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A geoarchaeological approach to the evolution of the town and port of Dover: Prehistoric to Saxon periods

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ABSTRACT

Dover is located at the mouth of a narrow valley that forms the only significant break in almost 20 km of chalk cliffs along the Kentish Channel coast. This, together with the close proximity of the Continent, has ensured the site's standing as a port since pre-Roman times. However, little is known of the sequence of events associated with the transformation of the area since the later prehistoric period, and in particular the evolution of the harbour which has had at least four different locations. Work to regenerate central Dover has however provided opportunities to address these issues and we report here on geological evidence for harbour development and coastal change from the middle Holocene period to the present day.

Foraminifera and ostracods recovered from boreholes and excavations in the town centre allow patterns of sedimentation to be identified and linked to archaeological finds such as the Dover Bronze Age Boat and Roman harbour installations. Radiocarbon dating, and archaeological spot-dating provides a chronological framework for these changes. In particular the later Prehistoric environments and their transformation to estuarine environments by the time of Roman activity in the area are examined (including the role of sea level change and coastal erosion). The history of sedimentation within the Roman harbour and the role played by human activity in accelerating sedimentation in the old valley mouth is also considered. Finally dune formation across former estuarine habitats is documented in the Anglo-Saxon period creating the topographic template on which the modern town is based.

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1. Introduction

Dover is located on the English Channel coast of Kent at the mouth of the River Dour (Fig. 1), where the narrow gap formed by its valley represents the only significant break in almost 20 km of chalk cliffs. This, together with the close proximity of the Continent, has ensured the site's standing as an important port and point of entry into Britain, probably since pre-Roman times. The operational maintenance of a port here, however, has not been easy, with geographical and strategic necessities often over-riding the limitations of the available natural facilities. Thus, throughout the centuries, the harbour has had at least four different locations, dictated by ever-changing coastal topography (Biddle and Summerson, 1982; Leach, 2005).

The original estuary and its associated Roman harbour have long since been infilled and much of modern Dover is built across the deep layers of sediment which fill the former haven. However,

little is known of the sequence of events associated with the transformation of the area from the later prehistoric to early historic periods. Unravelling this history of harbour infilling has a long history in Dover and began in the nineteenth and first half of the twentieth century (Elsted, 1856; Knocker, 1857; Bavington Jones, 1907). These early observations were augmented by opportunistic observations prior to the Second World War (Amos and Wheeler, 1929) and formal excavations during construction and infrastructure renewal following bomb damage after the war (Threipland and Steer, 1951; Threipland, 1957; Rahtz, 1958). Widespread investigations coincided with larger scale works associated with urban regeneration during the 1970s and 1980s (Philp, 1981a, 1989) and modifications to the A20 road and town sewers in the early 1990s (Bates and Barham, 1993). Because of the urbanized character of the area, coupled with the deeply stratified nature of the sediments within the former harbour, conventional approaches to the archaeological record required adaptation. Consequently as part of the A20 works, in addition to conventional set piece excavations and watching-briefs, a series of purposive boreholes were drilled in order to recover samples through the underlying sediments to reconstruct the sedimentary sequences

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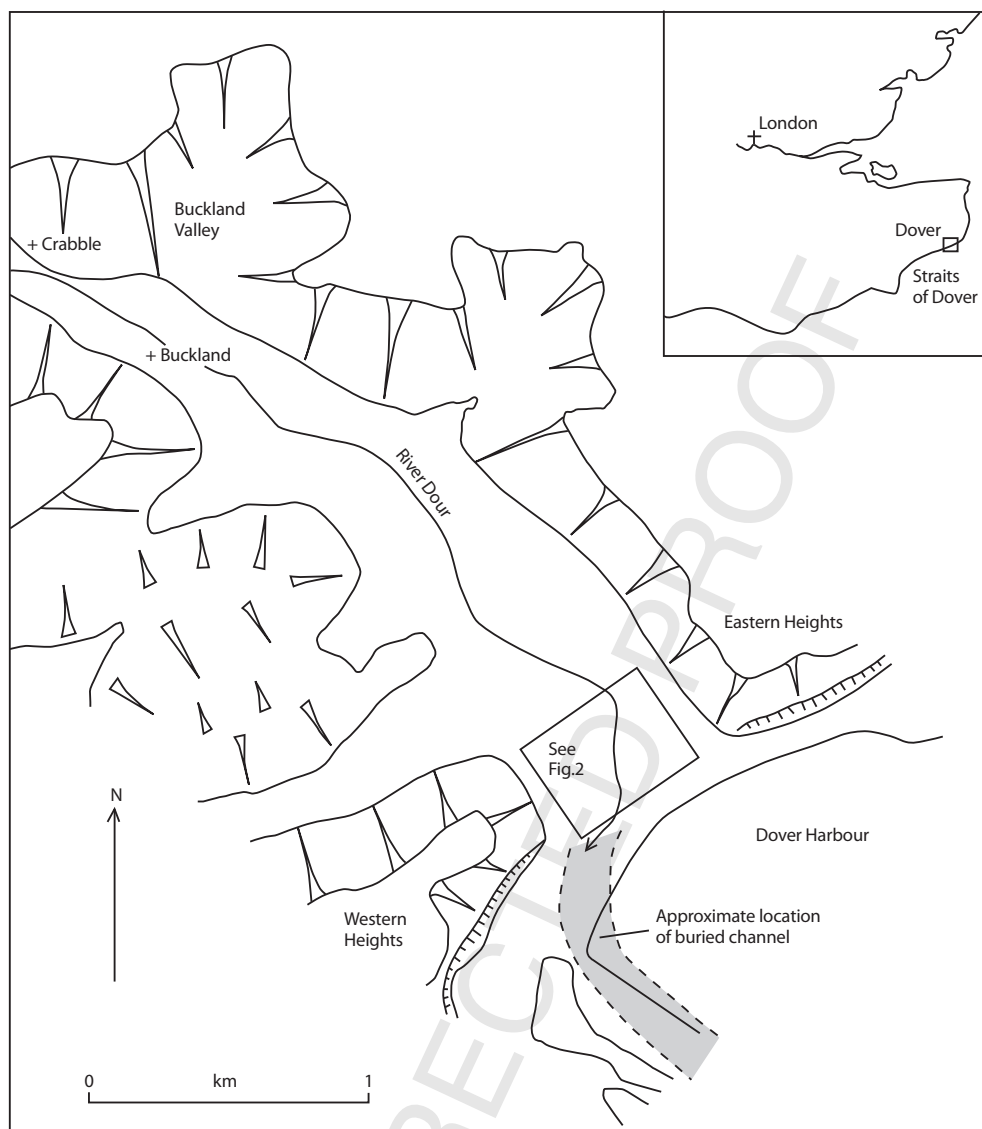


Fig. 1. Site location plan showing Dour Valley and the Western Docks including the approximate location of the buried channel of the Dour.

associated with harbour development, use and infilling. Here we report on the results of this work and present a model for the local evolution of the harbour area linking natural processes with human responses and activity.

2. Local geology and geomorphology

Bedrock in the study area is dominated by Turonian, Coniacian and Santonian Chalk of the Middle and Upper Chalk (Shephard-Thorn, 1988). The valley trends in a north-west to south-east direction (Fig. 1) that contrasts with the predominant drainage pattern in the area (Barham and Bates, 1990). Today the River Dour rises near Kearsney (just over 4 km from the sea) and is largely canalized in its lower course before entering a culvert beneath the town centre. Consequently, little of its natural predecessor is apparent today.

Sediments infilling the valley have been mapped by the British Geological Survey (BGS) and comprise of Alluvium, Estuarine Alluvium, Dry Valley and Nailbourne deposits in the valley bottom. Head and Head Brickearth, with Clay-with-flints cap the adjacent downland plateau and dry valley bases (Shephard-Thorn, 1988). Within the lower Dour Valley recent work (Barham and Bates, 1990; Bates et al., 2008) has demonstrated that a

complex sequence of sediments are preserved ranging from coarse, angular flint gravels through peat and tufa sequences to anthropogenic sediments associated with building, construction and demolition.

Adjacent to the valley the coastline is backed by cliffs that rise today to above 100 m. These world famous 'White Cliffs' are known to be eroding and are likely to have suffered severe erosion in the past as a result of both marine and sub-aerial processes (e.g. see McDakin, 1900; May, 1971; May and Heeps, 1985; Dornbusch, 2005a). Marine processes operating in the North Downs coastal zone today are governed by meso- to macrotidal ranges linked to near-shore tidal currents and subject to a trend in longshore drift from west to east as a result of the prevailing westerly winds driving waves eastwards up the English Channel.

3. Archaeological and historical background

The earliest evidence for human activity within the Dour Valley was identified in the Market Square (Fig. 2, site 1) where Rahtz (1958) reported calcined flints and a few derived worked flints of probable Neolithic date resting on brickearth. The most spectacular evidence for prehistoric activity is that discovered in 1992 in the town centre area (Fig. 2, Site 2) where the remains of a large, well

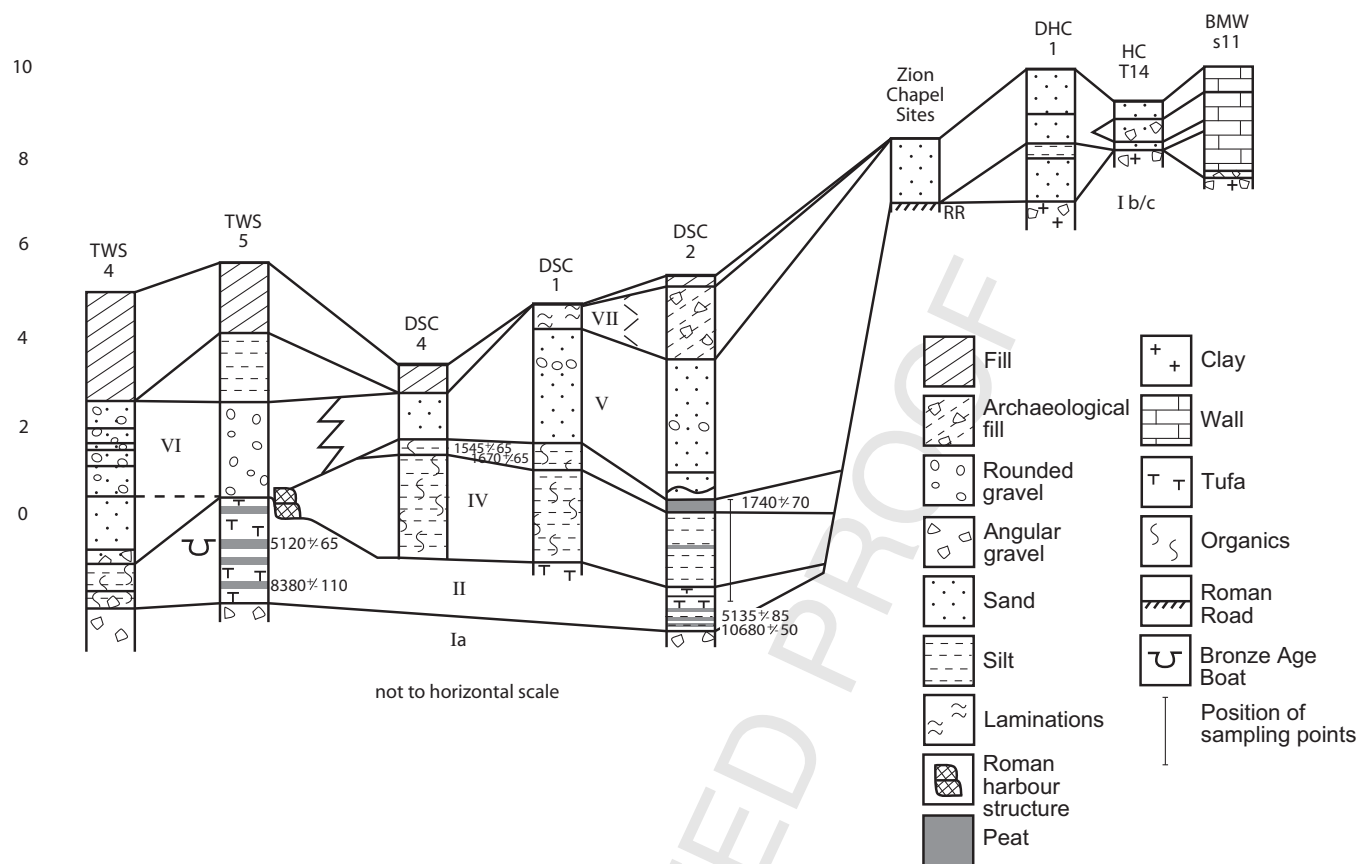


Fig. 2. Town centre area showing boreholes and archaeological sites investigated during the last 150 years. The position of the major Roman forts as well as the inferred position of the harbour edges are also shown beneath the modern street plan.

