Changing Holocene environments in Alderney, Channel Islands

J. Campbell[1], *H.C.L. James*[2] *and J.T. Renouf*[3]

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The Longis embayment in SE Alderney has an infill of windblown and peaty organic deposits exceeding 4 m in thickness confirmed by a series of boreholes. Comprehensive pollen and macroplant analyses of the peats and organic sediments underlying Longis Common indicate changing palaeoenvironmental conditions over the mid- to late-Holocene. Associated with these vegetation changes is evidence for variations in ground water levels. Seaward of the Common, further areas of thin peaty organic deposits occur at supratidal and high tide levels. Pockets of organic material are also found in shallow basinal structures which extend across the intertidal zone. A series of radiocarbon assay dates and archaeological findings help to constrain the chronology of the mid-late Holocene sedimentary sequences as well as that for sea level encroachment into the embayment. Finally, comparisons with similar sequences in Jersey and the region of the normanno-breton gulf and environs are noted.

[1]*16a Suffolk Avenue, Shirley, Southampton, SO15 5EG, U.K.*
[2]*School of Education, University of Reading, Bulmershe Court, Earley, Reading, RG6 IHY, U.K. (E-mail h.c.l.james@reading.ac.uk).*
[3]*Le Cotil des Pelles, Route du Petit Port, St Brelade, Jersey, Channel Islands, JE3 8HH, U.K. (E-mail renouf@argonet.co.uk).*

Introduction

The eastern part of Alderney (Figures 1A, 1B and 1C) consists of the Cambro-Ordovician Alderney Sandstone. This is a remnant of a major series of deltaic sandstone units deposited from an west-east flowing river following the denudation of the Cadomian mountain chain *c*. 500 ma ago (Went and Andrews, 1990). The eastern section of the island is dominated by Longis Bay and its landward extension, Longis Common. Borehole evidence (Figure 2) reveals the bedrock base of the current Bay and Common as a low angle abrasion platform co-extensive with the present foreshore rocks, extending seawards from the base of a palaeocliff at *c*. 2 to 3 m above Alderney Datum (A.D.) while Figure 3 shows a 5-10 m thick wedge of surficial sediments consisting of sands and occasional peaty units overlying the bedrock of this embayment. The contemporary rocky shore platform to the southeast of Longis Bay consists of a series of shallow basins terminated by tidal reefs which extend north-eastwards towards Fort Houmet Herbe. Occasional peaty, organic rich, deposits are preserved within some of the shallow basins of the intertidal zone (Figures 1 and 4).

The organic-rich horizons of Longis and associated sediments

The Quaternary geology of Alderney, the most northerly of the Channel Islands, was systematically mapped by Keen (1978, 1981) during the period 1972-75 as part of the British Geological Survey Channel Islands Sheet 1 programme. Boreholes (Figure 2, boreholes A-C) were drilled down to bedrock for water in different parts of Longis Common during the 1970s and none penetrated more than 10 m of surficial sediments in the deepest known part of the Common near the Mare du Roe (Figures 2 and 4). The 5 m of sediment in Borehole H rested upon a ridge of land separating the Barrackmaster's Lane Valley and the main Longis embayment; the Iron Age settlement at Les Huguettes (Wilson, 1984) lies several hundred metres upslope on the same spur with less than a metre thickness of surficial material. More recent boreholes (Figures 2 and 4: LJ 1-3 and JC) did not reach bedrock because of high water tables at the time of recovery but all proved organic-rich units at shallow depths. As noted above, peaty, organic-rich, deposits also occur within basins of the current rock shore platform in the intertidal zone and are best exposed on the east side of the causeway leading to Ile de Raz. Extensive finds of peaty organic deposits were recently revealed in the upper tidal and supra-tidal zone near the Rifle Butts (eastern) end of the anti-tank wall separating Longis Beach from the Common (James and Dillon, 1991). These latter deposits were subsequently found to extend for a distance of 600 m westwards to the Nunnery. Peaty material has also been reported offshore beyond the tidal reefs to the south-east at *c*. 20 m depth of water (Davenport *pers. comm*., 1985). Molluscan faunas and pollen remains were recovered from sandy silts and peat respectively from boreholes A to C (Figure 2) and were identified by Harland *et al.* (1980) and Beck (1980) respectively (in Keen, 1981) and indicate that sedimentation began on the bedrock in the centre of the Longis Common depression at a height of *c*. 0.5 m and 2.0 m A.D.

