches 1a and 3 are used as a basis for calculation, these suggest a rate of peat accumulation in the trench 1a profile of *c.* 0.02 cm/^{14}C yr^{-1}, by comparison with *c.* 0.06 cm/^{14}C yr^{-1} for trench 3. A very similar accumulation rate for the upper 50 cm of peat in trench 3 (0.05 cm/^{14}C yr^{-1}) is obtained if the date from 58-60 cm (Beta-157210) is compared with the uppermost date (Beta-157208) from that profile. Overall, these figures tend to indicate that peat accumulation was much more rapid in the trench 3 profile than in trench 1a. Moreover, the lower peats in trench 3 (ie below the silty clay band) appear to have accumulated much more slowly (0.02 cm/^{14}C yr^{-1}) than the peats above the silty clay band (0.42 cm/^{14}C yr^{-1}, which is comparable to the rate of peat accumulation in trench 1a). This may reflect the fact that the upper peats were much wetter, thereby supporting the suggestion of a positive sea-level tendency at that time. However, the above figures must be viewed with a degree of caution, partly because of possible errors in the radiocarbon dates, and partly because post-depositional stresses on, and within, the sediments overlying the peats could have led to differential compaction within the two peat sequences (see Allen 1999). Indeed, it has been suggested that the majority of sediments used as index points in sea-level change studies have been subjected to post-depositional displacement in altitude, largely as a result of compaction of the underlying peat, clay and silt (Shennan and Horton 2002). Morever, while the compaction of deposits with a high sand fraction appears to be low, compaction of peat may be as high as 90% by volume (Shennan *et al* 2000). Equally, in the case of the Wentlooge RFT sequences, the possibility cannot be excluded that some of the peats may have been eroded, although there is nothing in the pollen records to indicate that this might have occurred.

On the basis of the dating evidence, trench 1a appears to have been more susceptible to inundation than trench 3, in that the negative sea-level tendency reflected at the base of the profile is later and the positive sea-level tendency recorded in the upper part of the sequence appears to have been earlier than at trench 3. Insofar as the sequence in trench 3 is at a lower altitude than trench 1a (see above) the reverse might be expected, ie a relative sea level fall occurring first at the higher site (trench 1a) with the subsequent relative sea-level rise being recorded first at the lower site (trench 3). However, in view of the variations in patterns of sedimentation in these near-shore and salt-marsh margin contexts that can give rise to considerable vertical and lateral stratigraphic complexity over very short distances (Allen and Haslett 2002), allied to the possible effects of compaction in the sedimentary sequences (see above), what seem to be clear time-stratigraphic differences between the two Wentlooge RFT sequences may, in effect, be more apparent than real.

DISCUSSION

The various lines of palaeoenvironmental evidence are in broad agreement in showing that the buried sequences on the site of the proposed Wentlooge Railfreight Terminal reflect an initial episode of saltmarsh or intertidal conditions. As relative sea level fell, peat began to accumulate across poorly-drained land on the near-shore area on which an extensive alder carr developed. A mixed oak woodland, with hazel, lime and possibly also some pine, was to be found on drier sites to landward. A gradual decline in alder and an increase in grass and sedge pollen reflects a change from alder carr to *Phragmites*-dominated reedswamp, perhaps indicating a gradually rising water table as the sea encroached once again, a process which culminated in the complete inundation of these mires and the re-establishment of saltmarsh and tidal mudflats. This is reflected particularly in the diatom records from the two sites which shows evidence for increasing marine influence (and a decline in freshwater environments) in the upper levels of the profiles. The radiocarbon dates suggest that the transition from marine to terrestrial/semi-terrestrial and back to marine conditions occurred in around 1500 years, between *c.* 4200 and 2750 cal yrs BP (*c.* 2150-800 BC). This sequence of environmental and vegetational events is broadly comparable with that at other sites on the Severn Estuary levels, where peat deposits accumulated in near-shore environments during the Late Holocene (Smith and Morgan 1989; Walker *et al* 1998; Caseldine 2000). At some of these sites there is good evidence in the pollen and plant macrofossil records for human activity at that time. This is not the case in the Wentlooge RFT sequences, however, for while there *may* be indications in the pollen record for human activity, the evidence is by no means unequivocal. The charcoal finds are interesting and appear to indicate episodes of burning, possibly at the regional scale, although whether these can be attributed to people or are a consequence of, for example, lightning strikes, is a matter for conjecture.