preserved Bronze Age Boat were discovered (Clark, 2004). The boat, dating to c. 1550 BC, was discovered with a quantity of domestic rubbish, clearly indicating the presence of some nearby contemporary settlement site. Bronze Age activity is also attested to by the Langdon Bay Bronze Age hoard, found on the seabed just outside the Eastern Docks, quite possibly derived from a wrecked vessel (Coombs, 1976; Muckelroy, 1981) and by discoveries at Crabble Mill where a probable 'burnt mound' site has recently been identified (Parfitt, 2006; Bates et al., 2008). A small Iron Age settlement, with an associated round house, several pits and domestic rubbish, is known in the area of York Street (Philp, n.d.) and there was further Iron Age occupation on Castle Hill overlooking the eastern side of the valley (Biddle, 1969).

Roman activity within the region is now well documented (Amos and Wheeler, 1929; Wheeler, 1929; Rahtz, 1958; Rigold, 1969; Philp, 1981a, 1989; Booth, 2007) and consists of evidence for both harbour and urban (including military) activity. Direct evidence for Roman activity within the town centre area was recovered in the nineteenth century through the discovery of a large timber structure at Dolphin Lane (Elsted, 1856; Knocker, 1857; Rigold, 1969) (Fig. 2, Site 3), together with scattered fragments of a masonry building on the western side of the river. In the early twentieth century important contributions to the study of Dover were first made by Amos and Wheeler in 1929 (Fig. 2, Site 4), while the first serious attempt to contextualize findings (Threipland and Steer, 1951; Rahtz, 1958) within the layout of the harbour were made by Rigold (1969). Subsequently, extensive excavations conducted throughout the 1970s and 1980s greatly broadened our knowledge of Roman Dover and proved the existence, under the modern town, of two successive forts, important civilian buildings and further harbour installations (Philp, 1981a, 1981b, 1989).

As yet, there is no clear evidence for continuous, uninterrupted occupation in Dover following the decline of Roman rule in the early fifth century, but archaeological evidence does attest to Anglo-Saxon settlement inside the walls of the late Roman fort and outside the fort, further up the Dour valley (Evison, 1987; Parfitt, 1995a, 1995b; Philp, 2003), by the start of the sixth century A.D. A minster church dedicated to St. Martin appears to have been founded within the late Roman fort during the late seventh century (Rigold, 1977; Philp, 2003). The exact position of the Anglo-Saxon harbour remains unknown but, at least in the early Anglo-Saxon period, it may have utilised the surviving remnants of the Roman facilities, to the east of the late third century Shore fort.

Like its predecessors, the medieval town was situated on the western side of the valley, mostly across the site of the earlier Roman and Anglo-Saxon settlements, focused on the churches of St Martin le Grand, St Mary and St Peter, in the area of the present-day Market Square.

4. Recent investigations

In the early 1990s modernisation of the town's sewer system and the reconfiguration of the A20 from Folkestone (Bates and Barham, 1993) enabled, for the first time in the history of Dover's extensive archaeological investigation, a structured and integrated approach to be applied to the examination of both dry land archaeological sites and those areas traditionally associated with wetter ground and the Roman harbour. This project (A20 Road and Sewer Scheme) was the first in Dover to widely utilise geological and environmental archaeological approaches and methods and consequently a range of new sources of information were applied to archaeological interrogation. The approach adopted was

designed to accommodate difficulties in undertaking set piece excavations in advance of construction in predominantly urban areas where most impact was to occur within the confines of active road systems to which minimal disruption was vital in order to allow as near to normal operation of the town as possible. In order to investigate the sequences preserved within the town centre area a number of objectives were set:

1. That evidence of the stratigraphic sequences through the full sequence of deposits could be obtained.
2. That the investigation methods allowed the full sequences to be recovered for analysis.
3. That sufficient sample material was available for dating and palaeoenvironmental analysis.
4. That the sequence and calibrated palaeoenvironmental material could be combined into a series of 'master sequences' describing change within the area.
5. That the master sequences could be tied to archaeological evidence and consequently past human activity.

The urban environment of the town centre, where access to sites was restricted to temporary road closures coupled with the excessive depth of sediments (up to 10 m from ground surface), precluded excavated trenches through the entire sequence and consequently boreholes were used to obtain sediments to create master sequences. Despite the difficulties in using geotechnical borehole data for reconstructing buried archaeology (Bates et al., 2000) the controlled use of targeted boreholes specifically drilled for a geoarchaeological purpose provided the framework for identifying major stratigraphic units across the study area and allowed key sequences to be selected for detailed investigation. These observations were linked to key-hole excavations and trench records and subsequently those sequences selected for investigation were examined for dateable material (both archaeological and material suitable for ^{14}C dating) and microfossil analysis. This evidence is presented below. In all cases attempts have been made to contextualize the developed framework with the known archaeological sequences from previously published literature within the area.

5. Key sequences

The A20 observations (Bates and Barham, 1993) coupled to more recent work including that at Crabble Mill (Bates et al., 2008) have demonstrated the basic sedimentary sequence that exists within the Dour Valley downstream of Kearsney (Table 1).

Underlying all sequences below the town centre were angular flint and chalk gravels (Ia in Table 1) first described by McDakin (1900) as a gravel up to 18 feet (5.5 m) thick (Figs. 3–5). Geotechnical borehole records gathered during the A20 works indicate that similar sediments can be traced from Crabble Mill downstream to the town centre and westwards to the former Western Docks Train Ferry Terminal on the Admiralty Pier (Figs. 1 and 3–5). The poorly sorted, sub-angular nature of the gravels, together with the discovery of mammoth teeth in the Market Square and around the Admiralty Pier (Bates et al., 2008), suggest that these gravels were laid down in cold climate conditions during the Pleistocene. Closely related to these gravels are the finer grained silts and gravelly silts (often denoted as brickearths in geotechnical logs) that are recorded along the valley sides (Ib and Ic, Table 1). These are present beneath the Dover Discovery Centre and are clearly visible in Figs. 4 and 5. These are likely to be cold climate deposits (evidenced by the association of molluscs from Archcliffe Fort – Bates and Barham, 1993) but their precise relationship to the flint gravels has never been demonstrated within the Dour catchment.

Overlying the gravels, and associated with the Bronze Age Boat, is a thick sequence of tufa, peats and silts (II, Table 1; Figs. 3 and 6) documenting environmental change in the valley mouth during the later prehistoric period (Keeley et al., 2004; Bates et al., 2008). The sequences consist of inter-bedded tufa and compact, firm humified peats (Fig. 6A), being replaced upwards by minerogenic silts (IIIa, Fig. 6B). These deposits appear to have formed in a freshwater carbonate-rich floodplain or channel marginal environment. They only contain evidence for marine or brackish water conditions towards the top, within the minerogenic silts (Keeley et al., 2004). Age estimates for these sediment bodies indicate tufa/peat accumulation beginning in the valley by 9400 BP (Bates and Barham, 1993; Bates et al., 2008) ceasing sometime after abandonment of the boat (post 3500 BP) (Table 2).

Evidence for brackish water and intertidal conditions within the area is provided by the organic sands and silts found in the vicinity of the Bench Street-Market Square area (Unit IV, Table 1; Figs. 3–6 and 8). These deposits vary from poorly- to well-bedded sands and silts with a variable organic content that includes plants/wood, foraminifera, ostracods, diatoms and pollen. These sediments infill a basin-like depression that corresponds approximately to Rigold's 'Outer Harbour' (Rigold, 1969). Radiocarbon dates (Table 2) from the upper parts of these sequences date cessation of sequence formation in the later Roman or Saxon periods.

Higher energy marine conditions are attested by the presence of marine sands and probable windblown sands (Unit V, Table 1, Figs. 3–5 and 9) in the vicinity of Bench Street and Queen Street.

Table 1
Stratigraphic groups, locations, inferred palaeoenvironmental conditions and age estimates (^{14}C years B.P.) for key deposits in the Dour Valley.

Stratigraphic group number	Stratigraphic group	Location in valley	Inferred palaeoenvironmental conditions	Age ascriptions
VII	Anthropogenic sediments	Town centre		Medieval to post-Medieval
VI	Rounded flint gravels	Town centre	Littoral situation	Medieval to post-Medieval
V	Sands	Town centre	Littoral and aeolian sand infilling harbour basin	Late Roman to Saxon
IV	Organic sands and silts	Town centre	Estuarine to freshwater wetland	Roman to early Saxon
IIIb	Bedded fine grained silts containing angular flint clasts	Valley sides	infilling harbour	Bronze Age to Roman
IIIa	Laminated fine grained silts	Town centre		Bronze Age to Roman
II	Tufa/peat units	Crabble to towncentre	Carbonate rich fluvial systems with braided channels and surrounding damp ground, open and closed vegetation	<3300 B.P.
IId	Fine grained calcareous muds and silts			
IIc	Stromatolitic growths and tufa gravels/micrites			
IIb	Oncoidal tufa gravel			
IIa	Peat (humified/unhumified) and peaty silts			>9240 B.P.
Ic	Chalk rubble beds within fine grained silts	Valley sides, Archcliffe Fort	Solifluction under cold climate	
1b	Fine grained silts	Valley sides, Archcliffe Fort	Slope wash conditions	
Ia	Angular flint gravels	Valley floor, Crabble to Western Docks	Periglacial, braided channel systems.	>10,000 B.P.