Foreshore peats (Figure 2, Cy 1 and Cy 2)

In the intertidal zone, (Cy 2) at –0.2 m A.D., pollen from a 70 cm column of organic-rich sediment overlying weathered Alderney Sandstone bedrock was extracted and briefly described by Keen (1981). The pollen counts showed high non-arboreal pollen (NAP) dominated by freshwater aquatic taxa indicative of a maritime environment suggesting local conditions of an open pond near the sea while the paucity of arboreal pollen was probably the result of exposure to strong saline winds. A radiocarbon assay date of 5220±80 BP/ 6084 Cal BP (Beta-Analytic 39438) for the base of the peat indicated commencement of peat deposition during the Middle Neolithic (James and Dillon, 1991). This date also confirms the finds of Neolithic flint tools and other similar age artefacts from within the intertidal section (Jenkinson *et al*., 1991).

The pollen record from the sampled 70 cm monolith is divided into three local pollen assemblage zones (Figure 5):

Zone IDR1. This pollen zone represents the onset of peat accumulation with open conditions dominated by Poaceae and Cyperaceae while the high frequencies of *Isoetes histrix* spores (35%) is also a notable characteristic of this zone. Arboreal pollen values are low with the main taxa being *Quercus* (9%) *Alnus* (5%) and *Betula* (2%) and shrubs are represented by *Corylus avellana* (10%). The main herbaceous taxa present are Ranunculaceae,

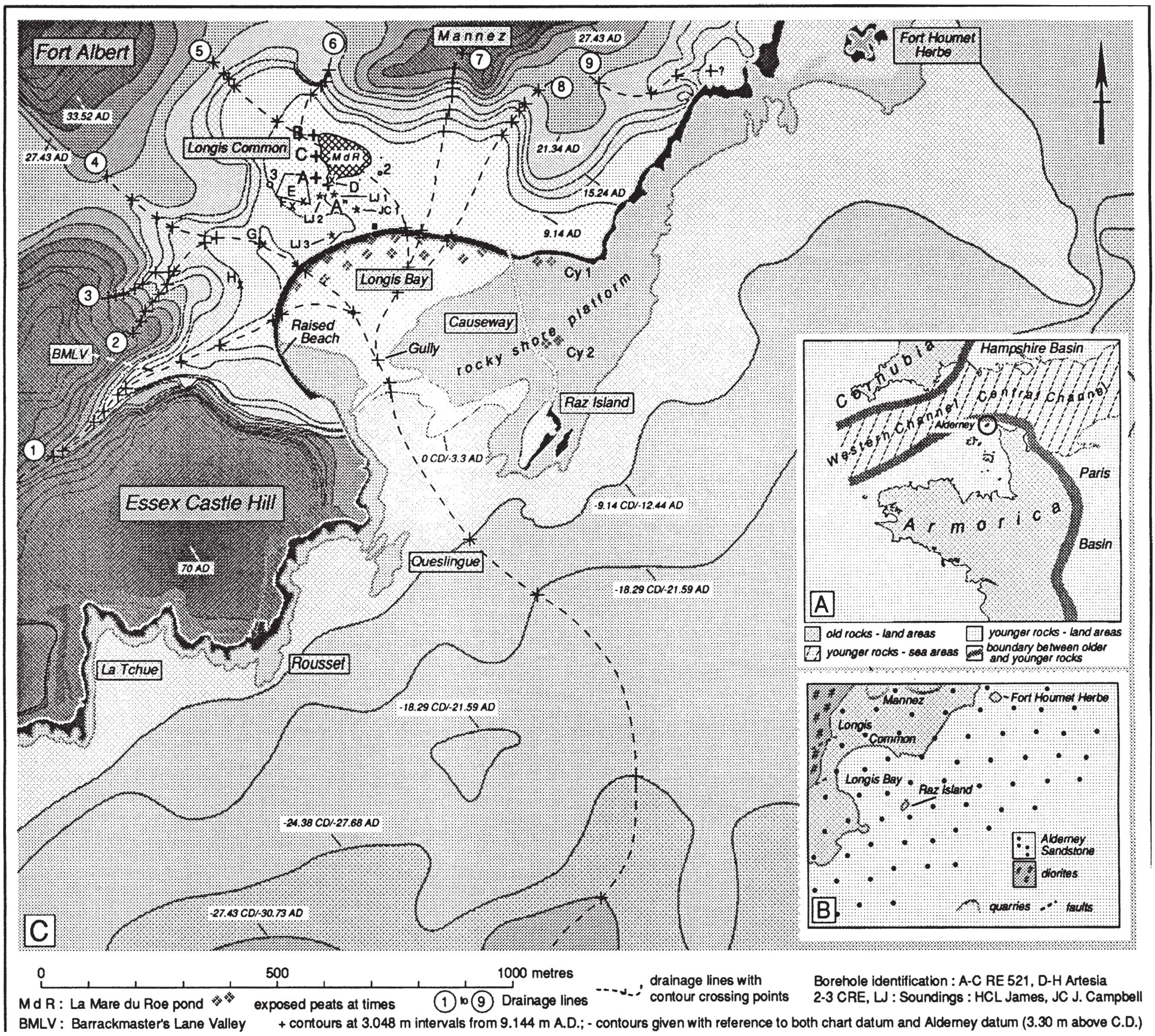

Figure 1. *The Longis embayment. A. Geographical location. B. Outline geology. C. General map showing position of boreholes.*

