ROMNEY MARSH

Persistence and Change in a Coastal Lowland

Edited by
Martyn Waller, Elizabeth Edwards and Luke Barber

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2. The Mid–Late Holocene Evolution of Southern Walland Marsh and the Origin of the 'Midley Sand'

Jason Kirby, David Clarke, Tim Shaw and Emma Toole

This paper documents new litho-, bio- and chronostratigraphic information and sedimentological data from sites at Sandyland on Broomhill Level, Midley and Lydd. These locations are situated between former tidal inlets at Romney and Rye which were instrumental in driving Foreland and Marshland environmental change during the last 2000 years. Peat formation commenced c. *4500 cal. yr BP at Sandyland and after 3700 cal. yr BP at Lydd. At Sandyland, eutrophic fen carr communities were replaced by acidic, nutrient-poor* Myrica*-dominated vegetation from* c. *4100 cal. yr BP, a shift reported from other sites on Walland Marsh and from neighbouring areas. At Lydd, there was no local development of* Myrica*, probably due to the proximity of the site to tidal channels associated with an opening in the barrier at Hythe. Inundation occurred sometime after* c. *2300 cal. yr BP at both sites although the upper contacts of the peat are sharp and have probably been eroded. The sedimentological investigations of the surface outcrops of 'Midley Sand' at Sandyland and Midley, combined with other stratigraphic and palaeogeographic evidence, are consistent with deposition in a tidal channel. The data support the existence of an open-ended channel connecting the inlets at Romney and Rye between AD 700 and the 12th century AD, which had already begun to infill and become reclaimed prior to the storms of the 13th century AD. The Wainway Channel appears to be a later feature which developed in the area after the closure of the Romney inlet and enlargement of the Rye inlet as a result of these storms.*

Introduction

The deposits of the former wetlands of the Romney Marsh region (Fig. 2.1) have been subject to detailed palaeoenvironmental scrutiny over the past few decades (see Long *et al.* 2007 for most encompassing work). This has provided a wealth of information on vegetation history (reviewed by Waller 2002), relative sea-level (RSL) change and coastal response (Long and Innes 1993; Long *et al.* 1996; 2006a; 2006b), barrier evolution (Greensmith and Gutmanis 1990; Long and Hughes 1995; Plater and Long 1995; Long *et al.* 2006a; Roberts and Plater 2007; Plater *et al.* 2009) and back-barrier environments (Waller *et al.* 1988; 1999; Long and Innes 1995a; Long, A.J. *et al.* 1998; Spencer *et al.* 1998a; 1998b; Plater *et al.* 1999). With a stratigraphic database consisting of thousands of borehole records, and over 30 radiocarbon-dated pollen diagrams the area probably now represents the most intensively studied coastal lowland in the UK. In recognition of its scientific and geomorphological importance, Dungeness

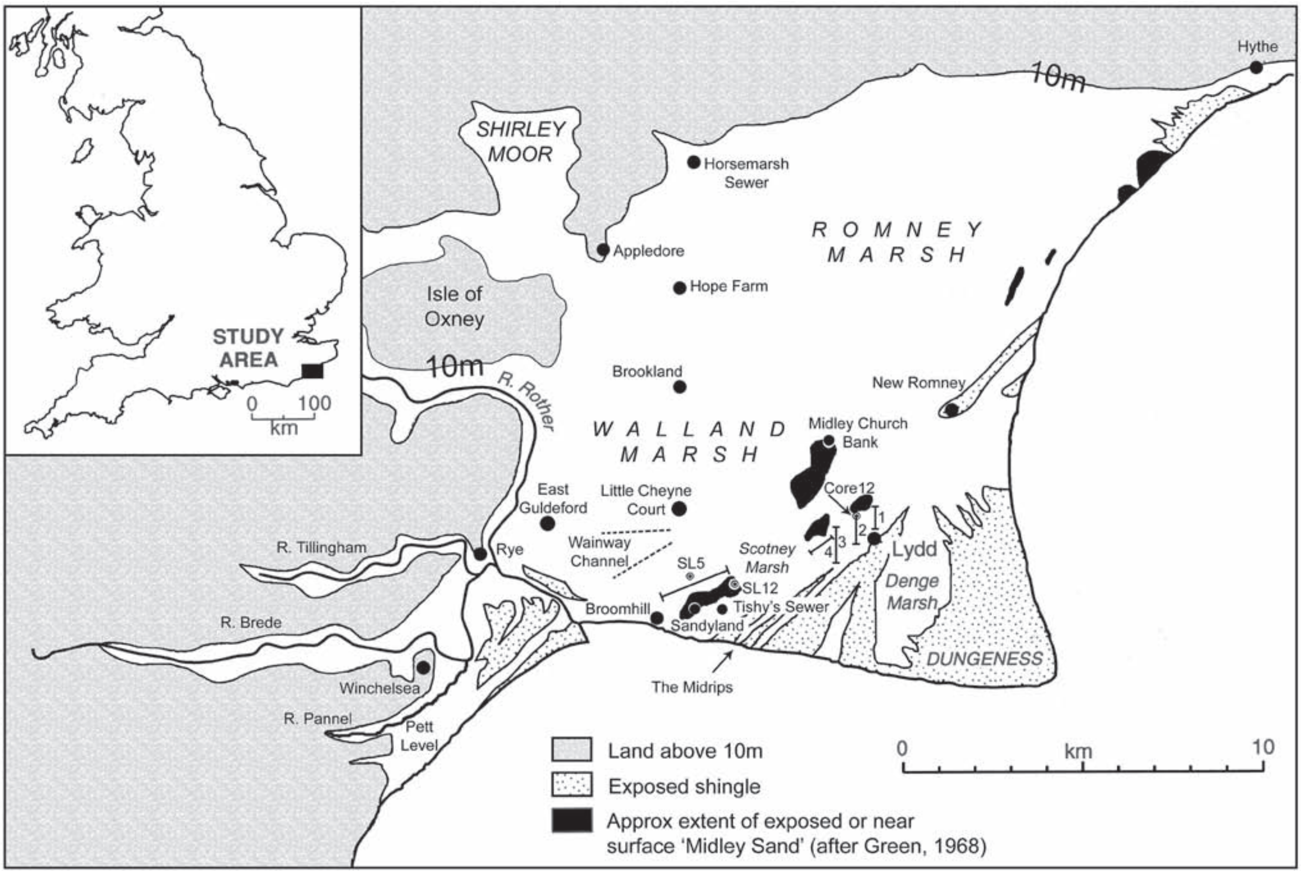

Fig. 2.1. Map of study area including location of core transects, sampled boreholes and sites mentioned in the text.

Foreland and its interfacing Marshland deposits were designated by Natural England as a Site of Special Scientific Interest (Dungeness, Romney Marsh and Rye Bay SSSI) in 2006.

This body of research has added considerable local detail to the basic stratigraphy first described in the pioneering work of Green (1968). The Holocene back-barrier lowlands of the Romney Marsh region and surrounding river valleys comprise well over 20 metres of unconsolidated wetland deposits (Long *et al.* 1996; Waller and Kirby 2002) typically consisting of four main stratigraphic units; a lower sand, blue clay, an extensive 'main Marsh peat' and finally a variable unit of oxidised sands, silts and clays near the surface (Waller *et al.* 1988; Long and Innes 1995a; Long, A.J. *et al.* 1998; Spencer *et al.* 1998a). The sands and clays underlying the peat accumulated during the early to mid-Holocene when the coastline was further inland during a period of rapid RSL rise (Long and Innes 1993; Long *et al.* 1996). Subsequently, the rate of RSL rise began to slow and the progradation of the gravel deposits along the coast created a sheltered back-barrier area in which freshwater deposits accumulated (see the palaeogeographic maps of Long *et al.* 2006a).

The freshwater wetlands consisted mainly of eutrophic *Alnus glutinosa* dominated fen carr environments which spread out from the valleys to the west from around 6000 cal. yr BP and out into the back-barrier area of Walland Marsh (Long and Innes 1995a; Waller *et al.* 1999; Waller and Schofield 2007a) reaching their maximum extent around 3200 cal. yr BP (Long, A.J. *et al.* 1998). These eutrophic wetlands persisted for several thousand years in the valleys and on edge of Romney Marsh (Waller 1993; 1994). However, the central and southern parts of Walland Marsh became progressively isolated from the nutrient-rich water draining from the uplands and so developed, through hydroseral succession, into *Betula*- and *Myrica gale*-dominated poor fen, and ultimately into raised bog at Little Cheyne Court and East Guldeford (Waller *et al.* 1999; Waller and Schofield 2007a; 2007b).

The deposition of the upper clastic sediments resulted from the final inundation of the Marshland peat deposits by marine incursion related to the progressive breakdown of the protective gravel barrier which enabled tidal inlets to develop and flood the back-barrier area. Reconstructions of these inlets based mainly on historical archives have been undertaken (e.g. Cunliffe 1980; Green 1988, reviewed in Tooley 1990) but the most recent and detailed model describing the complex coastal evolutionary changes during the late Holocene is that of Long *et al.* (2006a). Using a large database comprising geological (litho-, bio- and chronostratigraphic) and geomorphological data coupled with available archaeological and historical information, a detailed palaeogeographic model is proposed. Three former tidal inlets are central to this model, their emergence and closure playing a pivotal role in driving the pattern of back-barrier inundation and sedimentation during over last 2000 years.

Long *et al.* (2006a) suggest that at Hythe, an inlet was open to the sea from at least AD 400 which is corroborated by stratigraphic data (see Long, A.J. *et al.* 1998) and archaeological evidence including the existence of a Roman port and the remnants of salt-workings (Cunliffe 1988; Reeves 1995). By AD 700, the Hythe inlet had largely infilled (the calcified soils of Green, 1968) and the 'New Romney inlet' became the main conduit for tidal water into the back-barrier areas. The third major tidal inlet developed to the southeast (the 'Rye Inlet') and is historically well known due to its association with the storms of the 13th century AD (Green 1968; Eddison 1998). However, Long *et al.* (2006a) present evidence which suggests the existence of an inlet at Rye from *c*. AD 700. Radiocarbon dates of *c*. 1300 cal. yr BP from the surface of the peat and rootlets found within overlying marine sediments at West Winchelsea (Waller and Schofield 2007a) point to an earlier breach at a time when the inlets at New Romney and Rye may have been connected (Long *et al.* 2006a).

The breaches at New Romney and Rye are likely to be linked to sediment starvation associated with the continued northwards littoral drift of gravel towards Hythe and/or the existence of tidal channels flowing adjacent to the gravel beaches on the inside of the barrier – both of which would weaken the integrity of the barrier and render it vulnerable to breaching (Long *et al.* 2006a). The well-documented flooding that occurred associated with a period of major storms from AD 1250 (Eddison 1998; 2000), and resulted most famously in the abandonment of the town of Old Winchelsea, is related to this breakdown in barrier integrity, but rather than creating an inlet, it appears to have significantly widened a pre-existing opening in the barrier at Rye (Long *et al.* 2006a). This event precipitated the final inundation of Walland Marsh, the last area to be flooded being the raised bog which went under *c*. 900 cal. yr BP at Little Cheyne Court and East Guldeford (Waller *et al.* 1999; Waller and Schofield 2007a).

Previous Work on Southern Walland Marsh and Broomhill Level

The first stratigraphic investigations of the back-barrier sediments on Broomhill Level were undertaken by Tooley and Switsur (1988) and Tooley (1990). The gravel at Broomhill is largely buried by clays, silts and sands but occasionally, peats occur in the gravel lows. Tooley and Switsur (1988) describe one such organic deposit which directly overlies the gravel at Tishy's Sewer. The basal sample from this peat was radiocarbon dated to *c*. 3600–3800 cal. yr BP. This date is corroborated by pollen data (indicating formation after the *Ulmus* decline) and provides a maximum age for gravel deposition in the area. Subsequent optically stimulated luminescence (OSL) dating by Roberts and Plater (2007) on the shoreface sands beneath this gravel provides a minimum age for the deposition gravel of *c*. 4700 BP. A radiocarbon date from the top of the peat at Tishy's Sewer indicates a minimum age for deposition of the overlying clays of *c*. 3500–3200 cal. yr BP.

The work of Tooley and Switsur (1988) provides a detailed local palaeoenvironmental history for Broomhill but a much wider stratigraphic framework linking back-marsh, fore-marsh and barrier interface sites is required to establish the relationship between sites and provide a more holistic understanding of the evolution of Walland Marsh in response to changing boundary conditions (e.g. RSL change, barrier dynamics etc.). With this aim in mind, Long and Innes (1995a) presented a 12 km long, Marsh-wide stratigraphic transect connecting sites in the north and south of Walland Marsh. This revealed the typical Marsh stratigraphy described by Green (1968) and Waller *et al.* (1988) with a thick peat extending out and across the Marsh which is notable by its absence at the southern end of the transect on Broomhill Level where the sediments of the Wainway Channel are encountered and the back-barrier deposits interface with the gravel.

There is much less spatial consistency in the stratigraphy in the fore-marsh and barrier interface area of Scotney Marsh (between Broomhill Level and Lydd, Fig. 2.1) and the peat deposits here are less extensive than at the mid- and back-marsh sites on Walland Marsh. This relative complexity is well illustrated by the work of Spencer *et al.* (1998a; 1998b) who meticulously collected a lithostratigraphic database of over 3400 cores from Scotney Marsh and surrounding sites supplemented with palaeoenvironmental information (diatoms, pollen, particle-size data and radiocarbon dating). Spencer *et al.* (1998b) also present two *c*. 10 km long stratigraphic transects linking the barrier interface sediments of Scotney Marsh with the main back-barrier deposits on Walland Marsh. These demonstrate that in the main back-barrier environment, peat dating to *c*. 3900 cal. yr BP abuts the gravel west of Lydd and indicates deposition of the gravel here sometime before *c*. 4000 cal. yr BP. Recent OSL dates from the shoreface sands beneath the Midrips suggests gravel was in place in this area *c*. 4700 BP, soon after the deposition of the stratigraphically equivalent deposits to the west at Broomhill (Roberts and Plater 2007).