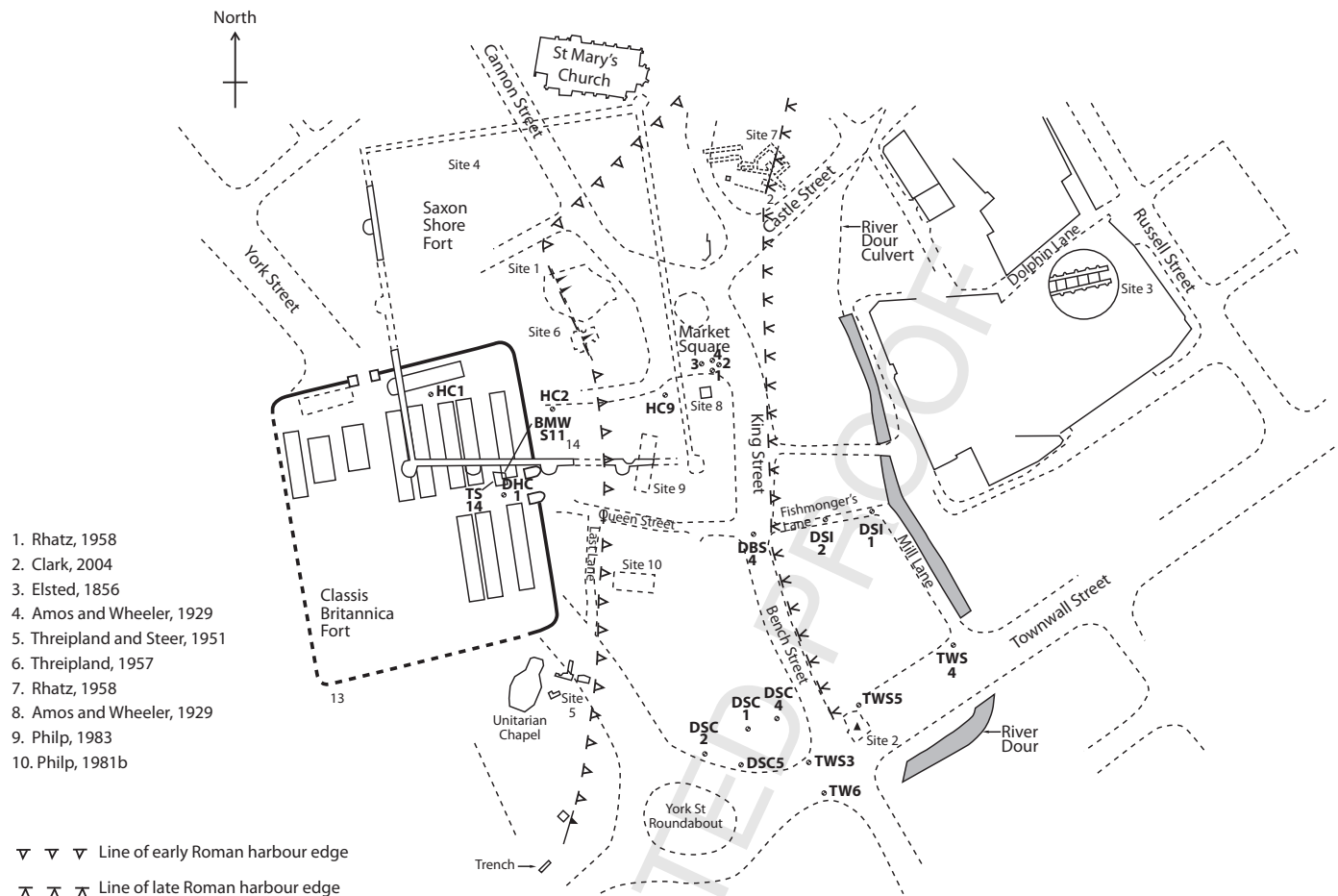


Fig. 3. Cross section based on borehole evidence from Dover Museum (BMW s11) to Townwall Street/Mill Lane across the probable location of the harbour mouth during the Roman period. Note the distribution of the sands of Unit V rising steeply to the north towards the Zion Chapel site.

These demonstrably overlie the harbour infill sequences and are coarsest beneath Townwall Street where well-rounded flint gravels (shingle?) were encountered. Inland, the deposits thin and form a wedge rising towards the south wall of the late Roman Shore Fort (Fig. 3).

5.1. Unit II. Tufa/peat associations: late prehistoric sediments and archaeology

Detailed investigation of the sequences have previously been undertaken on sediments associated with the Bronze Age Boat in the town centre area (Keeley et al., 2004) and upstream at Crabble Mill (Bates et al., 2008). While the investigations associated with

the Bronze Age Boat have been quite detailed, the restricted focus of the study on samples directly relating to the boat and the difficulty of cross-comparing the published results from different specialists make it difficult to assess the broader context of the results. This is particularly the case for the setting of the boat within the local topography and as part of a landscape undergoing long term change from freshwater to brackish conditions. Consequently for the sequences in the town centre area it has been difficult to ascertain the true nature of the setting for the boat or that of any contemporary activity on, or near, the valley floor.

Tufa and peat sequences are now well recorded across a range of boreholes from the town centre area (Fig. 2) and these sequences are thickest along the line of Townwall Street from York Street

Table 2
Radiocarbon age estimates from the town centre area and Buckland Churchyard.

Site code	Laboratory sample number	Material type	Sediment unit	Stratigraphic group	Radiocarbon age (years BP)	Calibrated age (95.4% probability) BP	Calibrated age (95.4% probability) AD/BC
GSF 21, 0.00–0.30 m	OxA-4183	Wood	Organic silts	IV (top)	1545 ± 65	1309–1554 (1.000)	396–641 (1.000)
GSF 21, 0.30–0.40 m	OxA-4184	<i>Equistem</i> sp. stem	Organic silts	IV	1670 ± 65	1408–1716 (1.000)	234–542 (1.000)
DSC-2, 4.99–5.01 m	OxA-4185	Peat (humic acid)	Organic silts	IV (top)	1740 ± 65	1522–1823 (1.000)	127–428 (1.000)
DSC-2, 7.09–7.11 m	OxA-4186	Peat	Peat/Tufa	II (top)	4810 ± 95	5319–5725 (1.000)	3776–3370 (1.000)
TWS-5, 6.39–6.41 m	GU-5323	Wood (<i>Quercus</i> sp.)	Peat/Tufa	II (top)	5120 ± 65	5710–5996 (99.2)	4047–3761 (99.2)
TWS-5, 6.72–6.74 m	OxA-4187	Peat	Peat/Tufa	II	4340 ± 85	4808–5093 (78.4)	3144–2859 (78.4)
TWS-5, 6.80–6.82 m	OxA-4188	Peat	Peat/Tufa	II	6315 ± 85	7146–7422 (84.9)	5473–5197 (84.9)
TWS-5, 6.90–6.92 m	OxA-4189	Peat	Peat/Tufa	II (base)	8380 ± 110	9090–9542 (99.8)	7593–7141 (99.8)
Buckland Churchyard, BC-90/27b, 1.78–1.87 m	Beta-38216	Peat	Peat/Tufa	II	9240 ± 100	10,229–10,664 (1.000)	8715–8280 (1.000)
DSC-2, 7.40 m	Beta-279929	Peat	Peat/Tufa	II (base)	10,680 ± 50	12,545–12,707 (1.000)	10,758–10,596 (1.000)

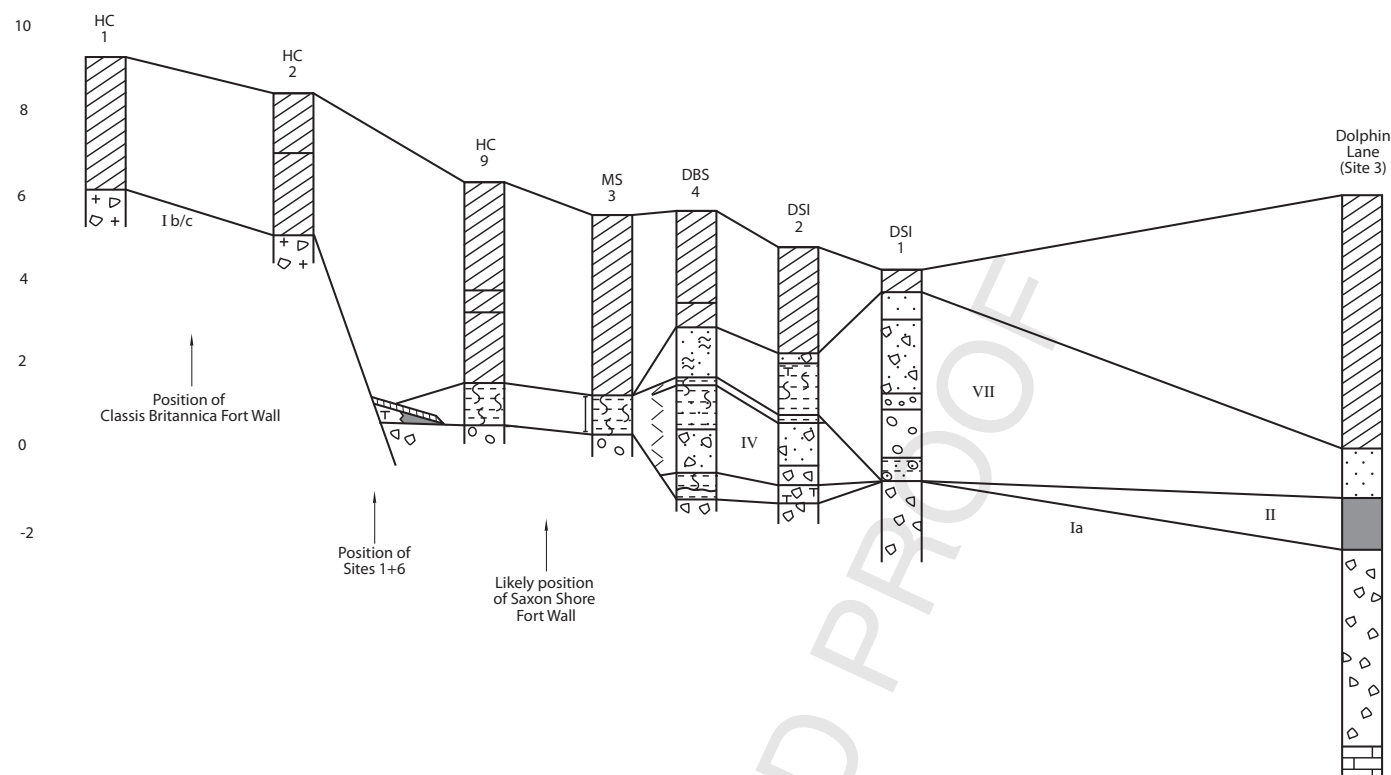


Fig. 4. Cross section based on borehole evidence from Dover Museum (DFHC 1) to Dolphin Lane. The approximate locations (although not stratigraphic positions) of the walls of the Classis Britannica and Saxon Shore forts are shown including a small wedge of tufa and peat sediments lying against the edge of the former estuary of the Dour.

Roundabout to the end of Mill Lane (Fig. 3). Tufa is absent along much of Bench Street but it has been recorded in boreholes at Queen Street (Fig. 4) and intermittently along the western side of the valley upstream as far as Crabble (Bates et al., 2008). In the Market Square at Site 1 (Fig. 2) Rahtz (1958) has illustrated a layer of 'fine, clean grey silt' resting on a surface he considered to represent the base of the old estuary as it rose upslope in one

section towards higher ground (Section C, Layer N). This layer, although not identified as tufa, was noted to be a 'highly calcareous very fine sand' and must have been micritic tufa (see below).