Chenopodiaceae and *Plantago lanceolata*. The lower zone boundary was radiocarbon dated as 4820 BP/5588 Cal BP/3638 Cal BC.

Zone IDR2. The lower boundary of this zone is drawn at a point where values for Chenopodiaceae and *Isoetes histrix* decline. Open conditions continue with Poaceae frequencies rising to peak values (30%) before falling while Cyperaceae values remain constant with an increase towards the top of this zone. Values for aquatic taxa rise with the appearance of *Myriophyllum verticillatum/spicatum* and *Sparganium emersum* type.

Zone IDR3. The lower boundary of this zone is drawn at a point where there is a significant rise in Cyperaceae (35%), Chenopodiaceae (15%), *Salix*, *Solanum dulcamara* and *Solidago virgaurea* type pollen. Poaceae frequencies begin to decline as do those for aquatic taxa, while arboreal pollen values remain unaltered.

A similar thickness of organic-rich deposits on the foreshore in the supratidal zone near the Rifle Butts (Figure 4, Cy 1) containing freshwater molluscs, pollen and macro-plant and faunal remains was revealed in 1990 following beach scouring and removal of storm beach material. A radiocarbon assay date of 2430+/-70 BP/2533 Cal BP/ 583 Cal BC (Beta-Analytic 38661)

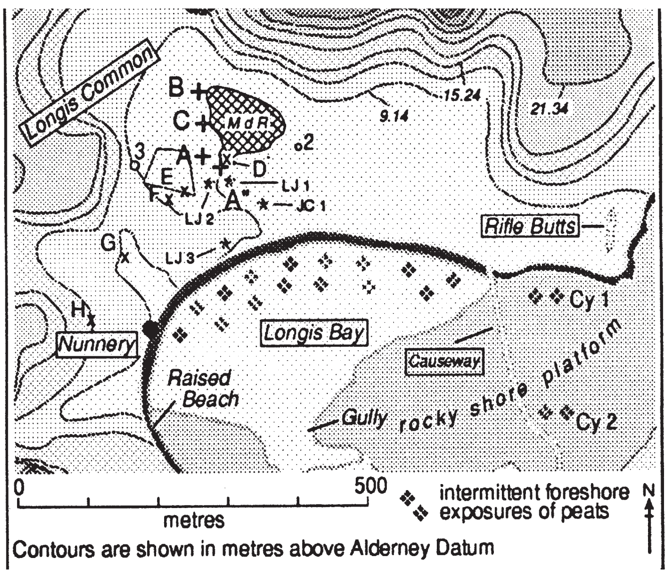

Figure 2. *Detailed map of the central section of the Longis embayment. The borehole designations (A-H, LJ 1-3, JC 1) are identified in the caption to Figure 4.*

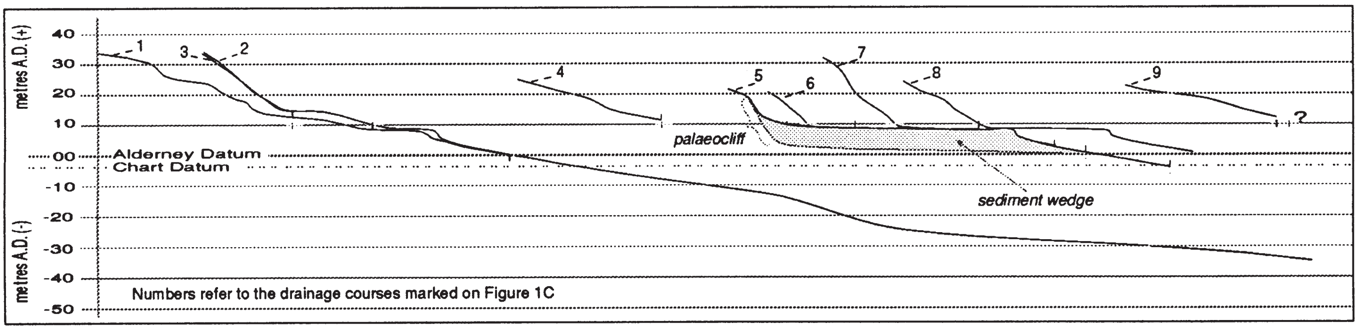

Figure 3. *Profiles of the thalwegs draining into the Longis embayment with the Holocene (Post Glacial) sediment wedge inserted. The course of the profiles is shown in Figure 1C.*