Scotney Marsh itself consists of an undulating subsurface of gravel with a prominent topographic low (the Scotney trough) bisecting two gravel ridges (Spencer *et al.* 1998a; 1998b). Several phases of peat development are recorded here with peat forming initially *c*. 3300 cal. yr BP under ponded freshwater conditions (Spencer *et al.* 1998a). However, clastic deposits overlying and intercalated with these deposits suggest multiple phases of inundation with tidal waters propagating behind the gravel soon after peat inception *c*. 3200 cal. yr BP (Spencer *et al.* 1998a). A second phase of peat accumulation is dated between *c*. 1600 and 2100 cal. yr BP (Spencer and Woodland 2002) followed by gradual inundation by marine waters.

Two major stratigraphic and topographic features characterise the deposits on southern Walland Marsh and separate them from the deposits typical of the back- and mid-marsh sites described above. The first of these is the Wainway Channel, a *c*. 1 km wide palaeochannel composed of clastic sediment (including heterolithic tidal rhythmites of laminated clays, silts and sands). This marks a striking stratigraphic divide between the widespread peat deposits occurring to the north and an apparent absence of laterally continuous *in situ* peat to the south (Tooley 1990; Long and Innes 1995a). The historical and sedimentological aspects of this channel have been documented by Eddison (1998), Evans *et al.* (2001) and Stupples (2002) but a robust chronology is lacking. Two dates on *Cerastoderma edule* mollusc shells are available which provide a minimum age for deposition of Wainway Channel sediments and range from 655–925 cal. yr BP (from near the top of the sequence, Evans *et al.* 2001) to 445–535 cal. yr BP from a much deeper stratigraphic position (Stupples 2002). Historical evidence suggests the feature existed from at least the early 13th century (Parkin 1973; Ward 1952, fig. 1) and the channel appears as a significant feature on maps dating from the 16th century (Eddison 1983; 1998; Green 1988).

However, questions remain regarding the role of this channel in the late Holocene evolution of Walland Marsh and its relationship (if any) with the emergence and closure of the tidal inlets described by Long *et al.* (2006a). Furthermore, organic material was recorded by Long and Innes (1995a) at the southern end of their stratigraphic transect at Sandyland, indicating that the Wainway may have cut through former peatlands and eroded peat balls are reported in the sediments of the Wainway by Evans *et al.* (2001) and Stupples (2002). This suggests that peat deposits associated with the final limits of the main Marsh peat might still exist between the Wainway and the gravel deposits on Broomhill Level. This is of particular interest since a large area of raised bog formerly existed in the area (Waller *et al.* 1999; Waller and Schofield 2007a) yet its full extent has not been properly determined and little is known about the nature of surrounding transitional vegetation communities or their relationship to the rest of the Marshland palaeoenvironments. The deposits of southern Walland Marsh are therefore pivotal to the understanding of late Holocene evolution of the Romney Marsh region, in particular the nature and extent of the former peatlands and their associated vegetation communities.

The second major stratigraphic feature is the so called 'Midley Sand' described and mapped by Green (1968, fig. 6) as a roughly linear series of distinct sand outcrops extending along the back of the gravel from Midley Church Bank to Sandyland on Broomhill Level (see Fig. 2.1). These were originally thought by Green to have been the surface expression of the lower blue-grey sands which underlie the main Marsh peat across much of Walland Marsh. This interpretation was central to some of the early theories of barrier formation and Marshland evolution since it led Lake and Shephard-Thorn (1987) and Greensmith and Gutmanis (1990) to suggest that they represented the remnants of a formerly more extensive sand ridge which acted as a precursor to the development of an early barrier. Long and Innes (1995b) conducted palaeoenvironmental investigations into the origins of the 'Midley Sand' and demonstrated conclusively that far from being one of the oldest deposits on the Marsh, they overlay a peat layer which has a surface age of between *c*. 2150 and 2350 cal. yr BP making them in fact one of the youngest Marsh deposits and as such, they could no longer be used to support any theories of early sand barriers. Tooley (1995) also noted that Green (1968) mapped surface deposits outcropping between gravel ridges on Broomhill Level as 'Midley Sand' which must post-date the emplacement of gravel here too.

Despite establishing the stratigraphic context of the deposits, Long and Innes (1995b) concluded that further sedimentological analyses were required in order to fully establish the depositional origin of the 'Midley Sand' and suggested several hypotheses; that they may have accumulated as an aeolian deposit, or that they represent water-lain sand banks possibly within a former tidal channel. It has long been recognised that as a consequence of differential erosion, transportation and depositional processes, sediments from contrasting depositional environments can possess distinctive particle-size distributions (Visher 1969; Middleton 1976; Bagnold and Barndorff-Nielsen 1980; Bridge 1981). This then provides an effective means of testing the various hypotheses for the origins of the 'Midley Sand'.

The aims of this paper can then be summarised as following:

- to present new stratigraphic information from Broomhill Level and Lydd which improve our knowledge of the late Holocene evolution of southern Walland Marsh, a key area for understanding the development of the tidal inlets at New Romney and Rye and any links between them.
- to establish the extent, nature and timing of organic deposition in the barrier interface environment of southern Walland Marsh, their relationship with the extensive peats elsewhere and any spatial differences in the vegetation communities.
- to establish the depositional origin of the 'Midley Sand' using particle-size characteristics.

Methods

Lithostratigraphic investigations were undertaken using a 1 metre long, 30 mm diameter, Eijkelkamp gouge auger and sediments were described according to the Troels-Smith (1955) method of classification. A modified Stitz piston corer was used to sample the peat at Sandyland whereas the peat at Lydd was sampled directly from the gouge auger in the field. The 'Midley Sand' at Sandyland and Midley was sampled in the field using an Edelman type auger. Samples were kept in cold storage prior to laboratory analysis. All core locations were surveyed using a Total Station to the nearest Ordnance Survey benchmark.

Pollen data were prepared in the laboratory following the standard treatments of Moore *et al.* (1991) and slides mounted in silicon oil. At least 300 total land pollen grains were counted in all samples apart from two samples at the base of the peat at Sandyland where preservation was poor and a count of only 200 was achieved. Nomenclature for pollen taxa follows Bennett (1994). Pollen data are expressed as a % of Total Land Pollen (TLP) and displayed graphically using the TILIA and TGView software developed by Grimm (1991; 2004). The data have been delineated into Local Pollen Assemblage Zones (LPAZs) statistically using the cluster analysis software CONISS within TILIA (Grimm 1987).

Diatom samples were digested in 30% H_2O_2 following Battarbee *et al.* (2001), subsamples evaporated on a cover slip and mounted onto slides with Naphrax glue. Foraminifera samples were sieved between 63 μm and 500 μm sieves and analysed wet under a binocular microscope. Particle-size analysis was carried out using a Coulter Laser Granulometer (Coulter LS200) on aggregated samples not subjected to treatment with H_2O_2 according to the method of Allen and Thornley (2004). Data were analysed and plotted in GRADISTAT (Blott and Pye 2001) which uses the statistical characteristics and descriptive terms of Folk and Ward (1957).

Results

Core Descriptions

Fig. 2.1 shows the position of 12 boreholes undertaken at Sandyland, Broomhill Level. This location was selected as it is situated in a previously unsampled area between the Wainway Channel and the gravel barrier. It also lies between the areas studied in detail by Tooley and Switsur (1988), Tooley (1990), Spencer *et al.* (1998a; 1998b) and the end of the north–south transect bisecting Walland Marsh completed by Long and Innes (1995a). The cores were positioned along a transect beginning a few tens of metres east of core 121 of Long and Innes (1995a), extending in an easterly direction from TQ 98986 19805 to close to Pigs Creek Petty Sewer (TQ 99859 19922). Core spacing was usually 100 m unless a sudden change in stratigraphy was noted in which case core spacing was narrower. Cores SL 1 to 5 contain a basal grey sand (Fig. 2.2) which extends

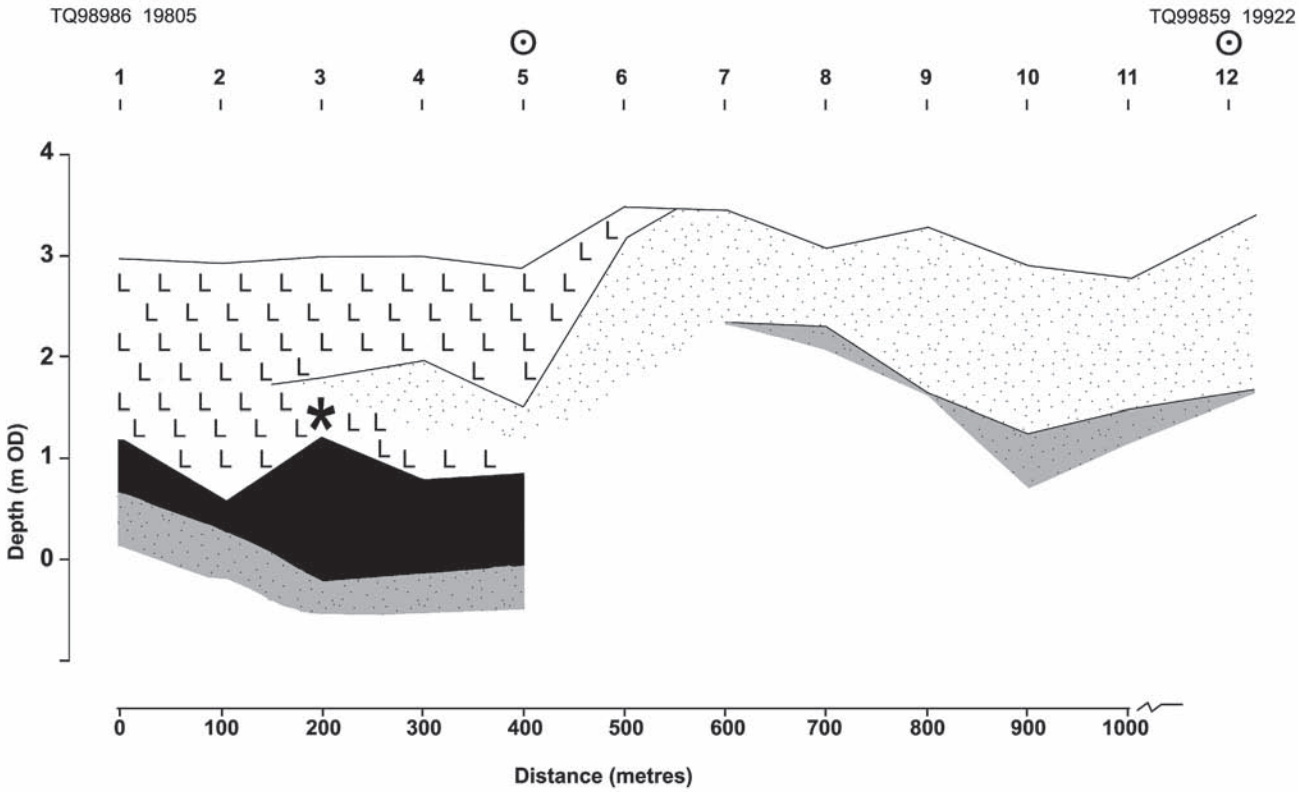

Fig. 2.2. Lithostratigraphy from Sandyland. Note that cores SL 1–11 are in a linear transect of cores and core 12 was sampled close to Pigs Creek Petty Sewer off the line of the transect. For key to the symbols used see Fig. 2.3d.

down to an unknown depth as saturation resulted in poor core recovery below the water table. This sand is directly overlain with peat up to *c*. 1 m in thickness which extends laterally several hundred metres and represents a spatially extensive deposit between *c*. 0 and 1 m OD. This is overlain by a variable unit of silty clay with sand containing orange oxidation mottles and sandy laminations. Remarkably, pottery was recovered in the gouge from this unit, at a depth of 1.57 cm in core SL 3 (see Plate 2.1). This has been identified as an 'oxidised (pale orange) jug bodysherd with traces of a dull green lead glaze on the exterior surface (most of the glaze has been worn off) and dates from the mid/late 13th to mid/late 14th century AD' (Luke Barber pers. comm.).

Cores SL 6 to 12 (note that core 12 is off the line of the transect) consist of an orange-brown sand at the surface (mapped by Green (1968) as 'Midley Sand'), which also occurs within the upper silty clay unit in cores SL 3, 4 and 5. This homogeneous sand becomes grey with depth as reduced conditions occur beneath the water table and becomes saturated preventing recovery below *c*. 2 m in depth. Core SL 5, containing the thickest organic sequence and apparently intact upper and lower peat boundaries (see Table 2.1), was sampled for palaeoecological analyses (pollen and diatoms) and core SL 12 was sampled for particle-size analysis.

A further 35 boreholes were sunk at 100 m spacing northwest of Lydd; 30 cores were aligned along three roughly north–south transects with an additional 5 cores taken along a fourth transect extending in a north-east/south-west alignment adjacent to the Tore Wall (see Fig. 2.1 for transect locations). This area was selected since it lies between Midley Church Bank (studied by Long and Innes 1993; 1995b) and the area investigated by Spencer *et al.* (1998b) where it was anticipated that potentially important Marsh sediments would interface with barrier deposits. All four transects (Fig. 2.3a, b, c and d) show a broadly similar stratigraphy; a grey sand containing occasional detrital organic debris (wood etc.) and shells occurs at the base, the bottom of which was not proved due to the difficulties inherent in recovering saturated sand in the corer. The only exception to this is core 11 at the end of transect 1 on the northern outskirts of Lydd, which is grounded in gravel overlain by a thin veneer of sand. Some gravel was also encountered in cores 10 and 20, again at the southern end of the transects within the grey sand, presumably as

Table 2.1. Lithology of the Sandyland SL 5 core. Description follows the Troels-Smith (1955) scheme.

Depth below surface (cm)	Altitude (m OD)	Sediment description (after Troels-Smith 1955)	Nig	Strf	Elas	Sicc	Lim Sup
0–21	2.87–2.66	Light brown sandy topsoil	2+	0	0	3	-
21–85	2.66–2.02	Light brown mottled sandy silty clay with indistinct laminations. As2, Ag1, Ga1, Th^0+, Lf+, Ptm+	2+	2	0	3	0
85–144	2.02–1.43	Brown-grey silty clay with sandy laminations. As3, Ag1, Ga++, Lf+, Ptm+	2+	3	0	3	0
144–151	1.43–1.36	Medium grey clayey sand. Ga2, As2	3	0	0	2+	0
151–202	1.36–0.85	Dark grey to black sandy clay with humified organic mottles and grey mottles of clay within matrix. As2+, Ga1+, Sh1	4	0	0	2+	0
202–226	0.85–0.61	Very dark brown to black well-humified, friable peat with traces of sand, dispersed but not throughout core. Sh4, Dh+, Ga+	4	0	0	2+	0
226–292	0.61 to –0.05	Medium brown woody peat with occasional *Phragmites* and *Menyanthes* seeds. Sand abundant from 2.63 downwards. $Th^2$2, Sh1, Dl1, Dh+, Ga+	3+	0	0	2+	0
292–300	–0.05 to –0.13	Grey sand with brown organic flecks and occasional clay banding (wood present over contact). Ga4, As+, Th^2+, Dl+, Sh+	2+	0	0	2	4
300–326	–0.13 to –0.39	Unrecovered saturated sand					

Table 2.2. Lithology of Lydd core 12. Description follows the Troels-Smith (1955) scheme.