Within the town centre area the sequences associated with the Bronze Age Boat produced a number of different sediment bodies and Fig. 5 illustrates a composite sequence through these deposits along the eastern edge of the excavations. Analysis of the

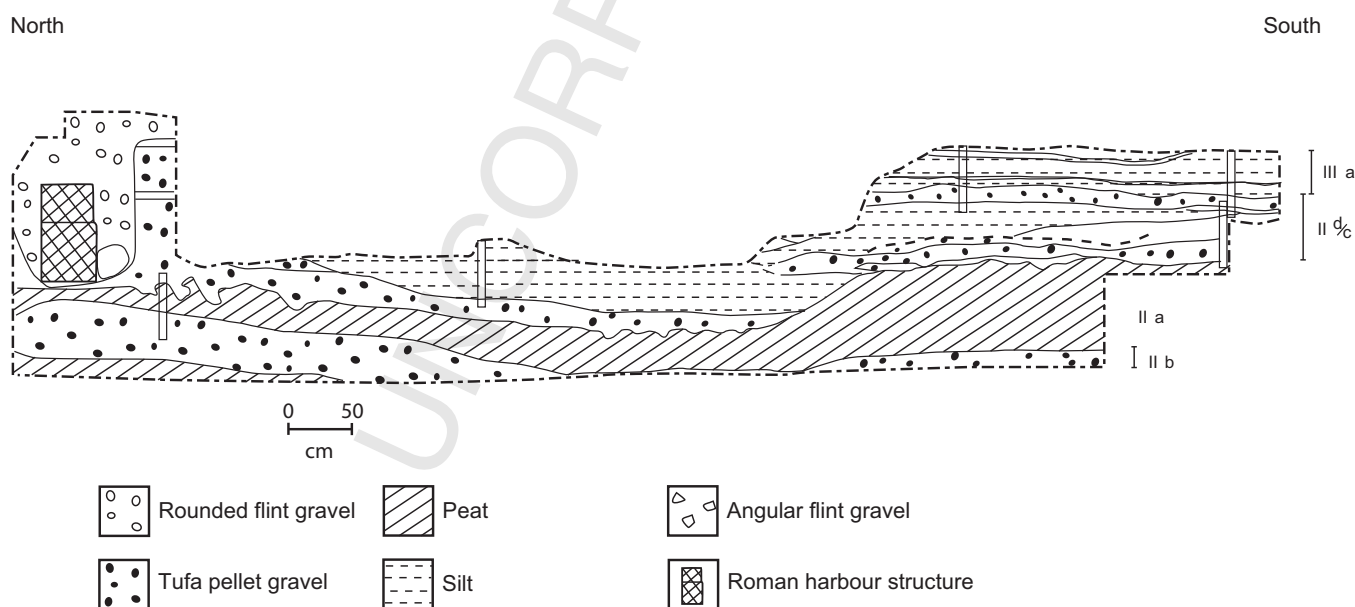


Fig. 5. Composite stratigraphic sequence along the eastern edge of Coffers Dam I and II. The profile shows the interbedded character of the tufa/peat sequences and the cut into these deposits within which the substantial timbers of the Roman harbour construction were placed. The surface of the main peat unit (IIa) forms the surface on which the Bronze Age Boat was resting. Sediments (III) at the southern end of the trench contain the evidence for the transition of the floodplain from freshwater to brackish conditions.

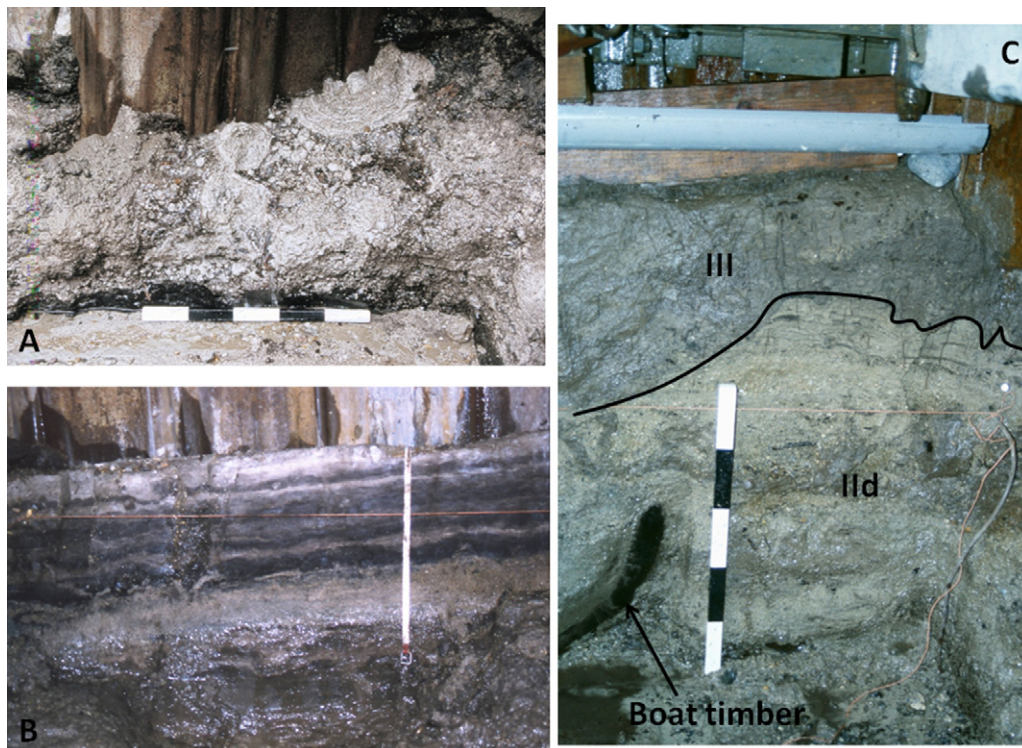


Fig. 6. (A) Tufa overlying peat in the Bronze Age Boat trench; note the presence of stromatolitic like growths in the tufa above the peat. (B) Laminated silts (III) overlying the boat contain evidence for the on-set of brackish water conditions in the valley. (C) Tufa and peat sediments (unit II) including part of Bronze Age Boat and overlying silts (III).

sediments shows that the base of the sequence consists of angular flint gravels where magnetic susceptibility values (Fig. 9) show a major peak associated with the top of the gravels. This peak may well be associated with weathering and pedogenesis on the gravel surface in the late Pleistocene/early Holocene, prior to inundation. A sequence of alternating tufa gravels and peats overlie the basal flint gravels; these are replaced upwards by finer grained silts. Three discrete zones can be identified on the basis of laboratory investigation of the sediments. The lowest part of the sequence, with very low organic content, consists primarily of tufa pellet gravels and sands with a declining inorganic content up-profile (IIb). The tufa commonly consists of well stratified gravels of sub-rounded to near spherical oncoids (Ordóñez and García del Cura, 1983) (IIb). A number of surfaces are noted within these sequences that clearly undulate and appear to describe fluvial bar bedforms. The oncoidal levels represent deposition in an active flow setting, but with much lower velocities than are needed to mobilise the underlying siliclastic clasts and are likely to be similar to those described by Pedley (1990) which form in, and infill, braided fluvial systems, suggesting the presence of shallow, clear moving water bodies.

A shift to peat deposition (IIa) occurs above the basal tufa deposits. The upper surface of the peat was well-humified and clearly subject to compaction and erosion prior to abandonment of the boat (Clark, 2004; Figure 3.11). Evidence from the mollusc samples investigated by Keeley et al. (2004) suggest this peat may have accumulated in a small channel isolated from the main river flow in which slow moving water, rich in plant debris and associated muddy areas, was dominant. The basal part of the peat is associated with a spike in inorganic content perhaps indicative of a lag deposit within the base of this channel. Weathering, humification and erosion are attested to by the nature of the upper part of the peat and imply a major unconformity at this point in the sequence. Pollen from the sequences has been examined by Branch and Lowe (1993) who determined that the lowest part of

this sequence contained pollen characterized by pine/hazel/elm. This spectrum was correlated with the Holocene II zone (*sensu* Keeley et al., 2004) and is comparable with pollen zone CM 5 from the detailed pollen record published recently at Crabble Mill (Bates et al., 2008). Up-sequence, Branch and Lowe (1993) document a shift towards mixed oak forest vegetation.

Overlying the peat and boat finer grained carbonate sediments are present (IIc, Fig. 7) where carbonate levels rise significantly at the top of the sequence. The transition into this part of the sequence is marked by some minor peaks in inorganic material suggesting influx of clastic sediment immediately following deposition of the boat. However, through most of the sequence these deposits consist of finer grained carbonate sediments of sand and silt sized grades of intraclast tufa with occasional thin seams of small oncoids (<1 cm diameter) and contrast significantly with the tufa gravels at the base of the sequence. Stromatolitic tufa or Phytoherm boundstone (Buccino et al., 1978) (IIc) and very fine micritic silts (Schafer, 1973) (IId) also occur. Magnetic susceptibility values are typically low but with a major peak below the rise in carbonate values towards the top of this zone. These sequences are compatible with the braided system model of Pedley (1990) but suggest channels carrying little bedload or channel margins in which the stromatolite domes develop on stabilized substrates. Generally lower flow velocities are indicated.

Palaeoenvironmental material associated with these uppermost tufa deposits (Keeley et al., 2004) appear to indicate deposition in freshwater conditions within environments entirely compatible with that indicated by the sedimentology. Pollen is dominated by non-woodland open, herb dominated vegetation with *Plantago lanceolata* and *Pteridium* suggesting weed-infested grassland. However, while oligohalobous-indifferent diatoms dominate the sediments below the boat, brackish and halophilous diatoms were noted to be present in some deposits immediately post-dating the boat contexts. The presence of brackish water species probably corresponds with the peaks in inorganic material



Fig. 7. Organic silts and sands (Unit IV) infilling the former Roman harbour resting below sands of marine origin (V). Archaeological horizons (VII) cap the sequence and date to the 11th century onwards.

1993) documents increasing percentage of *Chenopodium* type pollen with *Crithmum* type indicating waterbourne transportation of pollen from coastal plant communities. The molluscs (Keeley et al., 2004) suggest a shift towards a deeper, slower moving water body associated with a single channel. Attempts to date the organic material associated with the bedded silts (Bayliss et al., 2004) were compromised by reworking of the material in the sediments and consequently no age estimates are currently available for these deposits.

5.3. Unit IV. Organic silts and associated structures of the Roman harbour

The sequence of sediments belonging to Unit IV infilling the Roman harbour form a wedge of sediments lying between +1.0 m O.D. and –2.0 m O.D. and consist of a number of different sediment types ranging from fine gravels to clay-silts with variable organic content (Figs. 3–5, 8 and 9). Organic material includes plants/wood, foraminifera, ostracods, diatoms and pollen. Gravel deposits are locally present within the basal parts of the sequences (e.g. borehole DBS-4). These deposits are restricted to the lower Dour valley in the vicinity of the Bench Street-Market Square area (Figs. 2, 3 and 5). Exposures through the upper parts of these sequences were recorded in the Crypt Restaurant site (borehole DSC-2) on the western side of Bench Street (Bates and Barham, 1993), in boreholes along the line of Bench Street itself (DBS-2, 3, 4) and most recently in boreholes in the Market Square.

Depositional conditions have been reconstructed by examining sequences preserved in boreholes DSC-2, DBS-4 and Market Square 3. Sediment analysis through the deposits in DSC-2 indicates organic content is generally low throughout (Fig. 10) while carbonate content tends to show a rise through the profile. Grain size (Fig. 11) is consistent through much of the sequence, consisting of clay and silt, but with a slight decrease in clay

previously noted and as suggested by Keeley et al. (2004) may be indicative of spring tides or perhaps tidal surges up valley.