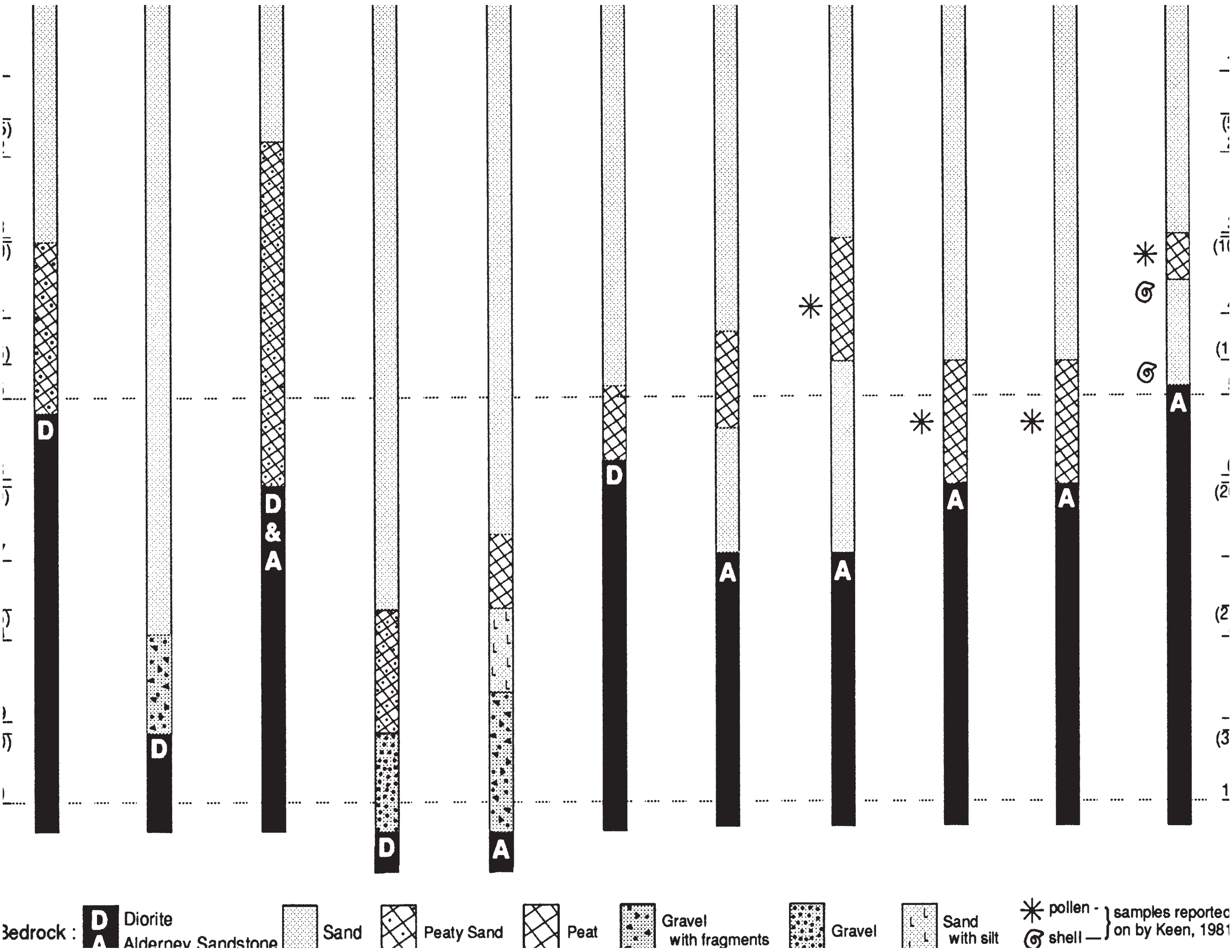

Figure 4. *Logs of the 1970s boreholes.*

was obtained from a large Bos (*Bos primigenus*) type bone extracted from within the peat (James and Dillon, 1991). A shallow trench was excavated into the peat and produced an extensive fauna of almost exclusively freshwater (94%) and some terrestrial (5%) molluscan species (Figure 6). Keen (*pers. comm.*, 1991) stated that the fauna was "overwhelmingly one of a sand bed pond while the land areas around the pond probably consisted of dunes, marshes and possibly semi-stabilised soils". He concluded that although the fauna indicated similar conditions to those now prevailing, the presence of freshwater pond sediments seaward of the modern high water mark suggested a lower sea level than at present.