Depth below surface (cm)	Altitude (m OD)	Sediment description (after Troels-Smith 1955)	Nig	Strf	Elas	Sicc	Lim Sup
0–40	2.21–1.81	Light brown topsoil	2+	0	0	3	-
40–141	1.81–0.80	Light orange-brown mottled silty clay with occasional sandy laminations. As2, Ag1, Ga1, Th^0+, Lf+	2+	1	0	3	0
141–173	0.80–0.48	Dark brown well-humified peat. Sh4, Ga+, As+, Th^2+, Dh+, Dl+	3+	0	0	3	1
173–190	0.48–0.31	Medium grey sandy clay with organic detritus and rootlets. As2, Ga2, Ag+, Sh+, Dg+, Th^2+	3	0	3	0	0
190–316	0.31 to –0.95	Medium, dark grey sand with humified organic detritus and occasional silty laminations and shells. Ga3, Ag1, Sh+, Ptm+	3	1	0	2	0
316–	–0.95	Borehole ends in unrecovered saturated sand					

wash-over deposits from the main gravel barrier to the south. Overlying the grey sand is a thin (max *c*. 30 cm) and discontinuous peat layer. In transect 1, this peat unit appears to have been eroded from many of the cores, whereas, in transects 2, 3 and 4, it is present in the majority. In some cores the transition from the basal sand into the peat consists of a blue-grey organic-rich silty clay with sand (e.g. cores 12, 22–5, 27–32, 33–5) whereas in others (e.g. 14–20), the peat lies directly on the sand deposit. The top of the peat is dry, compact and well-humified and the top contact with the overlying mottled silt-clay-sand

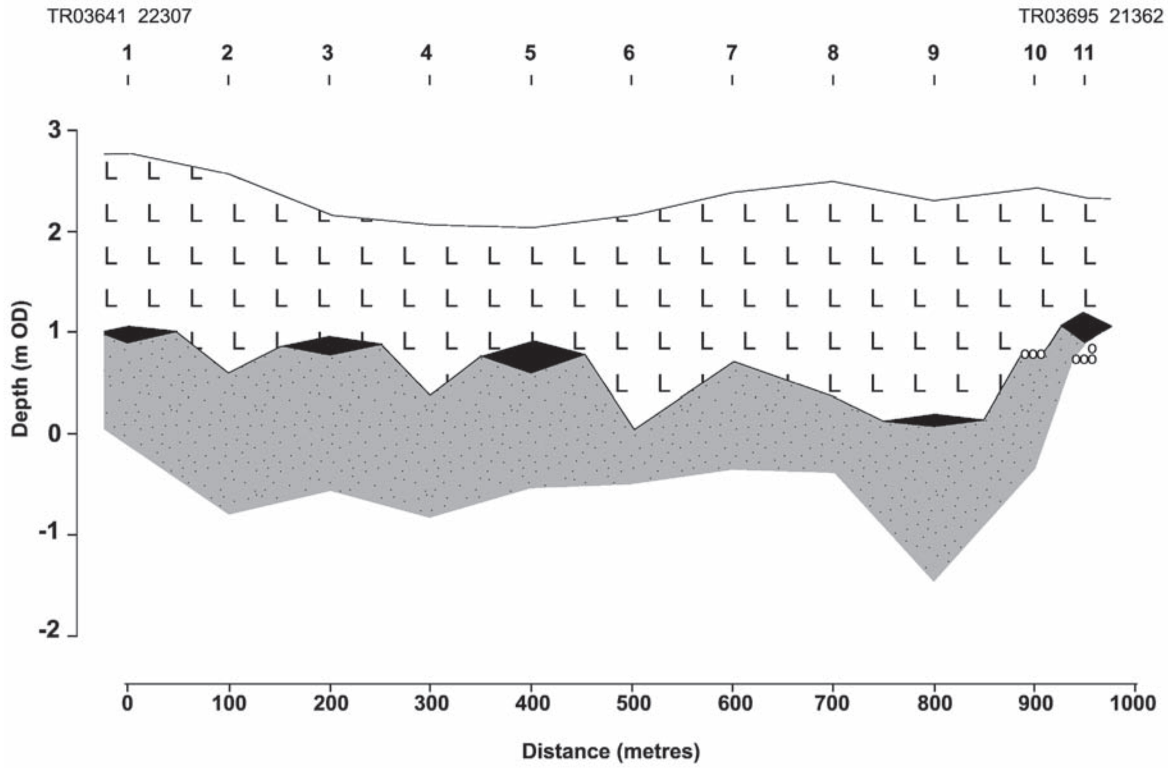

Fig. 2.3a. Lithostratigraphy from Lydd: Transect 1.

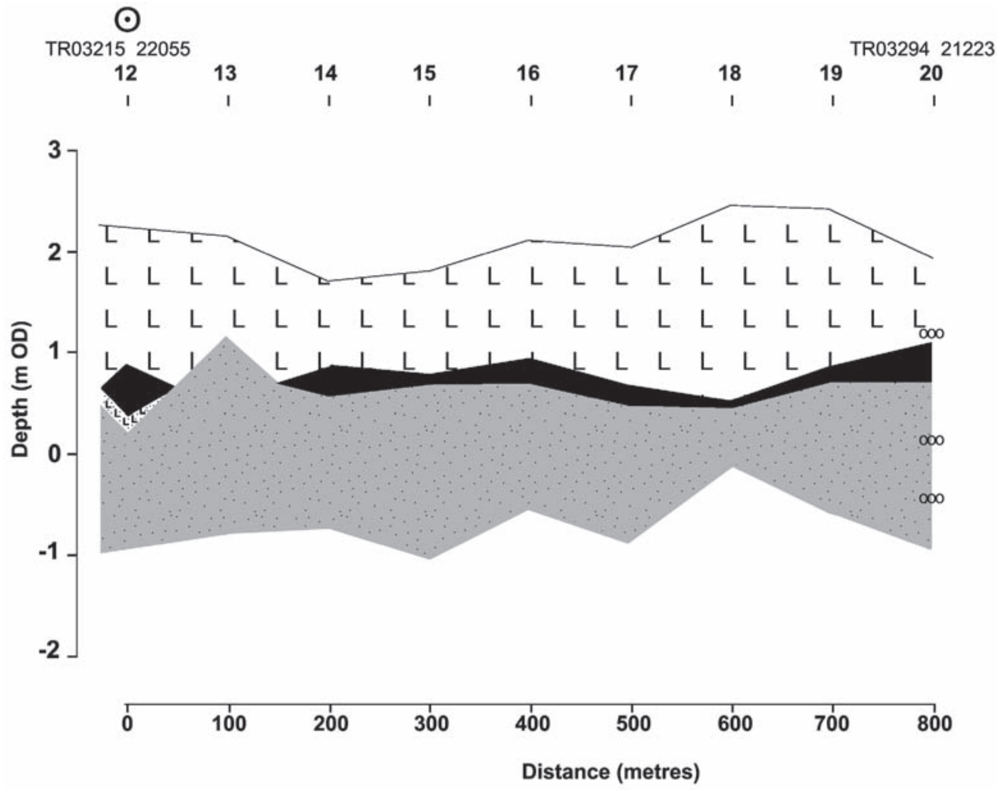

Fig. 2.3b. Lithostratigraphy from Lydd: Transect 2.

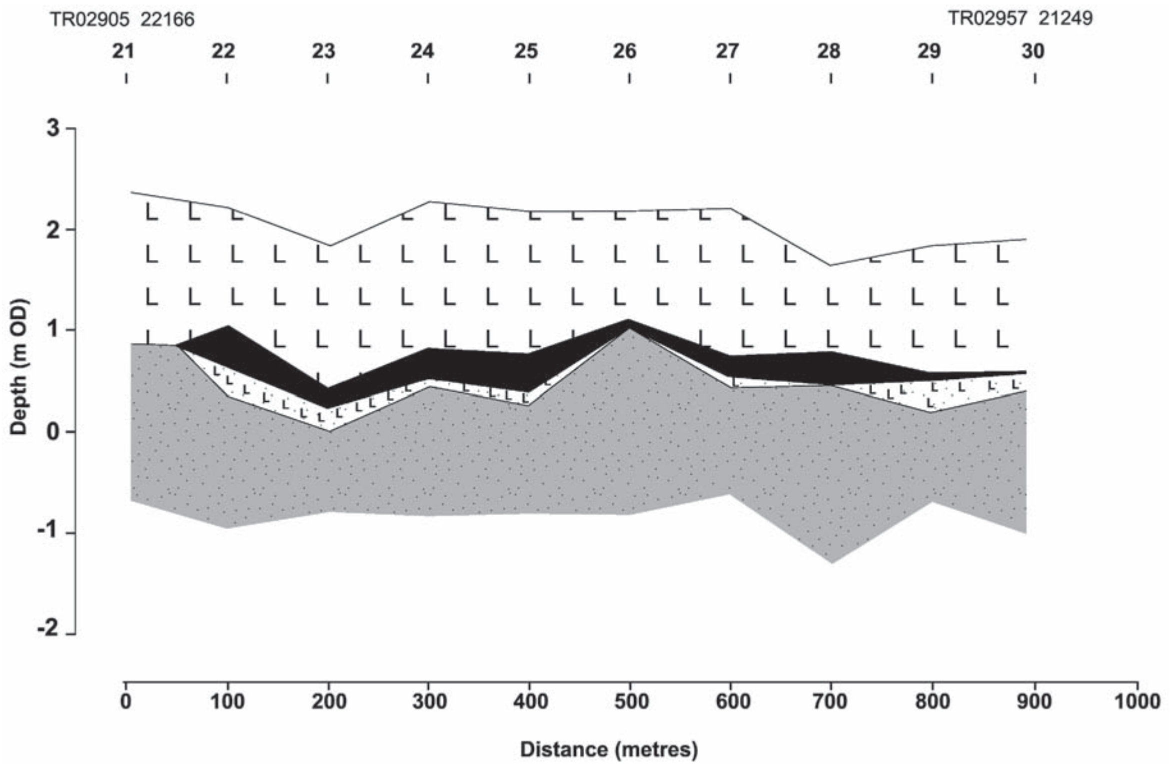

Fig. 2.3c. Lithostratigraphy from Lydd: Transect 3.

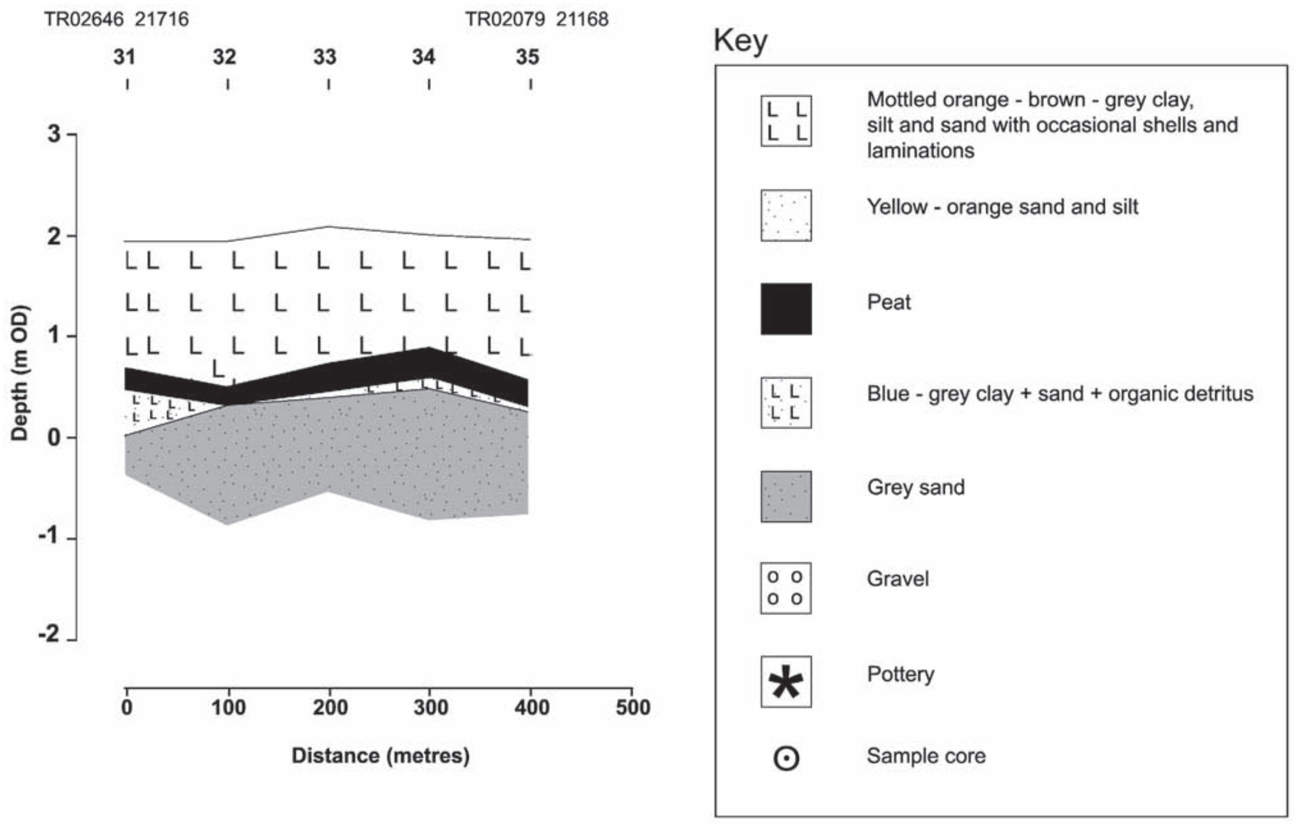

Fig. 2.3d. Lithostratigraphy from Lydd: Transect 4 and key to symbols.