Dates for the associated organic horizons within the sequences from the town centre area are shown in Table 2. Commencement of sequence accumulation prior to $10,680 \pm 50$ B.P. is indicated from the DSC-2 borehole (although this date might be compromised by inclusion of 'old carbon'). Comparison with age estimates and palaeoenvironmental data from Crabble Mill (Bates et al., 2008) suggest an early Holocene date for at least parts of the sequence. Although age estimates are difficult to ascertain for the top of the sequence, the age of the boat at around 1550 ca B.C., gives an approximation for a minimum age for the sequence.

5.2. Unit IIIa. Laminated silts: transitional landscapes

Sediments associated with the transition of the landscape from freshwater, tufa-dominated environments, to brackish and marine environments associated with the Roman harbour have only been exposed in the Coffey Dams associated with the Bronze Age Boat excavations (the bedded silts of Keeley et al., 2004). These sediments consist of laminated sands and silts (Figs. 6 and 7B and C) with a high carbonate content (Fig. 9, IIIa). The deposits show a marked increase in inorganic content probably consistent with influx of minerogenic sediments in tidal conditions. Carbonate values decline and vary while organic content declines up-profile.

Little detailed investigation of these sequences has yet been undertaken, however Keeley et al. (2004) describe mesohalobous (brackish) diatoms and a semi-planktonic marine species (*Cymatosira belgica*) from equivalent levels. Pollen (Branch and Lowe,



Fig. 8. Organic rich silts (IV) from Market Square borehole 3.

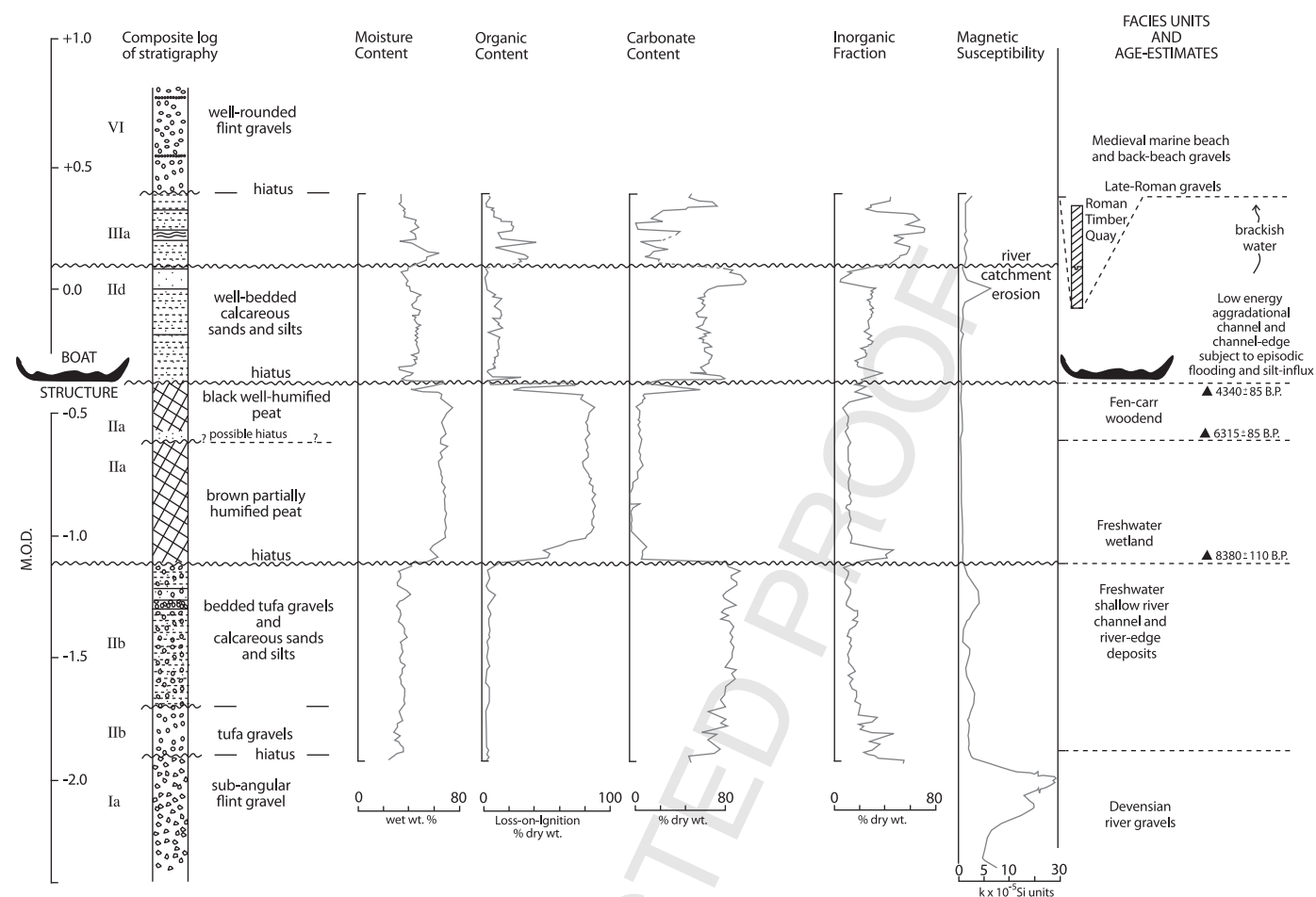


Fig. 9. Composite stratigraphy from DSC-2 through the tufa/peat, harbour fill and marine sands showing moisture, organic, carbonate and inorganic content and magnetic susceptibility values.

content upwards. Sand is also noted to occur towards the top of the sequence. An organic silt caps this part of the sequence. Periodic emergence of the sequences above water is attested to by areas of rooting and weathering within the sediment stack. The presence of gravel units (e.g. in DBS-4) is indicative of higher energy flows in the area that may indicate the location of the outfall of the Dour at low tide. Microfossil analysis of DSC-2 (Table 3 and Fig. 12) indicates that through much of the sequence assemblages are dominated by brackish-water foraminifera (particularly *Haynesina germanica*) and ostracods (*Leptocythere porcellanea*, *L. lacertosa* and *L. castanea*). An increase in numbers of individuals present is noted between -0.82 m and -1.02 m O.D. Brackish species are absent between 0.01 m and -0.32 m O.D. but re-appear in two horizons above (represented by the foraminifera *Haynesina germanica* and *Elphidium williamsoni*). This brief uppermost brackish event (between 0.08 m and 0.01 m O.D.) corresponds with a coarsening in grain size of the sediments from clay-silts to sandy clay-silts (Fig. 11). Marine foraminifera are associated with the base of unit IV and with the uppermost part of the unit associated with the presence of sand in the sequence at around 0 m O.D. Freshwater ostracods are present at two points in the sequence between -1.52 m and -1.72 m and between 0.01 m and -0.32 m O.D.; the latter corresponding with the disappearance of the brackish species noted previously. Freshwater ostracods (or more correctly, “non-marine”, as these species can tolerate low salinities in these type of coastal situations), include *Heterocypris salina*, *Candona neglecta*, *Prionocypris zenkeri* and *Potamocypris zschokkei*, albeit at low numbers. This evidence, taken together, suggests deposition of

the main body of the sediment under estuarine mudflat conditions, with the initial influx associated with marine faunas. The pulse of freshwater material (0.01 m and -0.32 m O.D.) suggests the local development of a minor freshwater event, perhaps including pool formation from springs at the valley margins, however whether this represents a minor regressive phase cannot be determined. The earlier occurrence of freshwater ostracods, which overlaps with the onset of tidal conditions at -1.62 m O.D. and the establishment of the initial phase of brackish mudflats, seems also to be related to (spring-fed) pool formation on the foreshore. Diatom floras from DSC-2 confirm that these sediments were deposited in sub-tidal or inter-tidal situations in a brackish or saline environment (N. Cameron, UCL, personal communication).

By contrast, boreholes DBS-4 (Table 4) and Market Square 3 (Table 5) contain somewhat reduced numbers of brackish foraminiferal and ostracod species (particularly of the latter) and a much increased freshwater component (Fig. 12). In DBS-4 (Table 4) the foraminifer *Haynesina germanica* is the only (almost) ubiquitous species present, although two horizons did contain single examples of the agglutinating saltmarsh species *Jadammina macrescens*. By contrast, the freshwater ostracod assemblage numbered no less than 14 species in total, and populations of several of them were common throughout. They included *Heterocypris salina*, *Candona neglecta*, *Prionocypris zenkeri*, *Cyclo-cypris laevis* and *Cyclo-cypris ovum*. These assemblages appear to indicate accumulation under freshwater/low brackish water conditions intermediate to estuarine mudflats and saltmarsh. Occasional inputs of water from local springs are also indicated.

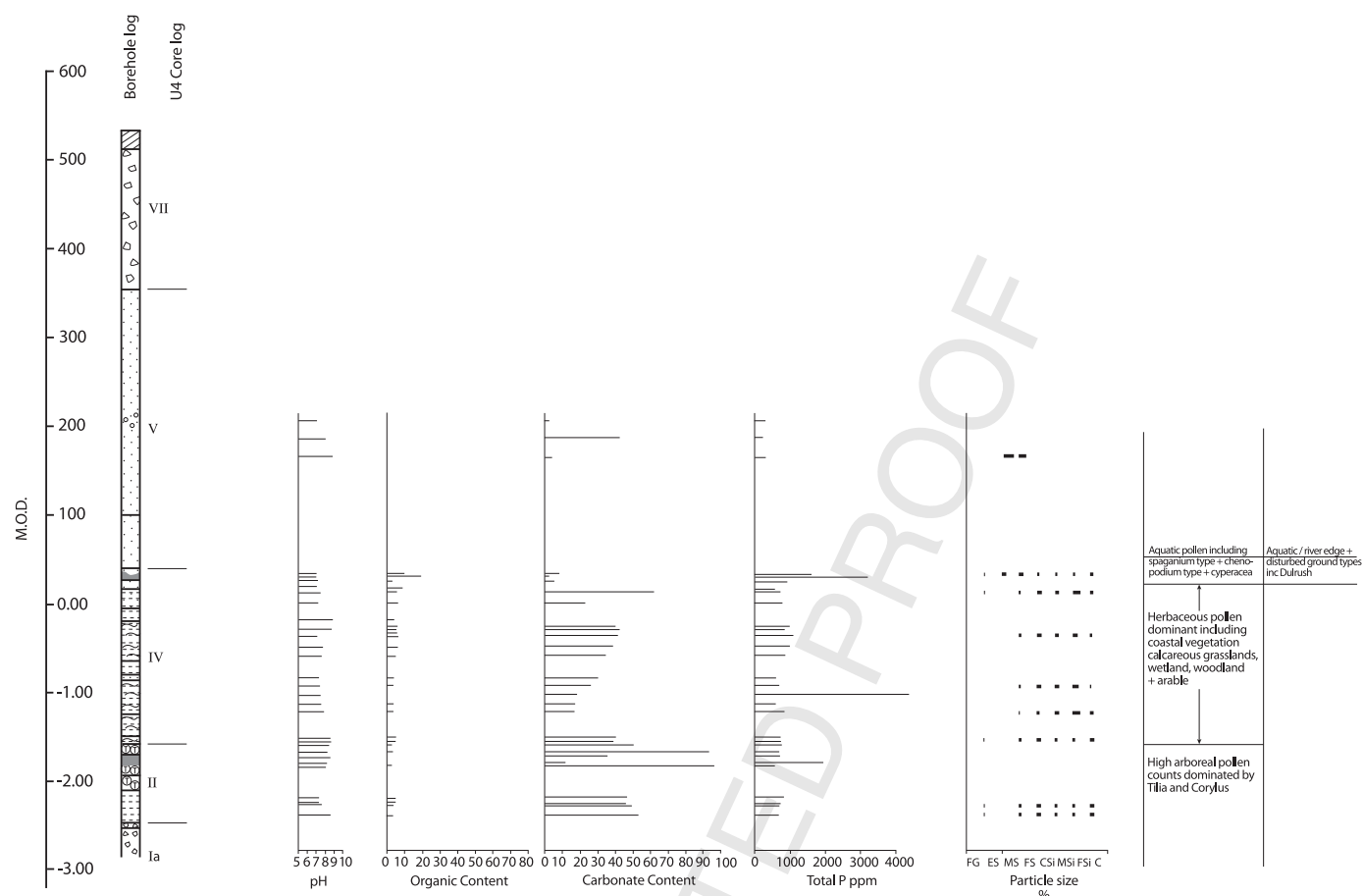


Fig. 10. Composite stratigraphy through the tufa, peat and laminated sediments of units II and IIa showing moisture, organic, carbonate and inorganic content and magnetic susceptibility values log sequences and results.