Longis Common peats

Campbell (2000) examined peaty organic deposits in Guernsey and Alderney and sampled sections from cores and excavations on Longis Common (Figure 4, JC 1) and took a monolith from the intertidal peat (Figure 2, Cy 2) alongside the causeway. The samples were subjected to detailed palaeobotanical analysis and a radiocarbon chronology was obtained.

Five local pollen assemblage zones from borehole JC 1 are identified for Longis Common (Figure 7):

Zone LC1 (3780 BP/4095 Cal BP/2145 Cal BC). This zone represents the onset of peat accumulation and is characterised by an open herbaceous vegetation dominated by Cyperaceae (40%) and Poaceae (40%). Arboreal pollen values are low with

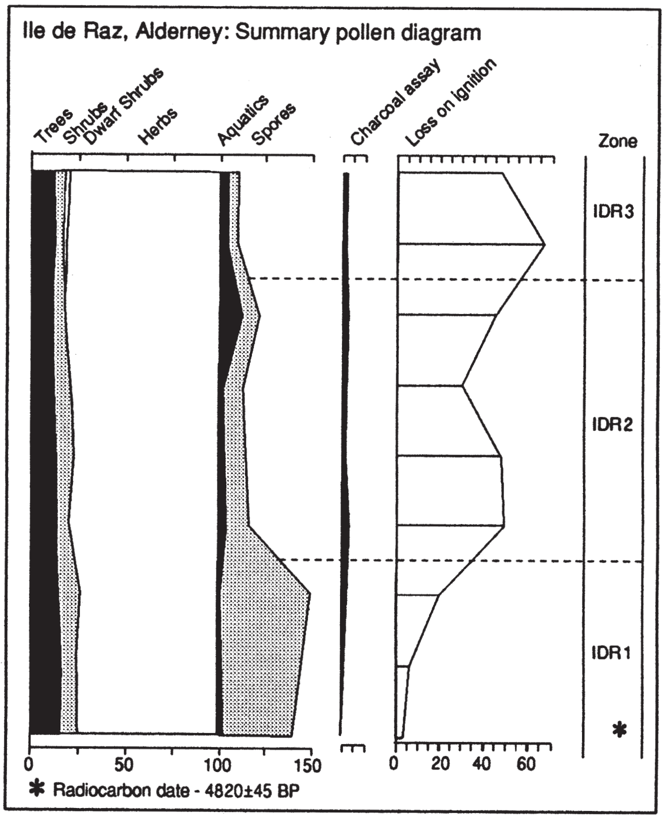

***Figure 5.** Summary pollen diagram for the Ile de Raz Causeway (Cy 2) peats. Detailed pollen diagrams for the Ile de Raz Causeway and the Longis Common peats may be obtained from the authors.*

the main taxa present being *Quercus* (5%) and *Alnus* (5%) while tall shrubs are represented by *Corylus* avellana type pollen (5%). The herbaceous taxa, Ranunculaceae (3%), *Hydrocotyle vulgaris* (3%), *Lotus* (4%) and Rubiaceae suggest the existence of damp grassland. Aquatic conditions are indicated by the occurrence of *Potamogeton*, *Hippuris vulgaris* and *Myriophyllum verticllatum/specatum.* Values for Pteridophytes are high to start with but fall towards the end of this zone. Anthropogenic disturbance may be evident with the presence of Chenopodiaceae, Brassicaceae, Lactuceae and *Solidago virgaurea* type along with *Plantago lanceolata* (5%) while cereal type grains are also present in this zone.