Table 2.3. Radiocarbon dates from Sandyland SL 5 and Lydd core 12 (calibrated using the INTCAL04 dataset).

Site	Depth below surface (cm)	Altitude (m OD)	Date (Radiocarbon years BP)	Calibrated age (cal. yrs BP) ± 2 sigma	Lab code	Stratigraphic context
Sandyland	202–203	0.85–0.84	2160±40	2040–2310	Beta-248989	Top of peat
Sandyland	224–225	0.63–0.62	2990±40	3060–3330	Beta-248988	Cyperaceae pollen rise in LPAZ SL-3b
Sandyland	255–256	0.32–0.31	3680±40	3900–4140	Beta-248987	*Myrica* pollen rise; LPAZ SL-2/SL-3a boundary
Sandyland	291–292	–0.04 to –0.03	3990±40	4410–4530	Beta-248986	Base of peat
Lydd	141–142	0.80–0.79	2240±40	2150–2340	Beta-259386	Top of peat
Lydd	149–150	0.72–0.71	2850±40	2860–3070	Beta-259387	*Myrica* rise below LPAZ LYDD-2/3 boundary
Lydd	172–173	0.49–0.48	3370±40	3480–3700	Beta-259388	Base of peat

unit is very sharp with obvious signs of erosion. The core location (12), with all units present, thickest peat and less-obvious signs of truncation was sampled for palaeoecological analyses (see Table 2.2).

The stratigraphy of Midley Church Bank was investigated by Long and Innes (1995b). They describe wet and structureless sand which in some cores extends up to the surface but in others, is overlain by a peat, or by silts and clays which are in turn overlain by peat. The peat is mostly directly overlain by sand. Core material for sedimentological analysis was obtained from two of the original core locations with contrasting lithostratigraphic contexts (see Long and Innes 1995b, fig. 3.2). These are Long and Innes core 8 (TQ 02694 22756) which consisted of sand down to a depth of 280 cm, and Long and Innes core 25 (TQ 02879 22972) where the top 150 cm of a sand which overlies peat was sampled.

Radiocarbon Dating

Owing to the high degree of humification and the lack of identifiable macrofossil remains, freshwater (terrestrial) bulk peat samples were AMS dated. The results are presented in Table 2.3. Radiometric ages are expressed in calibrated radiocarbon years Before Present (cal. yr BP). Dates have been calibrated using the CALIB Radiocarbon Calibration Programme (Rev 5.0.1) using the INTCAL04 Dataset (Reimer *et al.* 2004) and are quoted at the 2 sigma range (95% probability). Dates which refer to a historical period are referred to on the AD calendar timescale.

Sandyland Pollen

The pollen sequence from Sandyland SL 5 (Fig. 2.4) has been subdivided into three LPAZs (prefixed SL) which are described from the base upwards.

LPAZ SL-1

Non-arboreal pollen dominates the assemblage with Poaceae and Cyperaceae the most abundant taxa and *Plantago maritima*/undifferentiated and Chenopodiaceae also prominent. *Alnus glutinosa* and *Quercus* make up the majority of tree pollen. Pollen preservation is poor and the number of 'indeterminable' grains high.

LPAZ SL-2

The zone boundary is marked by a rise in *Alnus glutinosa* and Cyperaceae pollen and a decline in Chenopodiaceae, *Plantago maritima* and Poaceae. Pteridophytes, including *Osmunda regalis* are more abundant.

LPAZ SL-3

This zone, characterised by the presence of *Myrica gale* pollen, has been divided into three subzones.

LPAZ SL-3a

The transition to this zone is defined by a sudden fall in frequency of *Alnus glutinosa* and a rise in *Myrica gale* pollen. *Betula* pollen becomes more abundant. There is also an increase in the number of dwarf shrub and herbaceous taxa recorded which now include *Calluna vulgaris*, Rubiaceae, *Rumex*

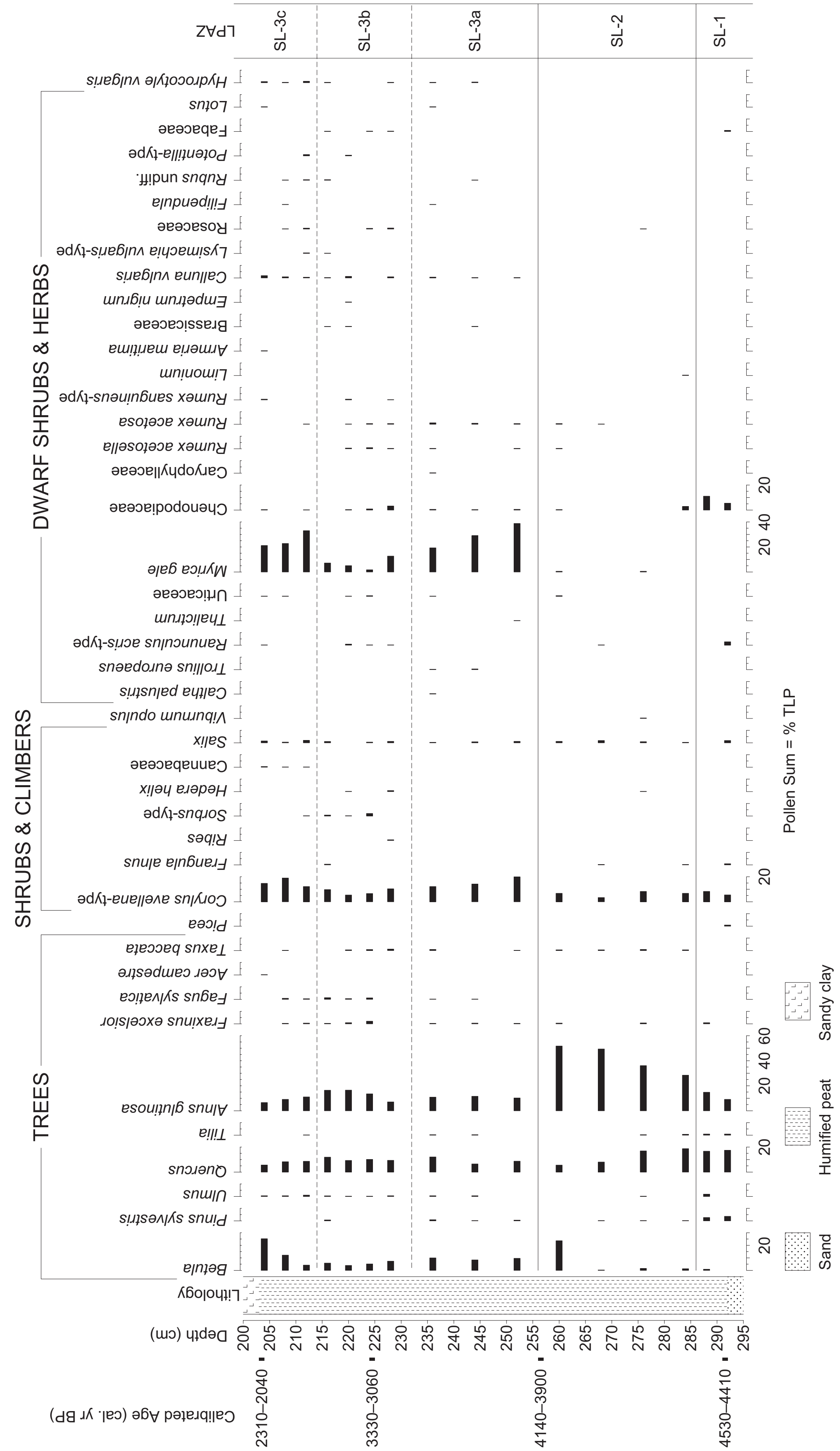

Fig. 2.4. Percentage pollen diagram from Sandlyland core SL 5.

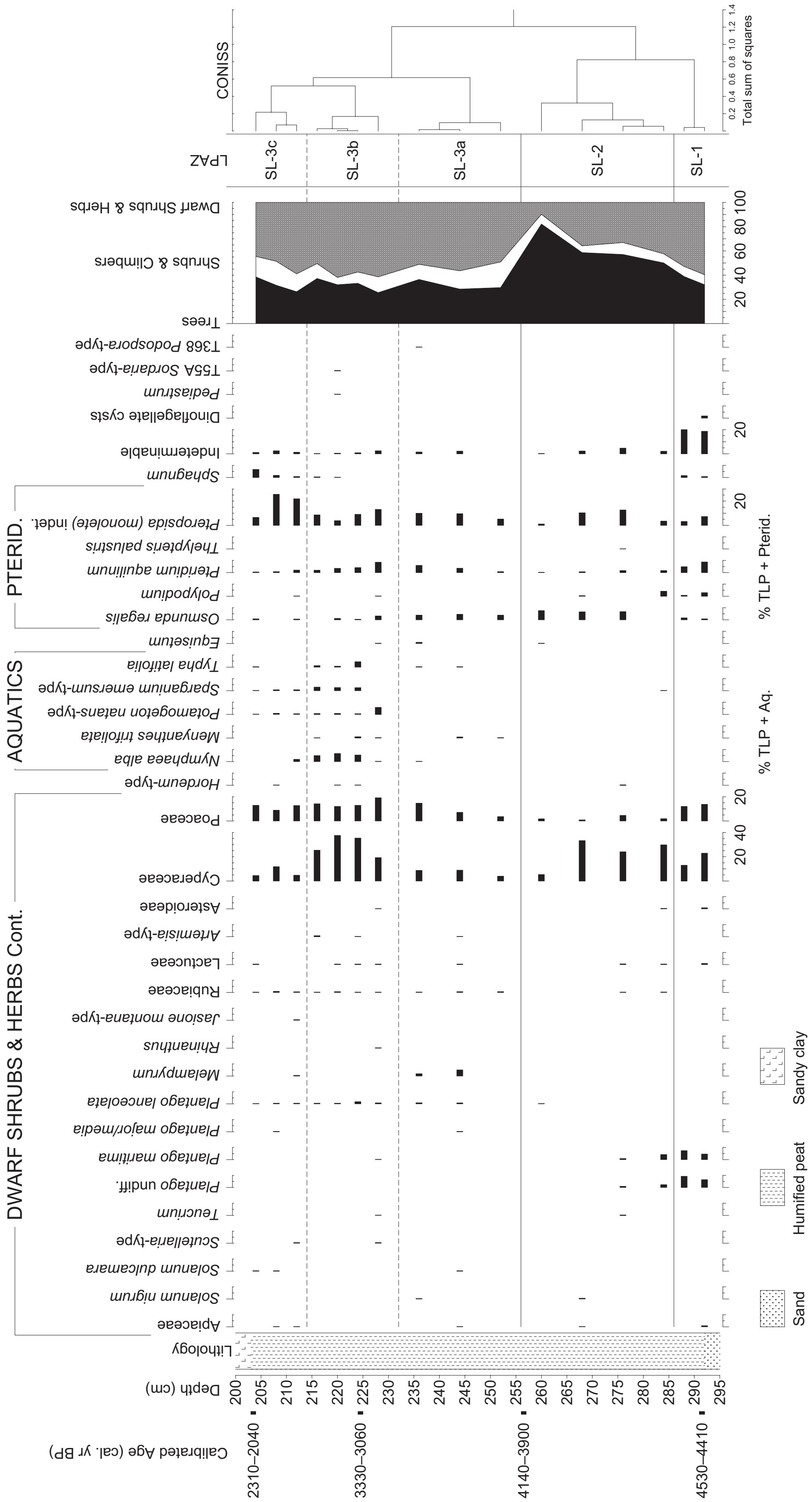

Fig. 2.4. continued.

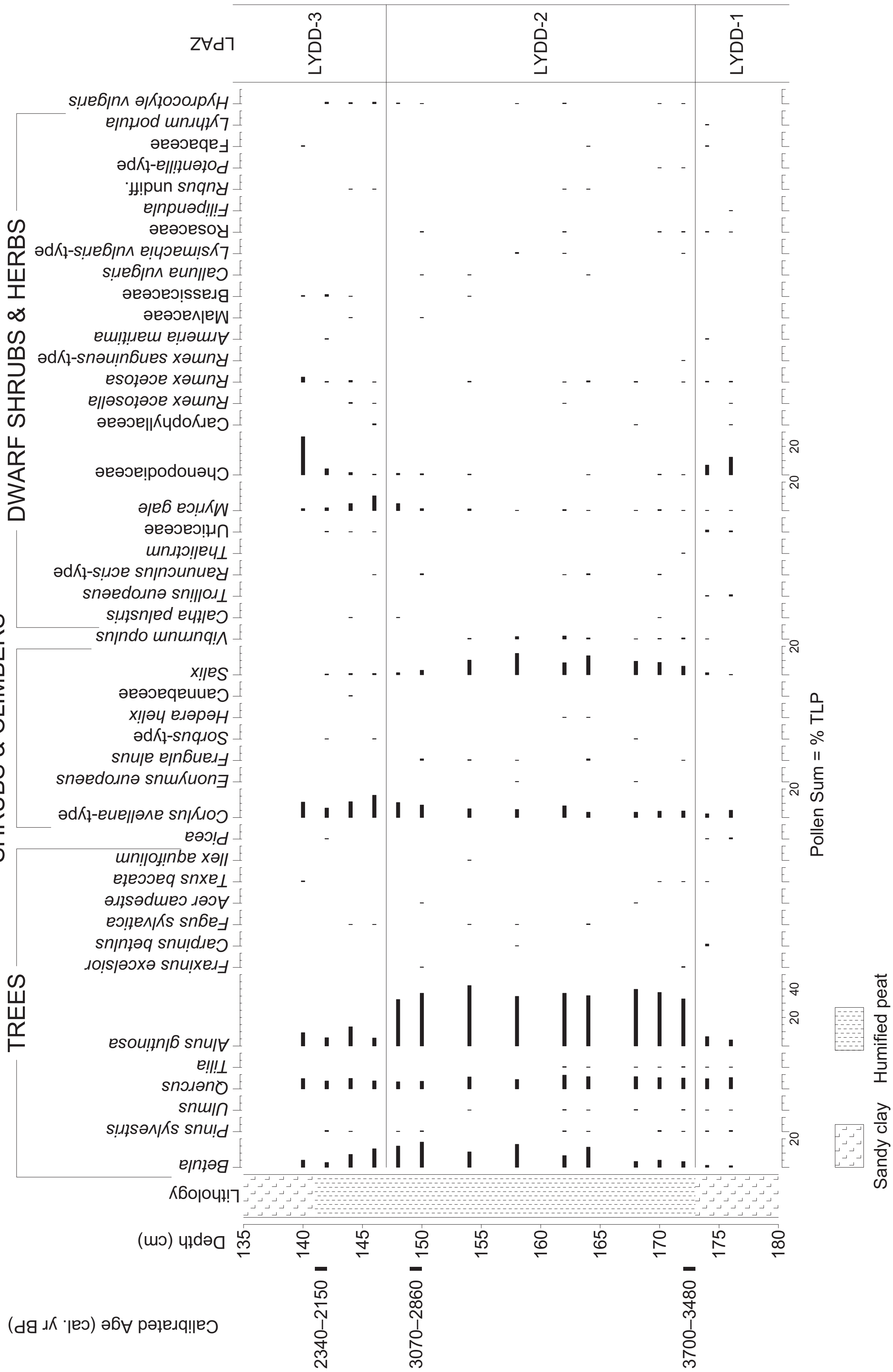

Fig. 2.5. Percentage pollen diagram from Lydd core 12.