Finally in Market Square 3 (Table 5 and Fig. 12) the only brackish species present are the high saltmarsh foraminifera *Jadammina macrescens* and *Haplophragmoides* sp. However a rich freshwater ("non-marine") ostracod fauna, including *Heterocypris salina*, *Candona neglecta*, *Prionocypris zenkeri*, *Ilyocypris bradyi* and *Herpetocypris* cf. *reptans*, are all present and often in large numbers. This assemblage appears to indicate freshwater weedy pools with local brackish conditions and a fringing high saltmarsh that becomes a freshwater/semi-terrestrial environment with shallow pools towards the top.

The sequence is capped by organic silts and peats (see DSC-2, Fig. 10). These sediments were rich in *Equisetum* remains (Horsetail) and bulrush beneath the Crypt Restaurant site suggesting the development of a vegetated wetland environment in the area once infilling of the harbour basin had occurred.

This evidence appears to indicate that accumulation of the group IV sediments occurred under predominantly brackish water conditions. Estuarine mudflats appear to have dominated seawards (DSC-2), being replaced by saltmarsh inland (DBS-4) and upper saltmarsh around the Market Square (Fig. 12). In the Market Square the maximum elevation of these saltmarsh sediments is c. +1.3m O.D. Within this area of estuarine conditions higher flow rates along the outfall of the Dour probably resulted in deposition of gravels as lags within low water channels. Locally, differential sedimentation may have resulted in discrete areas of predominantly freshwater deposition. The likely scenario, however, through this phase of activity is one of accumulating sediments infilling the former harbour area.

The dating of the sequences is based on recovered finds from the boreholes and three ^{14}C dates from the top of the sequence

(Table 2). Second century Roman pottery has been recovered from the base of this unit at the Crypt Restaurant site (MacPherson-Grant, personal communication) and large quantities of Roman mortar and cement were recovered from a gravel lying immediately below organic silts sampled in the Bench Street area (Bates and Barham, 1993). This suggests accumulation began after Roman occupation commenced in the area. Three ^{14}C dates (Table 2) from the organic horizons at the top of the sequence all indicate a date range between the 2nd and 5th century A.D. for final infilling of the harbour in this part of the valley.

The relationship between this infilling event and Roman activity has not been directly observed within the harbour however, some preliminary conclusions can be drawn. The clearest evidence for the position of the original west bank of the Dour and harbour edge is that published by Rahtz (1958) on the western side of the Market Square (Fig. 2, Site 1). Here brickearth and coombe rock at around 3.00 m. O.D. sloped down more than 3 m to the east. Immediately to the south the same feature, sealed below a Roman building, had been observed (Site 6; Threipland, 1957). Here the chalk block-built building was of second century date with pottery from the underlying make-up layers included samian ware dated c. AD 130–140. The only evidence for waterfront constructions close to the dry ground come from Rahtz's work (1958) at Stembrook (Site 7) where he recorded two separate Roman timber and chalk structures interpreted as a quayside and a jetty. The quayside was a chalk platform with a surface elevation of +1.90 m O.D. Sediments comparable to those of group IV deposits have been located at Stembrook between 0 m O.D. and +2 m O.D. (Site 1) (Rahtz, 1958). The bulk of the pottery from the site is of second century date and came from the layers deposited against the quayside and jetty

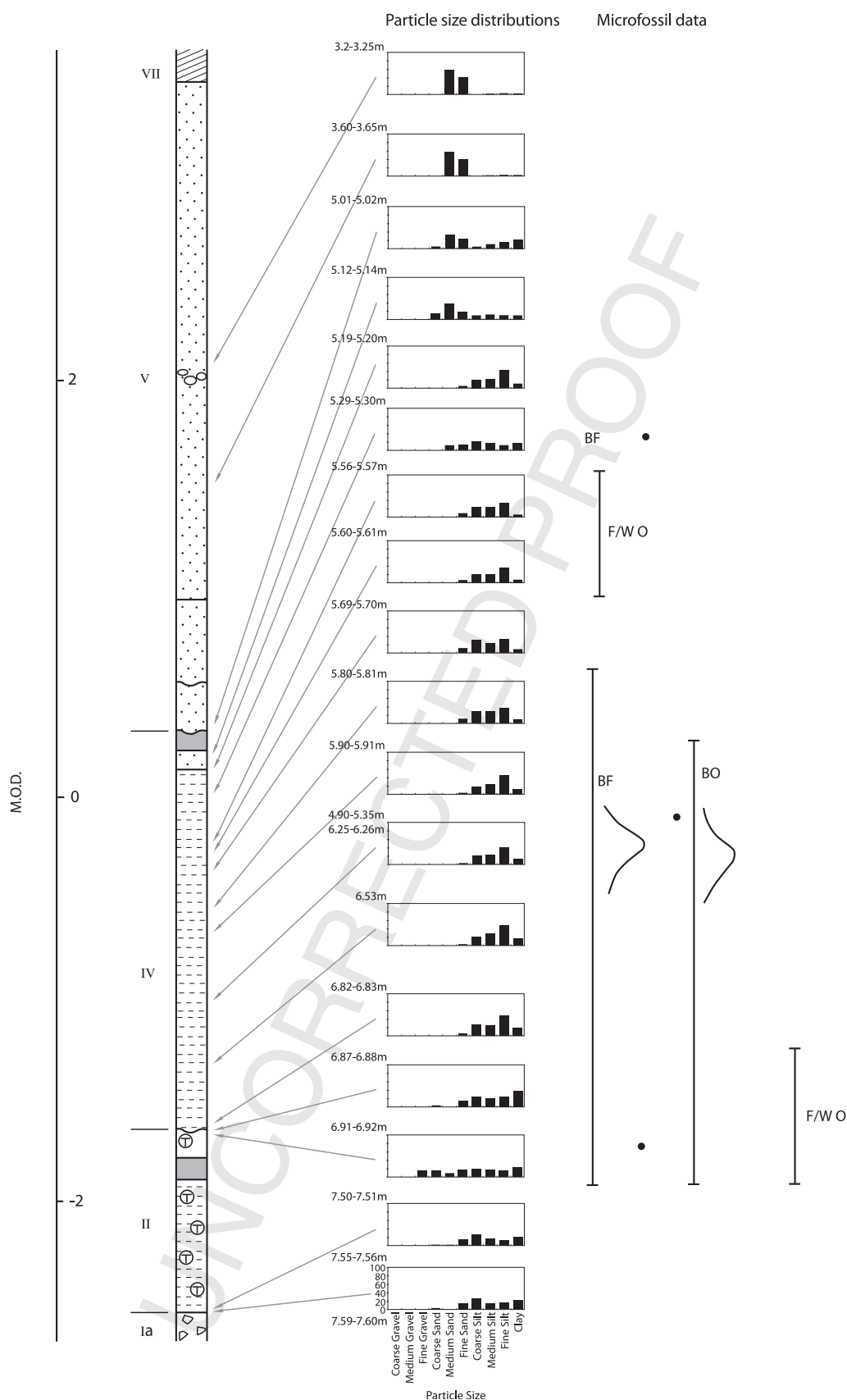


Fig. 11. Sedimentology and microfossil distribution from DSC-2.

Table 3
Microfossils from DSC-2.

Ecology	Barren sand	Estuarine mudflats, with two periods of spring-fed freshwater pool development on foreshore; calcareous substrate													Tufa springs with active flow; some associated marshy peat					Semiterrestrial surface		
	?	Brackish													Freshwater					–2.12	–2.22	–2.32
	0.28	0.18	0.08	0.01	–0.22	–0.32	–0.42	–0.52	–0.82	–0.92	–1.02	–1.12	–1.52	–1.57	–1.62	–1.67	–1.72	–1.82	–1.87			
BRACKISH FORAMINIFERA																						
<i>Haynesina germanica</i>		x	x				o	o	xx	xxx	xx	x	x	o	x							
<i>Elphidium williamsoni</i>		o								x												
<i>Ammonia</i> sp.									x	xx	x											
<i>Elphidium waddense</i>										x												
MARINE FORAMINIFERA																						
<i>Ammonia batavus</i> (ornate)				o										o								
BRACKISH OSTRACODS																						
<i>Leptocythere porcellanea</i>							o	x	x	x	x	x	x	x	x							
<i>Leptocythere lacertosa</i>								x	xx	xx				o	x							
<i>Leptocythere castanea</i>								x	xx	x												
FRESHWATER OSTRACODS																						
<i>Heterocypris salina</i>			xx	o																		
<i>Candona neglecta</i>			x										x	o	x		o					
<i>Prionocypris zenkeri</i>				x	x									o	o							
<i>Ilyocypris</i> sp.				o																		
<i>Potamocypris zschokkei</i>													x		o	x	x					
<i>Cryptocandona vavrai</i>																x						
<i>Pseudocandona</i> sp.																o						
<i>Cavernocypris subterranea</i>																	o					

Organic remains are recorded on a presence (x)/absence basis.

Foraminifera and ostracods are recorded: o – one specimen; x – several specimens; xx – common; xxx – abundant.