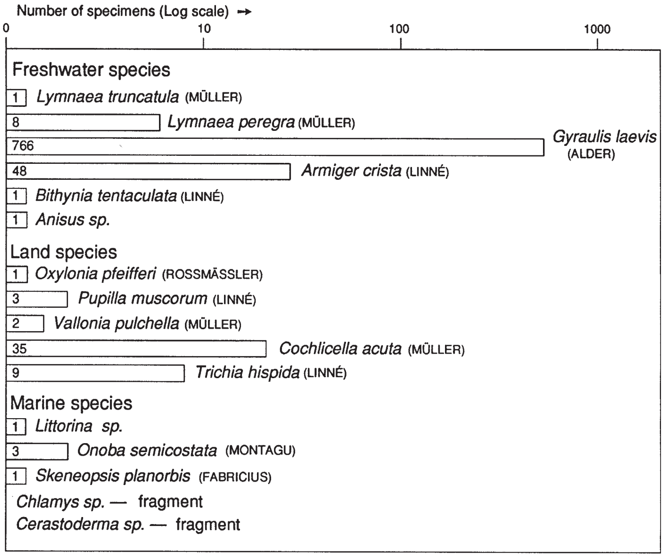

***Figure 6.** Histogram of mollusca identified from the Rifle Butts peat (Cy 1).*

Zone LC2 (3487 BP/3743 Cal BP/1793 Cal BC). This zone is characterised by a rise in the values of aquatic taxa indicating the development of bodies of open water with the assemblage appearing to indicate increasing water depths to *c*. 1.0 m by the end of this zone. Dwarf shrub pollen (*Calluna vulgaris* and *Vaccinium* type) frequencies rise possibly indicating the development of heathland in the vicinity of the site. Open conditions still predominate with the continued existence of damp grassland. Evidence for human disturbance is shown by the rise in frequencies for *Plantago lanceolata* while the increasing occurrence of *Isoetes histrix* indicates the existence of dune slack conditions.

Zone LC3 (2802BP/ 2922 Cal BP/ 972 Cal BC). This is characterised by large numbers of *Urtica dioica*, unidentified Chenopodiaceae, *Chenopodium glaucum* and *Rumex* sp. suggesting an increase in the level of disturbance. There is a rise in Cyperaceae (40%) with a reduction in values for aquatic taxa with the exception of those for *Myriophyllum verticillatum/ specatum*. Cereal pollen is constantly present while *Pteridophyte*s rises to a peak value of 20%. The increase in submerged aquatic taxa during LC3 suggests water depths rising to a maximum of *c*. 2.0 m.

Zone LC4 (2335 BP/2384 Cal BP/434 Cal BP). This zone shows an increase in *Calluna vulgaris* and *Vaccinium* type suggesting an expansion of heathland. Aquatic taxa frequencies fall while *Pteridophytes* rises to a peak value of 30% before declining at the end of this zone. Zone LC4 is also characterised by increased numbers of *Typha* sp. indicating the development of reed-swamp accompanied by scrubby waterside vegetation with *Rubus* cf. *fruiticosa* and *Solanum dulcamara*. The overall emergent nature of the assemblage appears to indicate a reduction in water depths to circa 0.3 m.

Zone LC5 (1740 BP/1712 Cal BP/238 Cal AD). The lower boundary for this zone is drawn at the point where the curves for Chenopodiaceae, Brassicaceae, Apaceae, Lactuceae and *Solidago virgaurea* type decline to negligible levels and where there is a significant increase in the curves for *Salix*, *Solanum dulcamara*, *Urtica dioica* and *Typha latifolia*. Arboreal pollen values continue to fall with the exception of *Fagus* while heathland dwarf shrubs are represented solely by *Vaccinium* type. An increase in the number of Helophyte taxa present together with the aquatic taxa again indicate an emergent community with possible water depths varying between 0.3 m and 0.75 m.

Palaeoenvironmental considerations

There is a good level of correspondence between the pollen and macrofossil data obtained from Longis Common (Figure 7) and the foreshore even though they are of different ages. The local environment of deposition appears to have been an unshaded mire or large dune slack, with areas of wetland, conditions not dissimilar to the present day. Anthropogenic activity is indicated by the presence of weed/ruderal species charcteristic of disturbed soil surfaces. Both arable and pastoral activities seem to have taken place in the area. The distribution of the dune slack area or areas along with any associated open water over the Longis embayment at any one time during the successions revealed in the core sampling cannot be determined with the present sub surface data. However, from the first evidence of dated sedimentation at the base of the Causeway peats during the Middle Neolithic (3628 Cal BC), a distinct pattern of sedimentation represented by peat formation and blown sand prevailed right through to the present day. Within this broad pattern, the fine detail suggests a number of environmental changes with time.