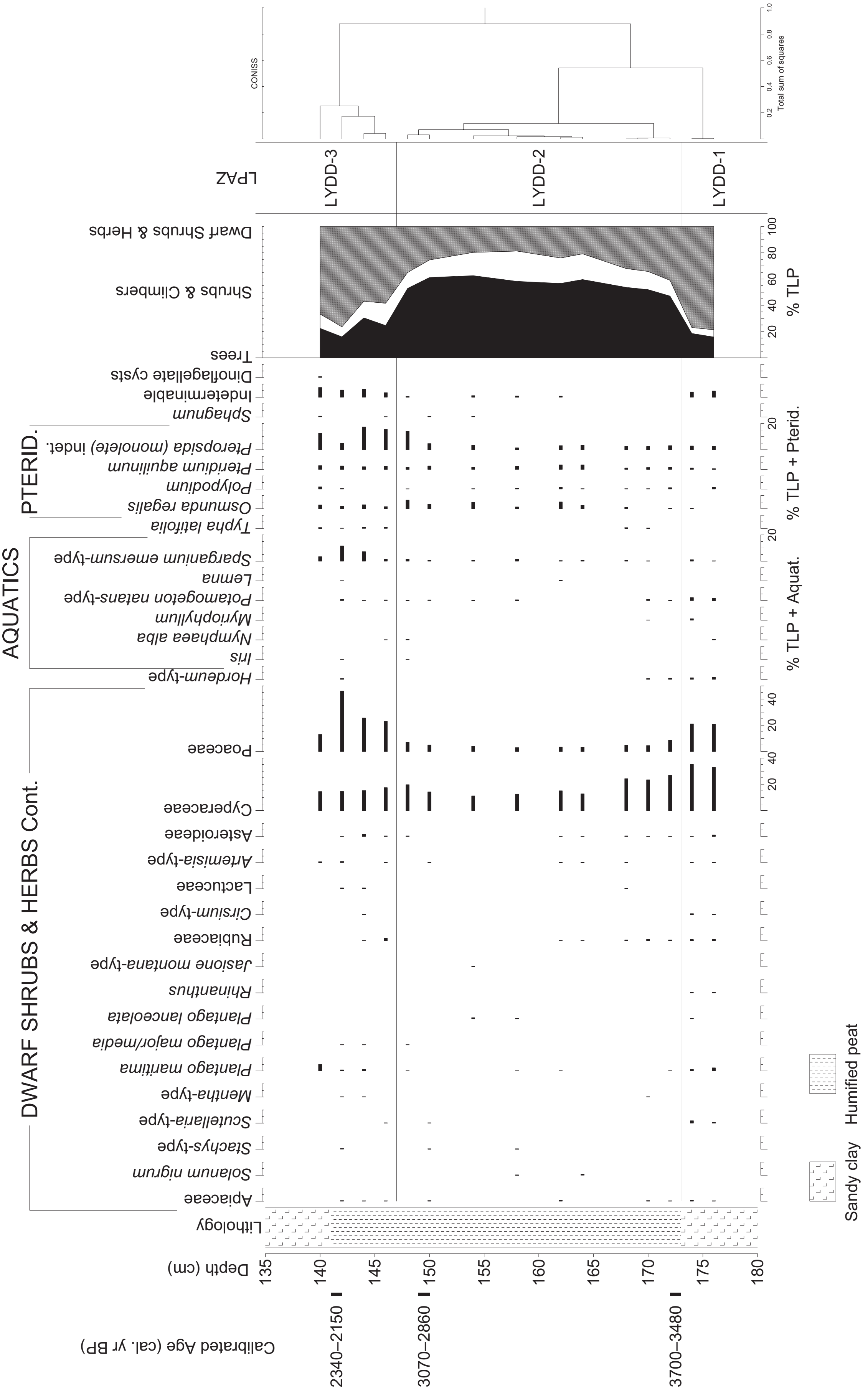

Fig. 2.5. continued.

acetosa/acetosella and *Melampyrum* which reaches *c*. 5% TLP mid-zone.

LPAZ SL-3b

Myrica gale pollen is much reduced in frequency in this subzone and Cyperaceae rises to dominance along with a range of aquatic taxa including *Nymphaea alba*, *Potamogeton natans*-type and *Sparganium emersum*-type. *Betula*, *Quercus* and *Alnus glutinosa* make up most of the tree pollen.

LPAZ SL-3c

This subzone is marked by a decline in Cyperaceae and a sudden rise in *Myrica gale* which occurs along with an increase in *Betula* and also Pteropsida (monolete) spores. *Corylus avellana*-type pollen also increases slightly. Poaceae is the most frequent herb pollen taxon and *Sphagnum* spores are consistently represented.

Lydd Pollen

The pollen sequence from Lydd 12 (Fig. 2.5) has been subdivided into three LPAZs (prefixed Lydd) which are described from the base upwards.

LPAZ Lydd-1

This zone is dominated by herbaceous pollen. Cyperaceae and Poaceae are most prominent but Chenopodiaceae is also important. Arboreal pollen (mostly *Quercus* and *Alnus glutinosa*) makes up only *c*. 20% of TLP.

LPAZ Lydd-2

The transition from Lydd-1 to Lydd-2 is associated with a decline in Cyperaceae, Poaceae and Chenopodiaceae and a sudden rise in *Alnus glutinosa* pollen. *Betula* and *Quercus* are subordinate tree pollen types. *Salix* also increases in frequency to *c*. 15% TLP.

LPAZ Lydd-3

The frequency of *Alnus glutinosa* declines in this zone and Poaceae rises to dominate the assemblage. *Myrica gale* pollen is notable over the Lydd-2/3 boundary but declines throughout the zone. *Sparganium emersum*-type is an important aquatic taxon and Chenopodiaceae and *Plantago maritima* pollen frequencies rise in the uppermost sample.

Diatom and Foraminiferal Analyses

Diatom samples were prepared from the peat contacts of both pollen cores and also into the overlying/underlying sediment. Very few diatoms were encountered and considering their ubiquitous distribution and frequency in all aquatic environments, this is almost certainly attributable to post-depositional silica recycling and diatom dissolution. Poor diatom preservation due to dissolution is particularly associated with saline and marine alkaline waters and iron-oxide-rich sediments where water table fluctuations cause repeated changes in redox conditions (Barker *et al.* 1990; Mayer *et al.* 1991; Ryves *et al.* 2009). Very occasional *Pseudopodosira westii* were observed in the pollen core from Lydd at 142 cm and all other samples were barren. Samples between 196 cm and 200 cm from above the peat top contact at Sandyland contained both occasional fragments and complete valves of *Caloneis westii*, *Navicula pusilla*, *Diploneis interrupta*, *Pinnularia* sp., *Nitzschia navicularis*, *Pseudopodosira westii*, *Paralia sulcata* and *Diploneis ovalis*. Whilst a statistically robust count was not possible, all of these diatoms are commonly associated with intertidal muds and saltmarsh environments (Vos and de Wolf 1988; 1993).

Samples taken from the sand cores at Midley and Sandyland were completely barren of both diatoms and foraminifera.

Particle-size Analysis

Down core plots of mean grain size φ for the three analysed cores (SL 12, Midley 8 and Midley 25) are dominated by fine to medium sands (*c*. 2–3 φ) while fine silts are found exclusively in SL 12 between 100 and 120 cm below surface (see Fig. 2.6). The samples have been divided into three types on the basis of the differences in grain size in the cores. Type A sands have a consistent mean of *c*. 2 φ while type B samples have an elevated mean grain size φ ranging from 2.6 to 4 φ. The upper sample of Midley 25 is also included in this group on the basis of its grain size distribution despite having a mean of 4.3 φ which classifies the sample as silt (Blott and Pye 2001).

The validity of these groupings is demonstrated by the plot of mean grain size against (standard deviation) sorting (Fig. 2.7). Sub-populations can be seen for each sample type demonstrating changes in the environment of deposition (Tanner 1991). Samples of type A and B appear to illustrate an environmental gradient along which deposits become both better sorted and physically larger. The fine silts, type C samples, are markedly different to all of the other samples and are the product of a significantly different depositional regime. All three cores exhibit a clear fining-up trend

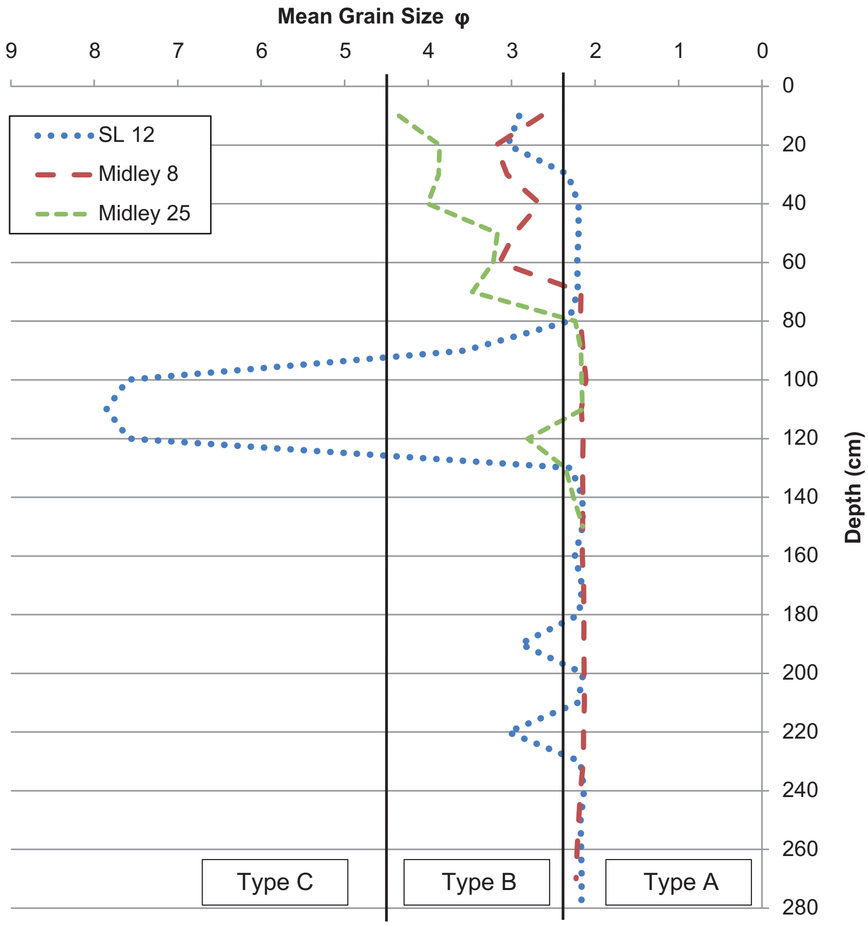

Fig. 2.6. Down-core plots of mean grain size φ for cores SL 12, Midley 8 and Midley 25. Size brackets for A, B and C sample types are shown.

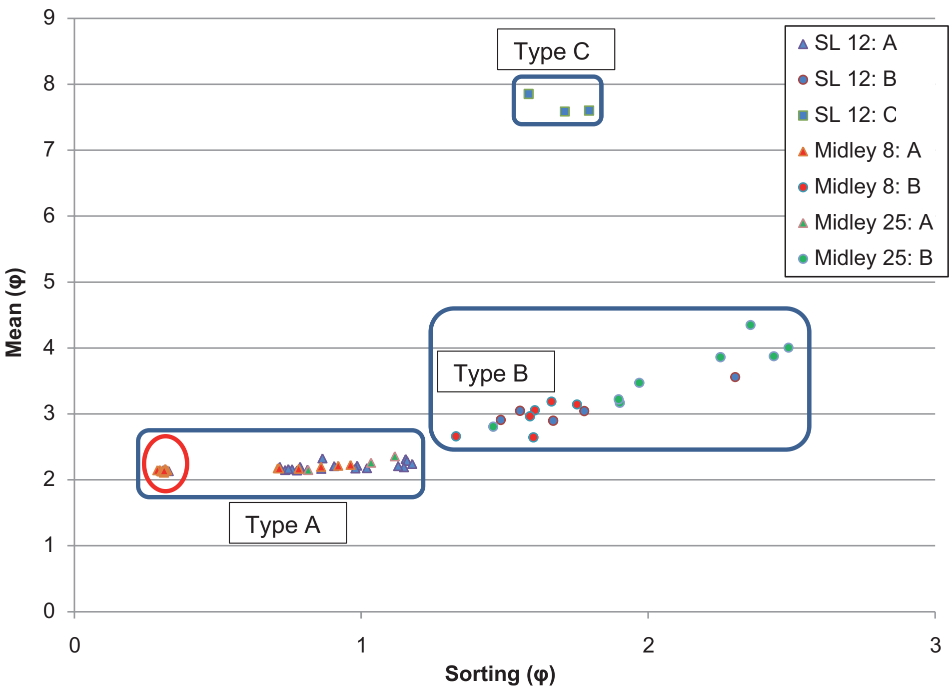

Fig. 2.7. Mean grain size against sorting. Sub populations of sample types A, B and C shown in rectangles. Samples which may be classified as 'dune sands' are circled.