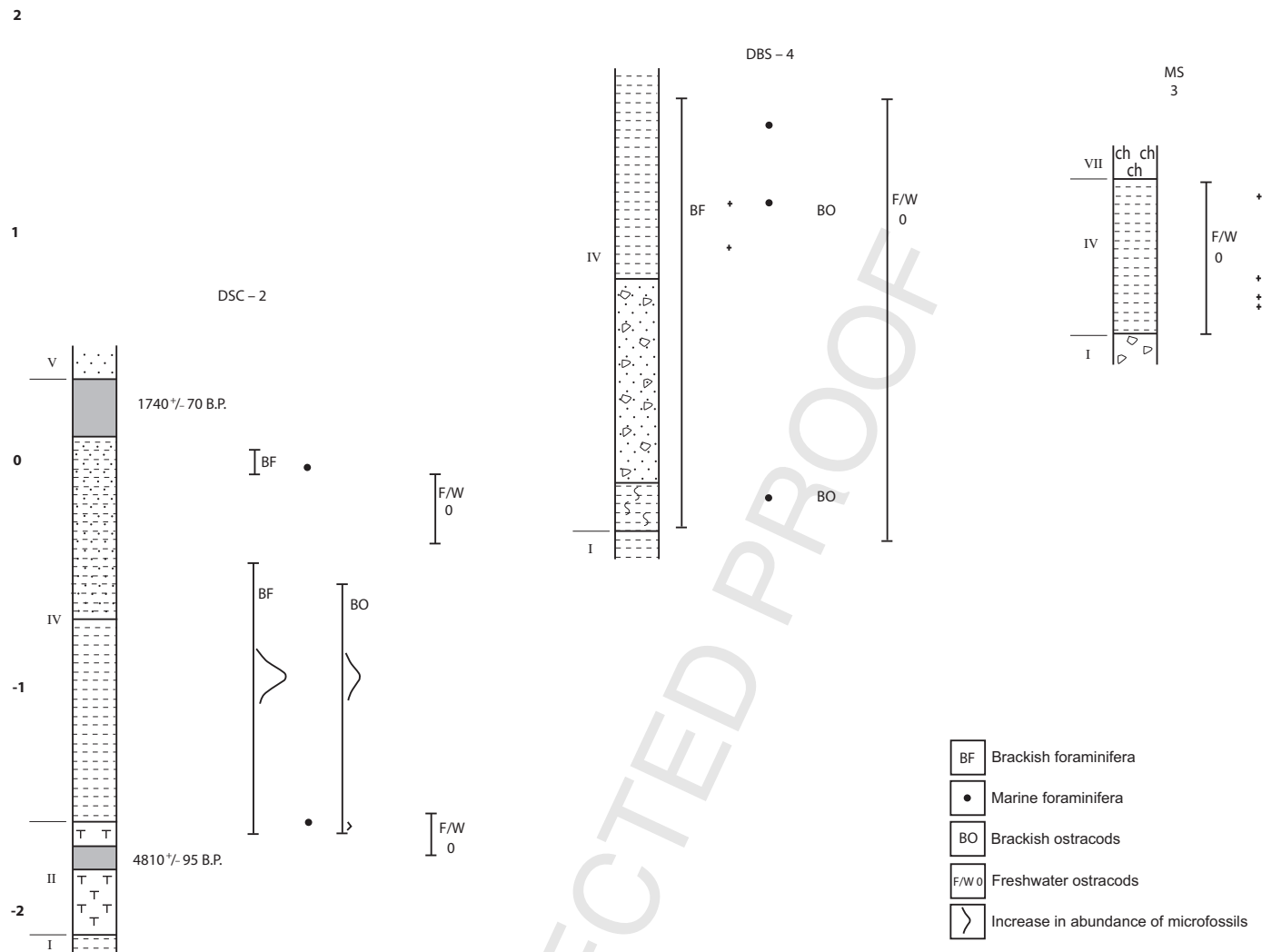


Fig. 12. Microfossil summaries from boreholes DSC-2, DBS-4 and Market Square 3 showing distribution of material relative to Ordnance Datum.

suggesting infilling of the harbour during or after the 2nd century. It is reasonable therefore to suggest that the original construction of these harbour structures (A and B) occurred during the later first–early second centuries AD. Deliberate infilling of the harbour edge has been noted in Church Street by Threipland and Steer (1951) where five main tip-layers could be distinguished. The lower parts of these were certainly Roman and contained several pieces of Roman tile (one stamped [CL.B]R – the mark of the Roman fleet in British waters) and second-century pottery. At Site 1 (Rahtz, 1958) the organic sediments were sealed by a succession of Roman clay and chalk dumps deposited between the later first and first half of the second century AD. To the south of the Market Square (Site 8) Amos and Wheeler (1929) reported the presence of the edge of a wall or platform, built from mortared flint, chalk, tufa and greensand, at least 4.50 m long, resting on what was probably made ground (mistaken by the authors for natural brickearth). To the south-west, a second century building was recorded on the site of the old Market Hall resting upon deep layers of fill and Q3 (waterlogged) sediment (Site 9) (Frere, 1983, 334–5; Philp, 1983; see also Wilkinson, 1994, 66). Excavations at Site 9 below the rampart of the Saxon Shore Fort wall exposed pre-Shore fort levels and revealed demolished clay walls and floors again relating to a second-century building. Further south, off Queen Street (Site 10), outside the area of the second century naval (CLBR) fort and the later Shore fort, excavations (Grew, 1981; Mynott, 1981; Philp,

1981b) recorded a late Roman metalled road overlying deep deposits of silt including deliberately deposited material probably imported from elsewhere in the town centre area (dumped deposits), mainly of second century date, that appeared to have been used to infill ground on the edge of the Roman harbour. Consequently there is good evidence for harbour infilling during or shortly after the 2nd century A.D. to and against Roman structures to a maximum elevation of +2.0 m O.D.

Another significant factor to consider is the position of the east wall of the late Roman Shore Fort which remains to be accurately positioned. Substantial sections of the west and south walls have been excavated by Kent Archaeological Rescue Unit during the 1970s and 1980s but the line of the north wall is based on Amos's observations at the old Royal Oak hotel (Amos and Wheeler, 1929, site 4), whilst the course of the fort's eastern wall remains largely unknown. Excavations on the old Market Hall site (see above, Site 9) established that the south wall of the fort, towards its eastern end, had been built across ground previously reclaimed from the estuary. The observations here, together with those from Sites 1 and 7, strongly imply that most, if not all, of the fort's eastern wall must have been built across ground deliberately infilled by humans and that the line of the wall lies close to the recently drilled boreholes in Market Square (Fig. 2).

Finally there is now good evidence for the existence of two major Roman timber structures running across the river mouth at

Table 4

Microfossils from DBS-4.

Ecology	Barren sand	Freshwater/low brackish weedy spring-fed pool adjacent to estuarine mudflats/saltmarsh; calcareous substrate											“Habitation surface” or infill	
	1.84	1.2	1.1	0.99	0.74	0.64	0.54	0.44	–0.06	–0.56	–0.66	–0.7	–0.76	–0.86
BRACKISH FORAMINIFERA														
<i>Haynesina germanica</i>		xx	x	x	x	x				x	x	o		
<i>Ammonia</i> sp.								x						
<i>Elphidium williamsoni</i>											o			
<i>Jadammina macrescens</i>					o		o							
MARINE FORAMINIFERA														
<i>Ammonia batavus</i> (ornate)			x		o					x				
BRACKISH OSTRACODS														
<i>Leptocythere porcellanea</i>					x					o				
FRESHWATER OSTRACODS														
<i>Heterocypris salina</i>		xx	x	x	xx	x	xx				x			
<i>Candona neglecta</i>		xx	x		x		x	x	x	x	x		o	
<i>Prionocypris zenkeri</i>		x	x	x	x	x	x	x	x	x	xx		o	
<i>Ilyocypris bradyi</i>		x	x	o	x	x	x	x	x	x	x	x	o	
<i>Cypria ophthalmica</i>		x			x	x	x	o			x			
<i>Cyclocypris laevis</i> (LV > RV)		x	x			xx	x	x	o	x	x	x	x	
<i>Candona candida</i>			o				o				o			
<i>Cyclocypris ovum</i> (RV > LV)					x	xx	x	x		x	x			
<i>Herpetocypris</i> sp.					x	x	x	x			x			
<i>Limnocythere inopinata</i>					o									
<i>Cyclocypris serena</i>						x	x			x	x			
<i>Darwinula stevensoni</i>							x						o	
<i>Potamocypris zschokkei</i>											o			
<i>Pseudocandona</i> sp.											o			

Organic remains are recorded on a presence (x)/absence basis.

Foraminifera and ostracods are recorded: o – one specimen; x – several specimens; xx – common.

Dover. Deep excavations for a new gas-holder south of Dolphin Lane (site 3, Fig. 2), in 1855–6 revealed part of a massive timber harbour wall, preserved in waterlogged deposits. The structure was buried some 6 metres (20 ft) below ground level (c. –1 m O.D.) and appeared to be running roughly east-west, at a right angle to the modern river (Elsted, 1856; Klocker, 1857; Amos and Wheeler, 1929, 52; Rigold, 1969, 90). Part of a second harbour wall was discovered in September 1992 running diagonally across the north-east corner of a deep contractor's excavation dug at the junction of Bench Street and Townwall Street. Here a 3.40 m length of what appeared to be the base section of another massive box-framed timber structure was revealed. Neither structure is closely dated although dendrochronological analysis of timbers from the 1992 structure suggested a felling date of sometime after A.D. 42 (Nayling, 2001).

The observations appear to indicate a relatively simple sequence of events resulting in the infilling of the harbour during the later part of the 2nd century A.D. and movement of the edge of dry ground eastwards. With the exception of the possible thin deposit of tufa at Site 2 little evidence exists for any sediments accumulating in the area until deposits begin to accrete adjacent to Roman structures. Evidence from Site 2 suggests accumulation of organic-rich sediments within the 2nd century and these deposits equate in elevation with those from Market Square BH 3 from which the palaeoenvironmental information suggest local conditions were dominated by upper saltmarsh systems with localized pools of freshwater perhaps issuing from local springs or the Dour outfall. It therefore seems likely that sedimentation with the Bench Street to Market Square/Stembrook area occurred during or shortly after the 2nd Century A.D. The development of a sequence of intertidal mudflats around the junction of Bench Street and Townwall Street gave way inland, to the north, to saltmarsh and upper saltmarsh accumulating against the rising edge of the estuary and harbour. Consolidation of these deposits, by deliberate infilling (dumping) across them, occurred in the vicinity of Market Square in order to create conditions suitable for construction of the later eastern Shore Fort wall.

5.4. Unit V. Sands: wind and waterlain

The final sequence of deposits beneath the substantial thickness of Medieval and post-Medieval deposits are thick sands first recorded by Amos and Wheeler (1929, 54). These deposits are known to occur within the area between Townwall Street and Queen Street, to the west of Fishmongers Lane (Figs. 2, 3, 5 and 8). The deposits form a wedge thinning inland along Bench Street and rising northwards (between datums of 2.0 m and 9.0 m above O.D.) where they come to rest against the south wall of the late Roman shore fort (Fig. 3). They consist of medium/coarse sand with occasional lenses of well-rounded flint clasts near Townwall Street but are finer grained medium sands at higher elevations against the wall of the Shore fort (Fig. 13). Thick beds of well rounded flint clasts interdigitate with the sands along the line of Townwall Street (parallel to the modern shore). In places the sands are bedded and exhibit both cross-bedding and sub-horizontal bedding. The sediments form a drape over the pre-existing landscape and overlie harbour infill sediments (IV) at lower elevations and archaeological deposits associated with the remains of the late Roman fort at higher elevations (Barham and Bates in Wilkinson, 1994). Late Saxon and Norman cultural levels inter-stratify within the upper levels of these sands or overlie the deposits (Fig. 14).

The sands from immediately outside the Shore Fort wall at DHC 1 (Fig. 2) are well to very well sorted and unimodal in the size range medium to fine sand (Barham and Bates in Wilkinson, 1994) (Fig. 13). This grain size distribution is similar to that of an aeolian sand, but slightly coarser than a typical dune sand (Tsoar and Pye, 1987). By comparison the marine sand from borehole DSC-2 exhibits a slightly coarser distribution (Fig. 13). Thus, derivation of the sands at higher elevation from the littoral sands is likely. The sand sheet appears to have a multi-depositional form with the sands at lower elevations (including the rounded gravels) forming within a beach or back-beach environment through a combination of wave over-flow and beach aggradation. Transitional from this point upslope are sands that were deposited across a variable slope

Table 5
Microfossils from Market Square 3.