At the commencement of deposition of the Causeway peat (3628 Cal BC), the rising Holocene sea level was beyond the tidal reefs of Longis Bay, that is, at least 3-4 m lower than the basal peat levels which is commensurate with that estimated for the region of the normanno-breton gulf and environs (Morzadec-Kerfourn,

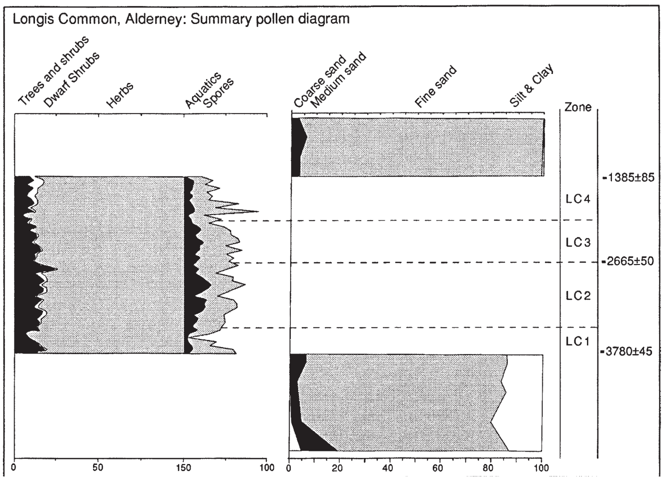

Figure 7. *Summary pollen diagram for the Longis Common peats.*

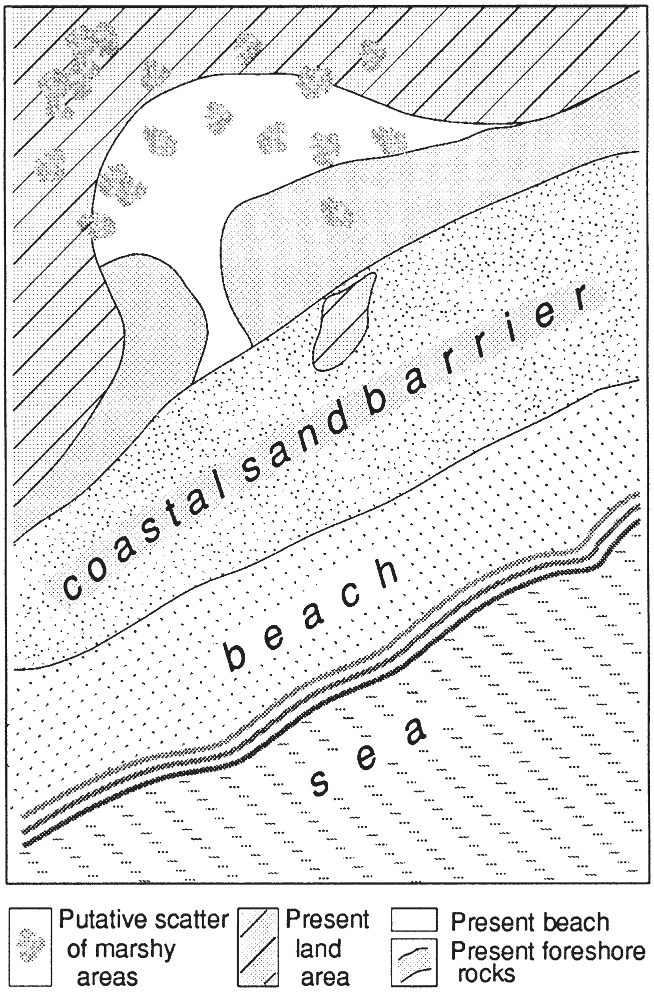

Figure 8. *Cartoon sketch showing a putative coastal barrier sealing in the Longis embayment prior to the breaching of the barrier probably during the later Iron Age.*

1974; Guilcher and Hallegouet, 1991). There is no evidence from boreholes and cores of marine or wind blown sand deposits in the embayment area before this time. However, subsequent infill of the embayment with blown sand would suggest that there must already have been a source area nearby and this is most likely to have taken the form of a fringing coastal sand barrier seaward of the present foreshore rock platform (Figure 8). This would have advanced towards the present coastline along with a rising sea level but in an interemittent fashion dependent upon local conditions (Renouf and Urry, 1976; Jones *et al.,* 1987; Jones *et al.*, 1990). The first occurrence of sedimentation was the establishment of a marshy area on the rock platform currently represented by the Causeway peat. Between this date, (3628 Cal BC), and the dated base of the Longis Common peats (2145 Cal BC), there is no available evidence for general palaeoenvironmental conditions. However, the general rise in sea level would have continued and could have been expected to have almost reached present mean sea level or just beyond (Jones *et al.*, 1987; Jones *et al.*, 1990). The problem of a sand source is as important over this period as it was earlier. It would seem likely that a putative coastal barrier continued in existence moving onshore but not extending significantly beyond its seaward location under conditions such that blown sand was able to overwhelm the extensive marshy and open water areas (*cf.* James and Guttman, 1992) as it was to do after the cessation of major peat deposition in the early Bronze Age.