Within this broad picture, however, there are some clear differences between the records from the two profiles, particularly in relation to sea-level change. For example, in trench 3 where the greatest thickness of peat is recorded, the lithostratigraphic transition from basal silts and clays to peat, which marks the sea-level index point (ie the point where the 'negative tendency' or sea-level fall is reflected in the profile) was not dated directly, but it lies almost mid-way between horizons dated at 3670 ± 80 BP (where rising *Alnus* values register in the pollen diagram) and 3750 ± 70 BP. A radiocarbon age for this horizon of around 3700 BP might therefore reasonably be inferred. In trench 1a, the comparable lithostratigraphic horizon is dated to 3400 ± 70 BP. At the latter site, the peak in *Alnus* pollen occurs at this level, ie at the lithostratigraphic transition from silts to peats; in trench 3, the alder maximum occurs at least 20 cm above the transition from the basal mineral sediments. The implication, therefore, is that marine conditions persisted at the site of trench 1a for some tens of years (maybe even hundreds of years) after the marine regression from the site of trench 3. On the calibrated timescale, the basal age determination from trench 3 points to marine regression from the site late in the fifth millennium BP (the third millennium BC).

As noted above, the radiocarbon dates on the upper parts of the profiles, ie on the contacts between the peats and the overlying silts clays, are statistically indistinguishable at the 95% confidence level (2610 ± 60 BP; 2770 ± 70 BP), although they differ at 1σ. In trench 3, however, a marked silt-clay band occurs some 20 cm below the upper silty clays (at 30-32 cm) and a radiocarbon date of 2660 ± 60 BP was obtained on this horizon, an age determination which is within 1σ of the uppermost date in trench 1a. In the pollen records, there is a degree of similarity between the spectra around the silt/clay horizon in trench 3 and the transition from organic to mineral sediments in trench 1a. Both of these levels follow the *Alnus* decline, *Quercus* values are falling, and there has been a significant increase in counts for Poaceae pollen. It is possible, therefore, that the positive sea-level tendency reflected in the transition from organic to mineral sediments is the same sea-level event, although at trench 3 the first registration, marked by the silt clay horizon, was relatively short-lived (a possible storm surge, for example). At that site, *Phragmites* reedswamp managed to survive complete marine inundation for a further few years before it too succumbed to rising sea levels. The date for this positive sea-level tendency of early/mid third millennium BP (first millennium BC) is broadly in accord with dating evidence from a number of sites for sea-level rise in the Severn Estuary (Godwin and Willis 1964; Allen and Fulford 1986; Walker *et al* 1998), although slightly earlier dates have been obtained from other sites, such as Goldcliff (Smith and Morgan 1989; Bell *et al* 2000 - Figure 1B).

CONCLUSIONS

1. The two buried peat sequences from the site of the proposed Wentlooge Rail Freight Terminal provide evidence of changing environmental conditions in the area from late in the fifth millennium BP to the early/mid third millennium BP (*c.* 2150-800 BC).

2. A negative sea-level tendency (marine 'regression') radiocarbon dated to 3750 ± 70 BP (4350-3900 cal BP) is recorded in the deeper (and thicker) of the peat sequences (trench 3), and marks the transition from tidal salt marshes to coastal mire. This transition from marine (or near marine) to terrestrial condition occurred some tens (possibly hundreds) of years later at the second site (trench 1a).

3. An extensive alder carr developed in the near-shore area, while to landward were areas of mixed oak woodland.

4. A decline in alder, radiocarbon dated to 3400 ± 70 BP (4240-3820 cal BP), and a gradual increase in grass and sedge pollen reflects a transition at both sites from alder carr to *Phragmites*-dominated reedswamp. This may be a consequence of rising water tables as sea level began to rise once more.

5. Both sites were inundated by rising sea-level and tidal saltmarshes re-established early in the third millennium BP. Radiocarbon dates place this event around 2600-2800 ^{14}C years BP (c. 3050-2500 cal BP).

6. There is evidence in both profiles for extensive burning episodes, and while these may be human induced, the lack of unequivocal indicators of human activity in either the pollen or plant macrofossil records suggests that these fires could equally have been the consequence of, for example, lightning strikes.

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