Plate 2.1. Medieval pottery recovered from 157 cm in core SL 3 (position within the stratigraphy shown by a star symbol in Fig. 2.2).

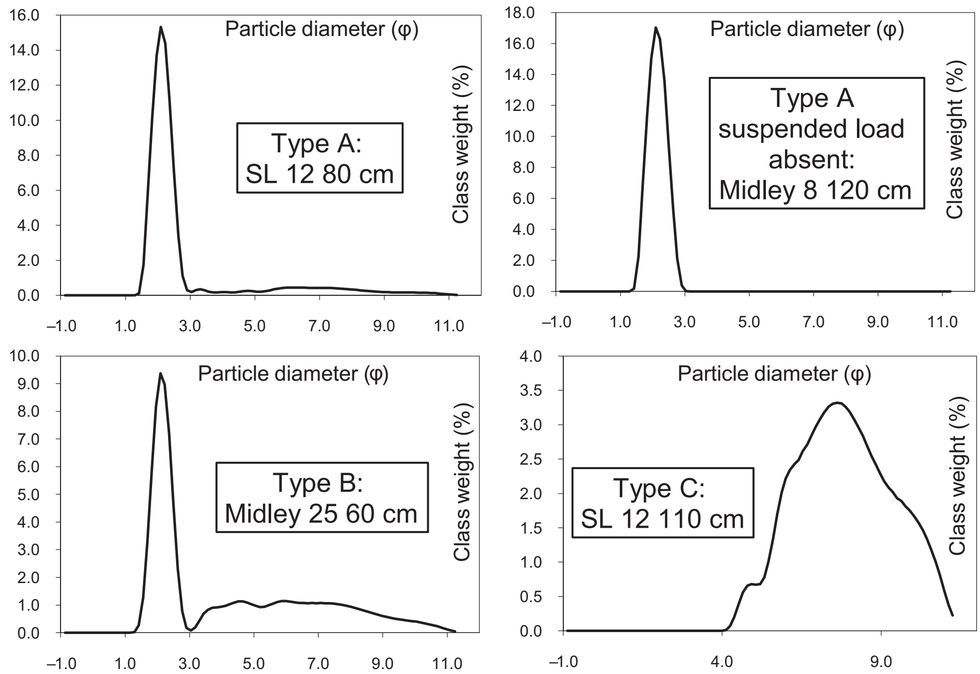

Fig. 2.8. Characteristic grain-size distributions of recurring sample types.

at the top of the sequence (see Fig. 2.6).

The sample groupings in Fig. 2.7 result from the consistent and characteristic grain-size distribution shapes found in each group. These distributions, and the differences in them between the groups, are illustrated in Fig. 2.8. Type A and type B samples have similar grain-size distribution characteristics. Both groups feature a well-sorted, leptokurtic saltation load of medium sand (1–3 φ) and a poorly sorted, platykurtic suspended load of silt and clay (3–11 φ), the difference between the groups being the relative prominence of the suspended load. Type A sediments feature a severely limited suspended load with none present at all between 90 and 230 cm in Midley 8 and only a negligible amount in samples 140 and 240 cm from the SL 12 core. Type B sediments reveal a subtle reduction in depositional energy which allowed for the deposition and entrainment of a greater proportion of suspended material into the sediment record. Sediments of type A and B characterise the environment of deposition for the 'Midley Sand'. Sediments of type C are dominated by the suspended load representing a localised and sustained reduction in depositional energy. The presence of these fine silts can be significant to the understanding of the sands deposited above and below (see Interpretation).

Interpretation

Sandyland pollen sequence

The pollen data from the base of the peat at Sandyland (Fig. 2.4) contains abundant maritime herbs (e.g. Chenopodiaceae and *Plantago maritima*). This indicates that peat formation began (around 4500 cal. yr BP) within a saltmarsh environment (zone SL-1). *Alnus glutinosa* then became established along with a range of plants associated with modern eutrophic fen carr communities (the *Alnus glutinosa-Carex paniculata* communities of Rodwell, 1991) such as *Salix*, *Frangula alnus*, *Osmunda regalis* and Cyperaceae. At the boundary of zones SL-2/3 *Alnus glutinosa* declines markedly and, from 3900–4140 cal. yr BP, the vegetation changes to a community dominated by *Myrica gale* indicating the presence of open acidic vegetation at the site. A progression from alder carr into similar *Myrica gale*-dominated vegetation is recorded at other sites on Walland Marsh and also to the west in the lower Pannel and Brede valleys (see Waller 1993; Waller *et al.* 1999; Waller and Schofield 2007a). This species is normally associated with dry surfaces in fen systems (Waller and Schofield 2007a) and its prevalence on Walland Marsh *c.* 4000 cal. yr BP is likely to be associated with a regional slow-down in the rate of groundwater rise related to a reduction in the rate of RSL rise (Long and Innes 1993). The continued lateral spread of peat promoted the spatial isolation of sites but the slowing of water table rise also resulted in vertical isolation of the Marshland from base-rich water and they subsequently became progressively drier and more acidic.

Amongst the herbs which appear to be associated with the *Myrica gale* community is *Melampyrum*. This taxon is under-represented in the pollen record and it is likely that the pollen frequencies recorded in zone SL-3a (between 2–3% TLP) record the presence of *Melampyrum pratense* at the site. Occurrence of *Melampyrum pratense* in woods indicates disturbed and/or wet locations but Hill *et al.* (2004) gives an intermediate moisture value of 5 (1 = extreme dry; 12 = submerged), so in a wetland context, it probably indicates growth in an open and relatively dry environment alongside *Myrica gale*.

By *c.* 3300 cal. yr BP (zone SL-3b), it appears that the site had become wetter, as the frequency of *Myrica gale* declines and increases occur in Cyperaceae and a range of aquatic species (*Nymphaea alba, Potamogeton natans*-type, *Sparganium emersum*-type and *Typha latifolia*). This suggests the presence of shallow nutrient-rich standing water. The composition of the pollen assemblage resembles that of the modern *Cladium mariscus* community of Rodwell (1995) but the peat was too humified to observe any recognisable macrofossil remains to confirm this. At Little Cheyne Court and East Guldeford, shifts to increased wetness were also noted in the biostratigraphy through increases in *Sphagnum* spores (Waller *et al.* 1999; Waller and Schofield 2007a). Dated to *c.* 2600 cal. yr BP, the latter appear to be associated with a climatic event (a shift from relatively warm continental to wetter oceanic conditions) recorded throughout north-west Europe (Van Geel *et al.* 1996). A regional increase in wetness could be expected to be recorded at Sandyland through an increase in the sediment accumulation rate. There is no evidence for such an increase at Sandyland (the sedimentation rate appears to decline, Fig. 2.9). It seems therefore that the increase in wetness recorded here is related to a local event such as the migration of a channel carrying nutrient-rich water close to the site.

The uppermost subzone SL-3c marks a return to drier nutrient-poor conditions with increases in the frequency of *Myrica gale* and *Betula* pollen. This is

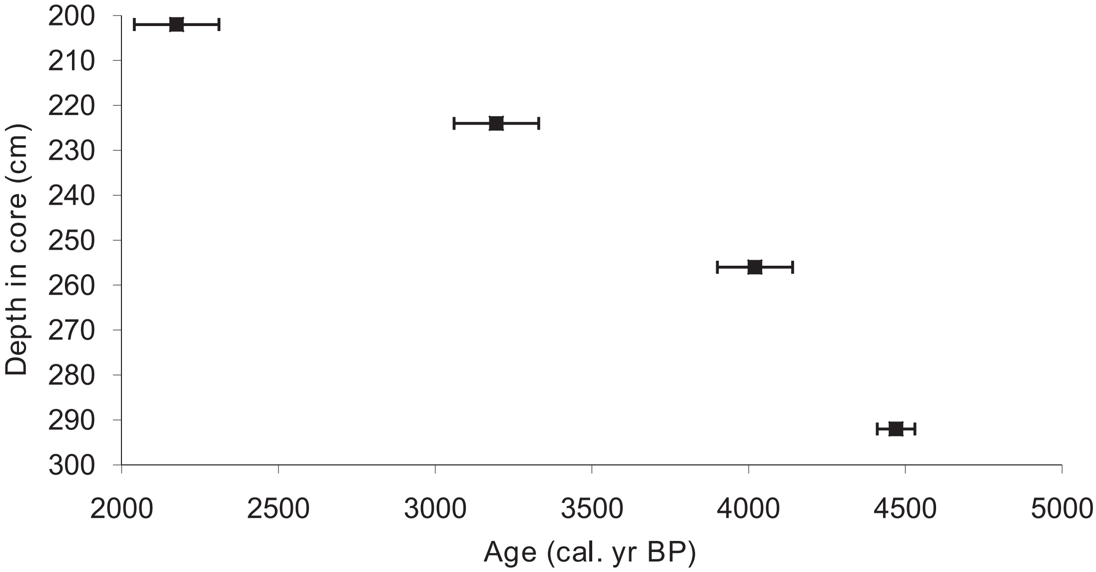

Fig. 2.9. Sediment depth plotted against calibrated radiocarbon age at Sandyland SL 5. The sediment accumulation rate declines from c. *0.53 mm/yr^{-1} between 4410–4530 cal yr. BP and 3060–3330 cal. yr BP to* c. *0.23 mm/yr^{-1} between 3060–3330 cal. yr BP and 2040–2310 cal. yr BP.*

likely to be associated with a decrease in sedimentation rate from *c*. 0.53 mm/yr^{-1} to 0.23 mm/yr^{-1} at the top of the sequence (see Fig. 2.9). Fern spores (Pteropsida (monolete) indet.) also increase in the top zone, which are also often considered an indication of drier conditions. This zone dates to around *c*. 2600 cal. yr BP and illustrates that here local site conditions effectively mask or override regional processes (e.g. climate change) recorded elsewhere at the same time.

The end of peat formation is dated to 2040–2310 cal. yr BP and the overlying sediments contain diatoms indicative of intertidal environments. However, there is little indication of saltmarsh development towards the top of the profile and the contact is abrupt. This suggests that there has been some truncation of the peat surface due to erosion associated with inundation, or that the site was flooded rapidly preventing the development of transitional coastal communities (or both).

Lydd Pollen Sequence

The peat at Lydd initially developed (3480–3700 cal. yr BP) under saltmarsh conditions. Values for Cyperaceae and Poaceae are high, and Chenopodiaceae, *Plantago maritima* and pollen from other halophytic plants are present in Lydd-1 (Fig. 2.5) suggesting a coastal marsh with fringing reedswamp. Zone Lydd-2 marks the arrival of fen carr conditions and *Alnus glutinosa* pollen dominates along with a range of other taxa associated with eutrophic fen woodland such as *Salix*, *Viburnum opulus*, and *Frangula alnus*. The relatively high values of *Salix* pollen (up to 15% TLP) are particularly significant since it is usually considered to be under-represented in the pollen record (see Bradshaw 1981; Huntley and Birks 1983) and values of *c*. 5% TLP have been taken to indicate the local presence of willow (e.g. Long D. *et al.* 1998). Dupont (1987) and Iremonger and Kelly (1988) consider *Salix* to be the most tolerant of the wetland trees to waterlogging and it is possible that the site was particularly wet, giving *Salix* a competitive advantage over *Alnus glutinosa*. An alternative explanation is that the site was more acidic (a possibility supported by the relatively high frequencies of *Betula*) but this would depend on the species of *Salix* present. The absence of macrofossil remains prevents a definitive conclusion.

Betula pollen is also well represented, particularly in the upper half of Lydd-2. *Betula* is a profuse producer of pollen and wind pollinated (Huntley and Birks 1983) which makes it difficult to determine the source area. It is possible that this pollen is derived from *Betula* trees growing locally in the fen carr (see Godwin 1978), although given the suggestion above that the local conditions may have been particularly wet, this is perhaps less likely than the pollen being derived from sources further away from the site.

Betula appears to have been a constituent of the fen carr community to the north-east at Midley Church Bank (Long and Innes 1995b) at this time (between *c*. 3500 and 3000 cal. yr BP). Poor fen dominated by *Betula* also occurs at mid-Marsh back-barrier sites (Hope Farm and Brookland) to north-west (Waller *et al.* 1999) and *Betula* was recorded at moderate frequencies at Sandyland.

Significant changes in the local vegetation are indicated at the Lydd 2/3 boundary as *Alnus glutinosa* pollen frequencies decline and Poaceae pollen increases along with *Sparganium emersum*-type. This is strongly suggestive of a rise in the water table and the development of reedswamp, possibly associated with encroaching marine conditions, with inundation occurring after 2150–2340 cal. yr BP. A short-lived peak in *Myrica gale* pollen also occurs over the same zone boundary which is likely to be related to an increase in the recruitment of bog myrtle pollen from extra-local/regional sources as the wetland became more open. *Myrica gale* communities were flourishing to the west at Sandyland at this time (2040–2310 cal. yr BP) and were also established at other sites in the centre and west of Walland Marsh (see Discussion).

The shift to transitional reedswamp vegetation communities towards the top of the pollen profile from Lydd, and occurrence of saltmarsh pollen in the top sample, provide more convincing evidence for progressive inundation here than at Sandyland, although the stratigraphic boundary with the overlying clastic unit is abrupt and shows some signs of erosion. Therefore, the date of 2150–2340 cal. yr BP should be considered a minimum age for inundation of the peat surface (see Discussion).

Particle-size Analysis

The origin of the 'Midley Sand' has been difficult to determine in the past due to the absence of sedimentological data and various hypotheses have been proposed for the environment in which they were deposited (see Long and Innes 1995b). The results here enable the range of possibilities to be discussed and these are considered in turn.

A wave-dominated beach environment can largely be discounted on the basis of the positive skew which characterises the 'Midley Sand' samples. Beach sands are almost universally negatively skewed due to the winnowing of fines which results from the contrast between landward and seaward wave energy (Friedman 1961; Briggs 1977).

When compared with representative statistics compiled in a dune sediment database for England and Wales by Saye and Pye (2004) the type B sediments appear insufficiently coarse and overly skewed to be dune sands. All of the type B samples and the majority of type A samples which feature a suspended load (those not circled in Fig. 2.7) have less than 98% of their overall composition in the saltation population. Visher (1969) would rule out the possibility that these samples were dune sand on that basis alone.