Within the organic deposits formed after *c.* 2145 Cal BC in the early Bronze Age there are a number of indications of changing palaeoenvironmental conditions. The maximum depth of the open mere recorded by the pollen and macroplant remains occurred in the Hallstat Iron Age (some time after 1000 BC). The next known date from the mid 5th century BC in the La Tene Iron Age reveals a marked reduction in water depth and the growth of a reed swamp. The maximum depth in the early Iron Age indicates an increasing ground water level resulting from a number of factors. These may have included changes in the rate of relative sea level rise alongside changing climatic conditions and/or a coastal sea barrier being driven onshore. The sea level evidence from around the normanno-breton gulf (*e.g.* Regnauld *et al.*, 1996; Morzadec-Kerfourn, 1974; Guilcher and Hallegouet, 1991) indicates a regressive phase for this period and coincides with a climatic downturn (Van Geel *et al.*, 1996) of wide geographical extent between 850 and 760 Cal BC. Lowering of sea level would have exposed sandy beaches generating a source of sand for wind blow to move onshore. One result of the climatic change appears to have been widespread sand accumulations over the coasts of NW Europe, this despite the agreed wetter overall conditions. However, as indicated by Gilbertson *et al.* (1999), if climatic conditions were wetter, it could also have been more stormy thereby contributing to sand movement. Any increase in height of the coastal sand barrier would have encouraged a rise in the ground water levels in the back dune slack areas and to an increased depth of any standing water.

This general situation appears to have continued for several centuries and may well have included the abandonment of the Les Huguettes Iron Age site (Wilson, 1984) which has yielded a radiocarbon assay date (490 Uncal BC) from the Hallstatt Iron Age which may have begun in the late Bronze Age. The site was abandoned some time after 490 Uncal. BC and covered by aeolian sand. The search for any settlement linked to this pottery firing site is unlikely to yield results since the whole surface of the Common was several metres lower than it is now and so well hidden beneath the later sand cover. Scattered finds of Neolithic, Bronze, Iron and later ages (Jenkinson *et al.,* 1991) over the Common may reflect episodes of sand scour and movement exposing lower horizons from time to time. A further important deposit at this time, dated at 583 Cal BC, is the Rifle Butts peat on the shore platform at current high and supratidal levels. Again, this is another commencement date for peat deposition in a shallow basinal structure within the upper shore platform indicating that the sea had not reached its present height; it is likely that there was a distance of several hundred metres between it and an intervening coastal barrier along the then shoreline. Evidence from a late Iron Age site in St Helier, Jersey (Finlaison, 1977) reveals a beach settlement overwhelmed by blown sand thereby demonstrating the multi-mechanism of a regressive episode to provide the sand followed by transgression moving the sand on-shore.

The absence of significant sand thicknesses below the peat units antedating the Iron Age within the Longis embayment suggests that the peats were established preferentially in the shallow basinal structures found on the basal abrasion surface prior to the arrival of the wind blown sand. This situation would have continued throughout most of the Neolithic and Bronze Ages as well as into the Iron Age. Subsequently, sand accumulation within Longis Common appears to have been more or less continuous from the early part of the 7th century AD with no further indication of the widespread open body of water that previously existed. A general thickness of >4 m of sand masking the peaty organic units is though to have been derived from the encroaching coastal barrier, blown inland as a result of probably stormy climatic conditions.

The postulated sequence of environmental events for Longis is comparable with the sequences of Holocene sedimentation described from Jersey (Jones *et al.,* 1987; Jones *et al*., 1990) where the irregular but continual onshore movement of coastal sand barriers is an essential feature of mid to late Holocene times but including considerable variation between different coastal embayments around the island.

Conclusions

Sometime after the last Cold Stage (Devensian) and before the Neolithic period, it is envisaged that the base of the Longis embayment was largely scoured of any periglacial head deposits apart from those surviving at the bottom of the steeper slopes, *e.g*. below Essex Hill and to a lesser extent, the palaeocliff of the Common. Beyond the present shoreline, a coastal sand barrier formed in advance of the rising Holocene sea level reaching the vicinity of the area by *c*. 7000 Cal. BC. Marshes behind the barrier formed on the bedrock now forming the foreshore along the causeway to Raz Island. Fluctuations in the rise of sea level, together with variations in climatic conditions including some landward sand movement, would account for the sequence of environmental events recorded by plant populations between the Neolithic and the middle of the first millennium Cal. BC when the first evidence for the sand invasion of the embayment is recorded in association with a slight regression and associated climatic deterioration. The Iron Age site of Les Huguettes was abandoned at this time. Thereafter, sea level rose and at some stage, perhaps late in the first millennium BC, breached the coastal barrier probably through the narrow gully west of Raz Island and began to scour out the present shape of Longis beach (Figure 1C).

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