Bivariate plots of summary statistics can be used to diagnose depositional environments with Friedman (1961), Tanner (1991) and Lario *et al.* (2002) providing good examples of this technique. When the samples from all three cores are presented in a plot of mean grain size (φ) versus sorting (φ) the sub populations fall into zones which imply differing environments (see Fig. 2.7). The majority of the samples analysed here are easily interpreted as originating from a channel context (see below). However, type A sediments with suspended loads fall into a cross-over section populated by both river and dune sands in a zoned plot presented by Friedman (1961) and the type A samples which lack suspended loads are placed in a 'dune sand' area. This population is circled in Fig. 2.7 and is the most difficult to assign an environmental context. As type A samples have a consistent mean grain size (i.e. coarse sands, no skew) this 'dune sand' diagnosis is made purely on the basis of increased sorting, which is a direct result of the absence of a suspended load.

Friedman (1961) is cautious to point out that this methodology should not be regarded as definitive as are Tanner (1991) and Lario *et al.* (2002). It is stressed that all results should be considered in context. The samples which may be classified as dune sands are those between 90 and 230 cm in the Midley 8 core and the 140 and 240 cm samples from SL 12. While a distribution featuring only a leptokurtic and well-sorted saltation component is characteristic of dune sands such sediments could equally be deposited in a tidal channel by a sustained period of increased high velocity flow or extreme events such as storms. Such explanations can comfortably account for the brief and dispersed occurrence of these samples in core SL 12. However, the prolonged dominance of these samples in the Midley 8 core requires further explanation.

The lack of a tidal signal and the maintenance of a sustained high-velocity flow required to deposit sediment with these characteristics suggests that this environment is markedly different to those of the other cores. Indeed, if one cross references the stratigraphy from Long and Innes (1995b) it is apparent that Midley core 8 is from a different stratigraphic context and was sampled for that reason. Instead of the sand overlying marshland deposits, here, the stratigraphy consists of a continuous 4 m sand sequence. The most probable explanation for this has to be a former channel (see below) and that this core marks the approximate position of its centre.

It is important to consider the stratigraphic and geomorphic context of these samples when attempting to arrive at conclusions. Whilst it is possible that the sediments may be of alternating aeolian and waterlain origin, this seems somewhat unlikely and any interpretation of dune origin makes little sense. For example, the samples occurring in SL 12 between 140 and 240 cm may be interpreted as aeolian dune sands, but these are immediately overlain by silts deposited in low-energy conditions, either in a ponded channel or on the muddy periphery of a tidal channel (see below). Similarly, while the samples between 90 and 230 cm in Midley core 8 may also fall into a category including dune sediment these are overlain by samples indicative of fining up in an infilling channel (see below). In these cases, an aeolian interpretation makes little sense stratigraphically.

Finally, the stratigraphy of Midley Church Bank presented by Long and Innes (1995b) clearly shows peat present within the sands (core 9 and 23). Whilst organic horizons can occur within aeolian deposits (e.g. dune slacks) the deposits here are described as having abrupt contacts and are likely to be eroded from peat deposits elsewhere on Walland Marsh (see Long and Innes 1995b). This can only readily be explained if they are washed in and deposited in a channel as it is not possible for eroded peats of this size and nature to be transported into dune belts by aeolian processes. Therefore on the balance of this evidence it appears unlikely that the 'Midley Sand' are dune sands.

Tidal deposits are characterised by a combination of high-velocity and slack-water conditions. If the grain-size distributions of type A and B sediments are taken to characterise the 'Midley Sand' then the environment would appear to be under tidal influence. The saltation component is consistent with a high-velocity flow while the suspended load dictates that energy levels were periodically reduced to allow the settling of fines (Dyer 1986). When the type B sediments were deposited reductions in depositional energy had become more prominent, while the type A sediments suggest reductions in flow velocity were limited or at least that the majority of any fines deposited were subsequently re-suspended. A tidal environment seems likely until we consider that the type B samples are primarily present in the fining-up sequences which approach the surface of all three cores. The majority of deeper sediments are type A with limited or absent suspended loads. These samples do not appear to be the product of a straight-forward tidal regime.

The sediments of the Wainway Channel are notable for their excellent preservation of tidal rhythmites (Stupples 2002), a feature distinctly absent from the sites discussed here. The absence of an overt tidal signature in samples from Sandyland and Midley (i.e. lack of significant suspended load) could be explained by a persistent flow within a large channel. Such a situation might arise if the sands were deposited in a tidal channel that was open to the sea at both ends. Indeed, it has been suggested by Long *et al.* (2006a) that such a channel is likely to have existed connecting the inlets at Rye and New Romney. This would result in a permanently submerged sub-tidal environment with sustained flows which would lack the emphasised contrast between high and low tide experienced in a dead-ended channel such as the Wainway. Hence, the sands may mark the location of a former 'Midley Channel' associated with the late Holocene inlets which transported sand from the coast during and after the breaches and also may have reworked some of the underlying shoreface sand deposits.

Another possible explanation for the limited or absent suspended load in the type A samples could be direct proximity to a source of fluvial discharge. A fluvial input into a tidal channel would sustain flows at low tide and perhaps hinder settlement of fines. For example, if we accept the 'Midley Channel' hypothesis as most likely, the Rother may have emptied into it during this time resulting in a locally more complex and variable flow regime. Reconstructions of the Wainway Channel imply significant spatial and temporal variations in the importance of marine and freshwater processes (Evans *et al.* 2001). Dependant on tides, currents, the drainage route of the Rother, barrier-inlet formation and closure and other local factors, the depositional environment of the sands at Midley might be expected to be more variable still.

Type B samples fall in to a 'channel or storm episodes' section in a zoned chart presented by Lario *et al.* (2002) while type C samples are designated as low-energy restricted estuarine deposits. It is most likely that the deposition of these silts (between *c.* 90 and 130 cm in core SL 12) was either caused by ponding in a channel allowing the fines to settle out, or a migration of the channel away from the sample site, so the core records lower-energy inter-tidal channel margin deposits as opposed to mid-channel sands. A return to predominantly coarser sands above this in the core may represent the migration of the main channel back to the core site.

A final feature of the particle-size results that points to the 'Midley Sand' being of a channel origin is that all the cores exhibit a distinct fining-up towards the top of the sequence (Fig. 2.6). Such a trend is to be expected as a channel infills and becomes dominated by lower-energy conditions as the water depth shallows (e.g. Evans *et al.* 2001).

Discussion

The Peat-forming Vegetation Communities of Southern Walland Marsh During the Mid–Late Holocene

Some interesting spatial differences are evident in the nature of the peat-forming communities of Walland Marsh (see Waller *et al.* 1999; Waller and Schofield 2007a). These include the persistence (for over 2000 years) of eutrophic fen communities around the periphery of the Marshland before their replacement by *Myrica gale*-dominated vegetation prior to inundation. At spatially isolated sites away from the river valleys, an initial fen carr phase is succeeded by poor fen and eventually, at Little Cheyne Court and East Guldeford, by a raised bog. The data presented here from Sandyland and Lydd indicate an early phase of eutrophic conditions, with *Alnus glutinosa* becoming established. The replacement of fen carr with *Myrica gale*-dominated vegetation at Sandyland after 3900–4120 cal. yr BP is similar to the sequence of events recorded at sites to the west during the late Holocene. Waller and Schofield (2007a) have discussed the origin of this vegetation and the length of time it persisted as an open community. The *c.* 1000 years indicated at some sites including Sandyland is difficult to explain in ecological terms since it is considered a transitional community. However, it is now clear that open, relatively dry and acidic *Myrica gale*-dominated vegetation not only existed for a long time but also occupied a large area of Walland Marsh, not only in the outer parts of the river valleys but also surrounding the raised bog.

Waller and Schofield (2007a) suggest that because a range of animals are known to graze on *Myrica gale*, then herbivory may explain the continued regeneration and persistence of this community. Certainly, given the proximity to the upland areas to the west, where there is evidence for significant human activity from the Bronze Age onwards (Waller and Schofield 2007b), this large expanse of open and relatively dry vegetation would potentially have been attractive for pasturage.

Van Geel *et al.* (2003) have demonstrated a link between grazing intensity and the occurrence of obligate coprophilous fungi (exclusively associated with animal dung). The Sandyland pollen slides were carefully examined for the presence of these fungal spores, only a few were observed (T55A *Sordaria*-type and T368 *Podospora*-type, Fig. 2.4). Although grazing must be considered a likely reason for the longevity of *Myrica gale*-dominated vegetation on Walland Marsh, this is insufficient evidence to confirm this explanation. A recent study by Blackford and Innes (2006) has demonstrated that in modern environments, even where grazing occurs intensively, the frequencies at which coprophilous fungi occur in surface samples is highly variable. Many fungal types are produced within decaying litter and are often not airborne or widely dispersed. Therefore, whilst coprophilous fungal spores are highly localised indicators of pastoral activity, an absence of spores in a sample cannot be taken to imply an absence of animals at the site (Blackford and Innes 2006), particularly a single core from an area as large as that occupied by the *Myrica gale*-dominated communities on Walland Marsh during the late Holocene.

Available data suggest that acidophilous vegetation spread over southern Walland Marsh (e.g. East Guldeford and Little Cheyne Court) around 4500 cal. yr BP, first poor fen and, from around 4000 cal. yr BP, *Sphagnum* bog (Waller *et al.* 1999; Waller and Schofield 2007a). Peat deposition at Sandyland commenced later and although nutrient-poor conditions developed, *Sphagnum* frequencies are low and there is no evidence here for the development of bog. The *Myrica gale*-dominated communities that prevailed at Sandyland and Brookland at the same time as the *Sphagnum* bog at Little Cheyne Court and East Guldeford, seem to mark the ecotone at the margins of the bog complex.

Although *Myrica gale* was dominant at Sandyland for much of the period of peat accumulation, it does not appear to have been a significant part of the peat-forming vegetation at Lydd, despite the fact that the deposits here appear even more spatially isolated from eutrophic water derived from the valleys to the west. Also, at Midley Church Bank (Long and Innes 1995a) the pollen data do not suggest *Myrica gale* growing at the site, although it is possible that some of the *Myrica gale* pollen was not distinguished from

Corylus avellana pollen. A likely explanation for this is that these sites were closer to drainage channels flowing behind the back of the barrier and the tidal creek systems associated with the opening in the barrier to the north-east at Hythe (Long *et al.* 2006a). This water would have raised the trophic status of the sites sufficiently to ensure the persistence of eutrophic fen throughout the period of peat formation.

The pollen diagram from Lydd is comparable with that from Midley Church Bank (Long and Innes 1995b) and it appears that fen carr (perhaps with a component of *Betula*) was the dominant vegetation at both sites from *c*. 2500 to 4000 cal. yr BP. However, to the south in Scotney Marsh, Spencer *et al.* (1998a) record much lower percentages of tree pollen at this time and the wetland environments here are dominated by grasses, sedges and a range of aquatic species associated with tall herb fens. An undated pollen sequence from a comparable stratigraphic context has also been published from Lydd Quarry on Scotney Marsh revealing similar pollen spectra (Scaife and Seel, in Barber and Priestly-Bell 2008). These peats developed within topographic lows between gravel ridges and such locations would have experienced particularly wet, ponded conditions and were also proximal to channels (Spencer *et al.* 1998a).

There appear to be few similarities between the pollen records at Sandyland and nearby Tishy's Sewer (Tooley and Switsur 1988). The period of peat deposition at Tishy's Sewer was from *c*. 3200 to 3800 cal. yr BP which corresponds broadly with zone SL-3a (Fig. 2.4) when *Myrica gale* was dominant at Sandyland. However, the peat at Tishy's Sewer suggests much wetter eutrophic conditions dominated by *Alnus glutinosa* and fen herbs including *Typha angustifolia* suggesting that perhaps the hydrology of this site was influenced by water draining off the gravel ridges nearby or perhaps the presence of channels proximal to the site.

Origin of the 'Midley Sand'

Many local and methodological factors hinder the identification of universally diagnostic characteristics in analogous depositional environments (Friedman 1961; Visher 1969; Lario *et al.* 2002; Sun *et al.* 2002; Pye and Blott 2004; Flemming 2007). While grain-size analysis can be very useful it is often used to aid, rather than to dictate, environmental reconstructions. Ideally palaeoecological data, diatom or foraminiferal assemblages, would be used to support the interpretation of the 'Midley Sand' cores but this was not a possibility as the samples proved to be barren of any microfossils. Despite this some conclusions can be reached.

The grain-size analysis data presented here are consistent with deposition in a high-energy, sub-tidal, spatially and temporally variable channel environment with limited but significant deposition of suspended sediment, an interpretation which makes the most sense considering the wider stratigraphic and geomorphic context. Some of the type A samples (circled in Fig. 2.7) are also consistent with dune environments (as classified by Friedman, 1961) and while this may be a very unlikely origin (see above) some aeolian transportation of sand is possible. The sand component of the peat sampled at Sandyland (see Table 2.1) must have an aeolian origin and it is likely that some of the sand which accumulated in the 'Midley Sand' cores was also wind-blown. The source of this material is uncertain but reworking of the shoreface sands upon which the gravel sits and sand sources in Rye Bay must be likely candidates.

The majority of type A sediments have more in common with a channel or a high-energy sub-tidal regime. In this context the type A sediments circled in Fig. 2.7 which lack a suspended load, are thought most likely to be the result of sustained high-energy channel conditions with variable tidal and fluvial influence. The type B sediments were laid down under a tidal regime, most likely in a channel. The fining-upward sequences observed in all three cores also suggest deposition in water and the gradual infilling of accommodation space as a channel silts up, while the presence of type C sediments in the SL 12 core must be the product of localised ponding (or channel migration) which further supports water as the medium of sediment delivery.

The palaeogeography, geometry and particle-size results from the 'Midley Sand' deposits investigated at Sandyland and Midley Church Bank fit the hypothesis that the sands were deposited in a large tidal channel. Therefore the deposits are interpreted here as representing a former 'Midley Channel' possibly connecting the inlets at New Romney and Rye. The historically documented changing course of the river Rother (Green 1988; Tatton-Brown 1988; Evans *et al.* 2001) could help to explain the spatial and temporal variations in tidal and fluvial influence on the 'Midley Sand', and the fact that the 'Midley Channel' is likely to have been open at both ends would explain the reduction of tidal signals in these sediments when compared to those of the Wainway Channel.

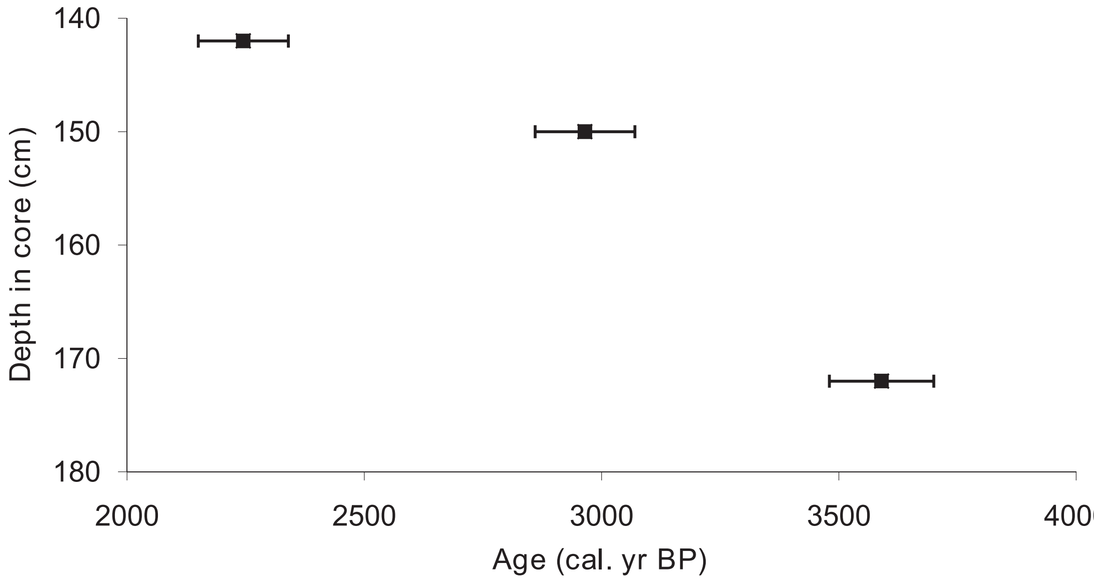

Fig. 2.10. Sediment depth plotted against calibrated radiocarbon age at Lydd core 12. The sediment accumulation rate declines from c. *0.37 mm/yr^{-1} between 3480–3700 cal yr. BP and 2860–3070 cal. yr BP to* c. *0.11 mm/yr^{-1} between 2860–3070 cal. yr BP and 2150–2340 cal. yr BP.*

Timing and Causes of Peat Formation and Inundation on Southern Walland Marsh

Peat spread out from the valleys to the west of Walland Marsh in a time transgressive manner from around 6000 cal. yr BP. Peat was also accumulating around this time at Horsemarsh Sewer in the north (Tooley and Switsur 1988). As the rate of RSL rise slowed into the mid-Holocene, the progradation of Dungeness Foreland continued, providing sheltered conditions in the back-barrier area for peat-forming wetland communities to expand, reaching their maximum extent *c*. 3400 cal. yr BP (Long, A.J. *et al.* 1998). It is now clear that an almost continuous spread of peat accumulated, reaching all the way up to the gravel at Scotney Marsh (Spencer *et al.* 1998a; 1998b) and Broomhill (Tooley and Switsur 1988) by *c*. 3900 cal. yr BP. New data presented here confirm this, with spatially continuous peat accumulating at Sandyland from 4500 cal. yr BP and Lydd from 3700 cal. yr BP.

All the evidence points to peat formation ending with inundation from tidal waters but the timing of this flooding is difficult to ascertain for a number of reasons (Waller *et al.* 2006). Firstly, a radiocarbon date from the top of the peat may not accurately reflect the age of the inundation event if peat accumulation slowed, or even stopped for a period of time prior to flooding and large errors can be introduced if erosion occurred during flooding. Waller *et al.* (2006) discuss these problems in relation to the Romney Marsh area where dates from the top of the peat range from 2840–3170 cal. yr BP to 1050–1290 cal. yr BP. Therefore, a radiocarbon chronology based on dates from the top of peats is only adequate in providing limiting ages for the timing of the deposition of overlying tidal sediments (Waller *et al.* 2006). The age-depth profiles for both Sandyland and Lydd demonstrate a slowing down in the rate of peat accumulation towards the top of the sequence (Figs. 2.9 and 2.10). Whilst some of this may be attributable to differential compaction of the upper sediments, comparison with data from elsewhere in the Romney Marsh region suggests that this decrease in sedimentation rate is ‘real’ and relates to the slow rates of RSL rise maintaining a low base level in the Marshland and the progressive drying of the peat-forming communities (Long *et al.* 2006b).

The most likely age for inundation in the Rye area is provided by a date of *c*. 1300 cal. yr BP from West Winchelsea where peat formation is followed by the development of saltmarsh. East Guldeford was also inundated with tidal water shortly after (Long *et al.* 2006a; 2006b; Waller and Schofield 2007a). The Marshlands would then have been progressively inundated as the water drained out of them into the encroaching tidal creeks causing them to collapse, lowering the peat surface, resulting in rapid flooding and further peat compaction (Long *et al.* 2006b).

Whilst it seems likely that the date of the inundation is overestimated by the radiocarbon ages from Sandyland and Lydd for the reasons discussed above, there are other age indicators that can be used to constrain the deposition of the overlying clastic sediment

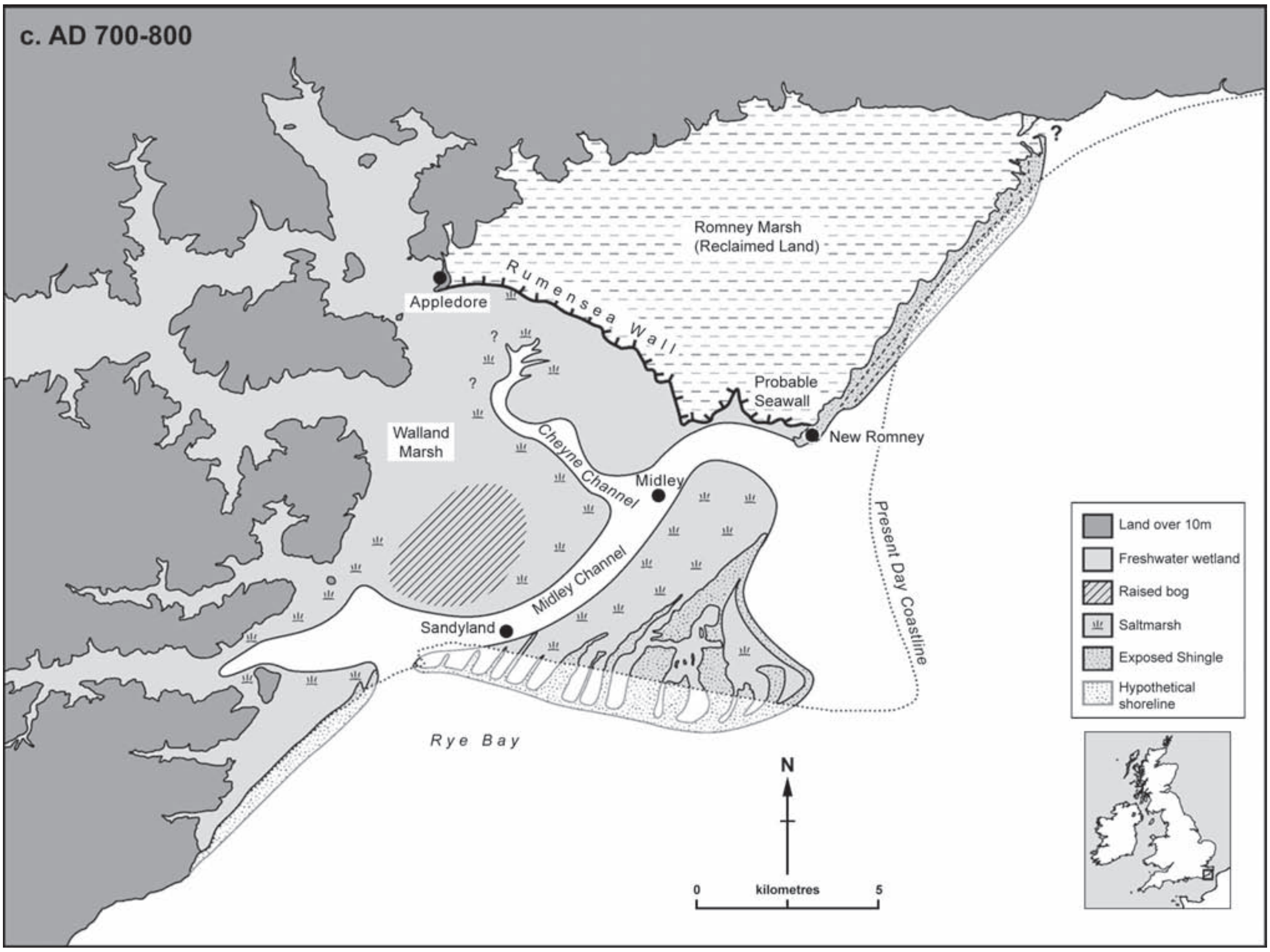

Fig. 2.11. Palaeogeographical reconstruction of Dungeness Foreland, Walland and Romney Marshes (AD 700–800) showing New Romney and Rye inlets connected by the 'Midley Channel'. (Reproduced and modified from Long et al. *2006a.)*

at Sandyland. Here, the peat dating to 2040–2310 cal. yr BP is overlain by clastic sediments clearly associated with the channel conditions recorded from the deposits at SL 12 (Fig. 1.2). The recovery of medieval pottery from this sediment demonstrates that deposition of tidal water was underway from at least the 12th century AD. Historical evidence shows that reclamation of this part of Sandyland was underway shortly after this time as a sea wall dating from the early years of the 13th century AD is clearly situated on top of the deposits close to SL 12 in the map of Gardiner and Hartwell (2006). This wall certainly pre-dates the major floods of the period AD 1250–1350 as shingle associated with these storms is banked up against the wall forming linear features of surface gravel still visible in the landscape today (Gardiner and Hartwell 2006). This suggests that attempts were underway to reclaim land from the edges of the 'Midley Channel' from the west shortly after *c*. AD 1200 and implies that a major tidal conduit towards New Romney existed at this time (see Long *et al*. 2006a).

Late Holocene Tidal Inlets and Back-barrier Channels

The data presented here reinforce the palaeogeography presented by Long *et al.* (2006a) and demonstrate not only the occurrence, but also the importance of tidal channels along the back of the gravel barrier between Broomhill and Lydd (see also Spencer *et al.* 1998b). Radiocarbon and particle-size data from Sandyland provide evidence for a sand-dominated tidal channel which existed from sometime after the end of peat formation (2040–2310 cal. yr BP) until reclamation in the early 13th century AD. Such a channel is likely to have burst through the barrier in the area marked by arrows on the AD 300–400 map of Long *et al.* (2006a), linking up with the creeks existing behind the barrier near New Romney mapped by Green (1968) and the tidal inlet here by AD 700–800 (see Fig. 2.11). This channel is referred to here as the 'Midley Channel' and not the 'Wainway' as labelled on the map of Long *et al.* (2006a).

The alignment of the surface expression of the 'Midley Sand' mapped by Green (1968) marks the former course of this probable 'Midley Channel' which is also likely to have captured freshwater channels issuing out of the expansive wetlands to the north and also a possible former course of the river Rother (the 'Cheyne Channel'; see Long *et al.* 2006a) in the area of Midley Church Bank. Indeed, many of the outcrops of 'Midley Sand' lie along the route of the two major channels which Green (1988) and Tatton-Brown (1988) proposed were former courses of the river Rother in the 13th century AD. The smaller and most southerly of these water courses (as mapped by Gardiner, 1988) is presumably the 'Midley Channel' proposed here, suggesting it survived quite late into the medieval period.

The environment of deposition of the 'Midley Sand' on Romney Marsh proper (north-east of New Romney, see Fig. 2.1) needs to be determined by stratigraphic or sedimentological analysis. However, it is feasible that these deposits have a similar origin to those investigated here and represent former tidal channels (probably unrelated to that invoked between Broomhill, Midley and New Romney) running along the back of the barrier associated with the tidal inlet at Hythe.

Finally, the data presented here not only lend evidence to support the co-existence of the tidal inlets at New Romney and Rye, connected by a channel (the 'Midley Channel'), they also suggest that the main Marsh peat extended at least as far south as Sandyland and the gravel at Broomhill (Tooley and Switsur 1988). The Wainway Channel is therefore a relatively late feature of the Marshland and at least post-dates the inundation of the peat which it cut a swath across sometime after the formation of the Rye inlet (AD 700–800).

Conclusions

The stratigraphic and sedimentological data presented here shed new light on the late Holocene evolution of southern Walland Marsh. Spatially persistent peat deposits are present on Broomhill Level and Lydd, associated with the lateral spread of the main Marsh peat over Walland Marsh, with peat formation at Sandyland slightly earlier (from *c*. 4500 cal. yr BP) than at Lydd (from *c*. 3700 cal. yr BP). Peat formation at both sites was initially under saltmarsh and reedswamp conditions and then fen carr. At Sandyland, nutrient-poor, acidic conditions developed around *c*. 4000 cal. yr BP with *Myrica gale* common in the pollen record as the site became spatially isolated from base-rich water. At Lydd, these communities did not occur due to the proximity of the site to the channels and creek systems associated with the Hythe inlet, which kept the groundwater table high and maintained the nutrient status of the wetlands. Peat formation ended due to flooding by tidal water at both Sandyland and Lydd sometime after *c*. 2300 cal. yr BP. Transitional coastal communities are evident at Lydd but are lacking from Sandyland suggesting either rapid inundation or erosion of the peat surface during flooding (or both).

Sedimentological investigations of outcropping 'Midley Sand' at Sandyland and Midley Church Bank has enabled the probable origin of these deposits to be assigned to a tidal channel. Whilst some of the samples are suggestive of aeolian deposition, interpretation of the results in the light of their stratigraphic and palaeogeographic context leads to the conclusion that they were deposited within an open-ended channel connecting the New Romney and Rye inlets after *c*. AD 300. Historical evidence suggests that this channel must have silted up enabling the reclamation of the Marshland at Sandyland from the 12th century AD.

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