Ecology	Shallow pool on foreshore; freshwater/semiterrestrial												Freshwater/low brackish weedy pool at back of foreshore with fringing high saltmarsh; calcareous substrate											
	1.23	1.22	1.19	1.18	1.13	1.12	0.83	0.82	0.8	0.79	0.77	0.76	0.72	0.71	0.69	0.68	0.66	0.65	0.63	0.62	0.55			
BRACKISH FORAMINIFERA																								
<i>Haplophragmoides</i> sp.					xx	o	x								xx	x	x	o						
<i>Jadammina macrescens</i>					xx		x								x	x			x					
FRESHWATER OSTRACODS																								
<i>Candona neglecta</i>	x	xx	x	x	x	xx	x	x	x	x	x	xx	x	x	x	x	xx	x	x	x	xx			
<i>Cyclocypris ovum</i> (RV > LV)	x	x	x	o			x	x	x	x	x	x	x	x	x	x	x	x	x	x				
<i>Ilyocypris bradyi</i>	o			o	o	x	xx	xx	xx	xx	xx	x	x	x	x	x	x	x	xx	xx	x			
<i>Cypria ophtalmica</i>		x										x												
<i>Prionocypris zenkeri</i>					x	o	xx	xx	xx	xx	x	xx	x	x	xx	x	x	x	xx	xx	x			
<i>Herpetocypris cf. reptans</i>							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
<i>Heterocypris salina</i>																								
<i>Potamocypris zschokkei</i>							x	x	x	x	o						x	o	o					
<i>Limnocythere inopinata</i>								o	o	o	o						o				o			
<i>Candona candida</i>								o	o		x													
<i>Candona angulata</i>												x	x	x	xx	x	x	x	x	x				
<i>Darwinula stevensoni</i>																					x			

Organic remains are recorded on a presence (x)/absence basis.
Foraminifera and ostracods are recorded: o – one specimen; x – several specimens; xx – common.

topography and as there is no natural source of well-sorted sands either upslope or up-catchment suggest deposition by wind transport from deflating tidal flats at low tide is likely (Barham and Bates, in Wilkinson, 1994). Thus the sands describe a beach and dune system built up over the former harbour infill sequence.

6. Evolution of the landscape from late Prehistoric to Saxon times

6.1. The palaeoenvironmental context of late Prehistoric activity in the lower Dour Valley, the impact of coastal evolution and the onset of marine conditions

In order to understand the transformation of the lower Dour valley from freshwater to estuarine conditions (Table 7), the nature of the late Prehistoric environment and its relationship to the coast need to be determined. The absence of marine or estuarine conditions anywhere in the town centre area until sometime between the Middle Bronze Age and the Roman period is perplexing given the proximity of the coast today to the town centre and is probably a result of changes to the local topography during the last 3500 years.

The distribution of gravels laid down by the late Pleistocene river are illustrated in Fig. 1. The southwards trend of the gravels through the modern Wellington Dock and the subsequent swing to the south-east beneath the Admiralty Pier imply the extension to the valley through this area during the late Pleistocene. Any extension of the valley across the area will have been associated with a substantial eastern side of the chalk-cut valley. This implies that not only was the valley form substantially longer in the late Pleistocene but that significant trimming back of the valley has taken place during the Holocene. Substantial erosion of the chalk beyond the valley floors and margins is only likely to have occurred consequent with rising sea levels and thus valley foreshortening is probably a result of the coastal erosion of cliffs either side of the valley mouth. The previous positions of the cliffs and the speed of retreat are however difficult to quantify.

Coastal erosion along the Chalk clifflines of Kent and Sussex is well established (e.g. McDakin, 1900; May, 1971; May and Heeps, 1985; Dornbusch, 2005a) however, little information is currently available to calibrate such processes and assess the scale of erosion since the prehistoric period. Erosion rates are primarily influenced at a regional scale by rock type (Carter, 1988) but at smaller scales are a function of a number of factors (McDakin, 1900; Dornbusch, 2005a) including rock structure, water saturation, presence/state of aquifers, precipitation, marine processes, configuration and aspect of coastline, height of cliff, width of shore platform, nature of the beach, topography of the shore platform, presence of cliff top superficial deposits and human activity. Consequently, calculating retreat rates for coastal cliff erosion is notoriously difficult. Historical literature from Dover, however, indicates that localised cliff collapses have been a common feature of town life (Table 6).

Early attempts to calculate erosion rates was made in the late 19th century by McDakin (1900) who reported rates of only half an inch [0.014 m] in a year. By contrast May and Heeps (1985) suggest a mean rate for cliff top retreat for the North Downs sector as a whole of 0.12 m/year. More recent calculations (Dornbusch, 2005a) have used historical records covering the last 100 years or so to suggest somewhat lower average rates of cliff recession of 0.07 m/year for Kentish Chalk cliffs. However, in places significant proportions of the Kent coast show almost no retreat at all over such time scales. Dornbusch (2005b) implies that some of these differences may be a function of the fact that the coast in this part of Kent is characterized by low frequency but high magnitude cliff-fall events. For example the collapse in January 2001 when a large piece of chalk, estimated at over 100,000 tons, collapsed from the

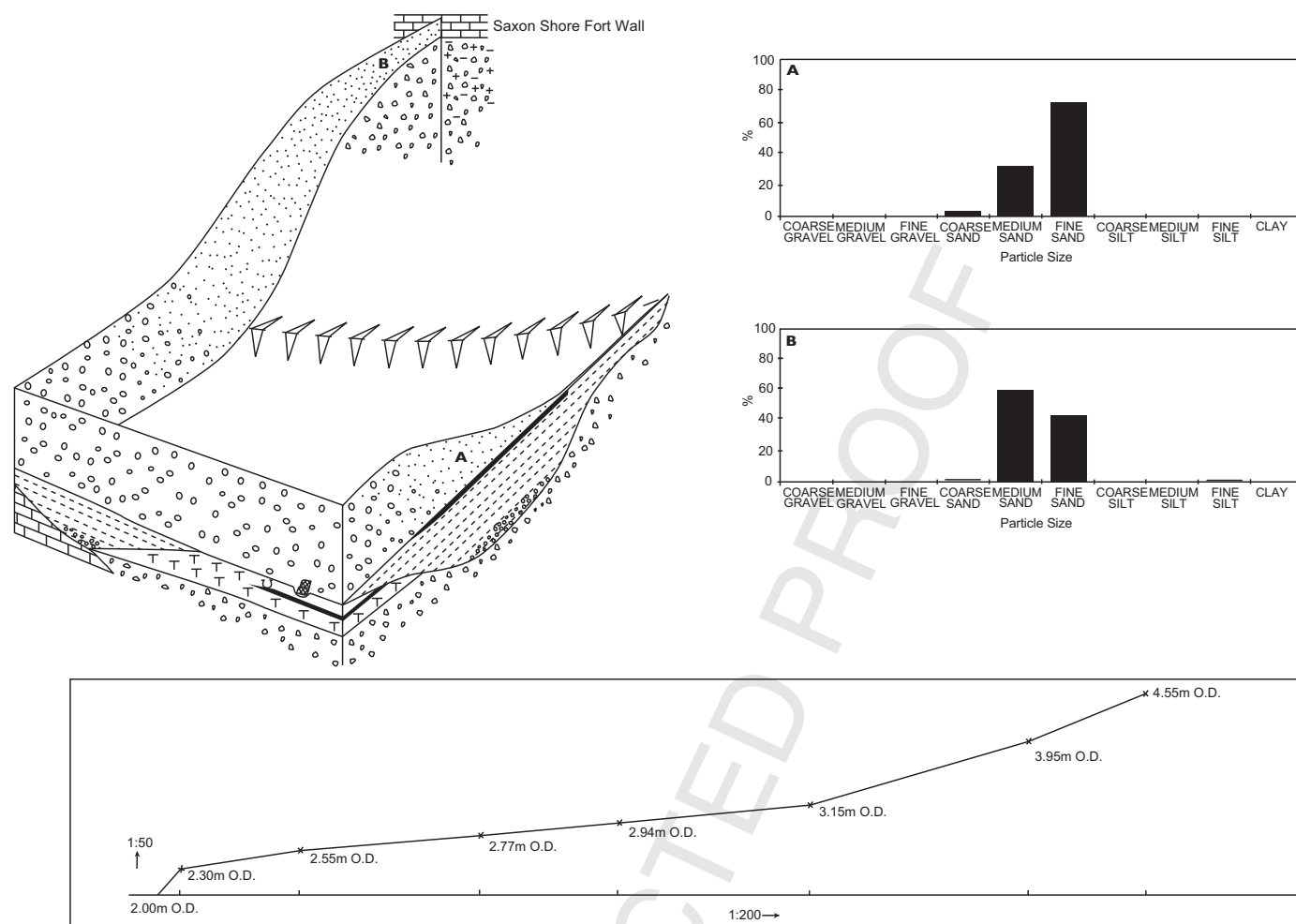


Fig. 13. Sand surface profile along Bench Street showing how the sand rises to the north and its landward distribution is determined by the presence of the Classis Britannica fort wall. Particle size diagrams from sands taken from borehole DSC-2 (A) and adjacent to the fort wall at the Heritage Centre (B) illustrate the slight differences in grade of sand at these two locations. Inset: surface elevation of the sands along the line of Bench Street showing the declining elevation of the surface of the sands from right (seawards) to left (inland).

cliff north of Dover. Using the average rates of cliff top erosion provided by May and Heeps (1985) of 0.12 m/year a simple retrodiction indicates a total distance of some 420 m of coastal erosion over the last 3500 years (Table 8), since the deposition of the Bronze Age Boat (Figure 17). Using the alternative rates provided by Dornbusch (2005b), of 0.07 m/year, projected retreat

rates over 3500 years would be of the order of 245 m. However, as Dornbusch (2005b) shows the calculated rates of coastal erosion for the Langdon Bay to St Margaret's section of the coast actually vary from less than 0.1 m/year to in excess of 0.3 m/year. Using these figures retreat distances of up to 1050 m over a 3500 years time span might be anticipated in certain situations (Table

Table 6
Major topographic events recorded for the Dover area (predominantly 19th century). Unless otherwise stated all events are recorded in a diary held in Dover Museum written by a Mr Pattenden.

Date	Event type
c. 1300 AD	Sea wall breached, harbour choked with pebbles (Stratham, 1899).
6/4/1580	Earthquake. Cliff collapse and outer walls of harbour cam down (Stratham, 1899; Batcheller, 1829).
1612	Wall of the Great Pent (the Henry VIII coastal defences and harbour) breached during a storm (Stratham, 1899).
1772	Several falls of the cliff caused great alarm (Stratham, 1899).
14/12/1810	Seven members of family killed in cliff collapse at East Cliff. Pig buried in cliff cave after fall, dug out alive after 160 days.
12/11/1844	Fall of cliff, 2 children killed.
18/2/1847	40,000 tons of cliff fall from Shakespeare Cliff.
21/1/1849	100,000 tons of cliff fall from Shakespeare Cliff.
20/1/1853	100,000 tons of cliff fall of chalk in Limekiln Street.
26/2/1853	Several thousand tons of chalk fall at Cobblers Rock, East Cliff.
5/4/1859	2 men killed by fall at Snargate Street.
12/5/1868	Great fall of cliff below Adrian Street.
15/11/1872	Cliff collapse near castle destroys 2 houses.
12/1/1877	S.E. Railway blocked for 2 months by fall of chalk cliff.
13/3/1881	S.E. Railway blocked by cliff fall at Abbots Cliff.

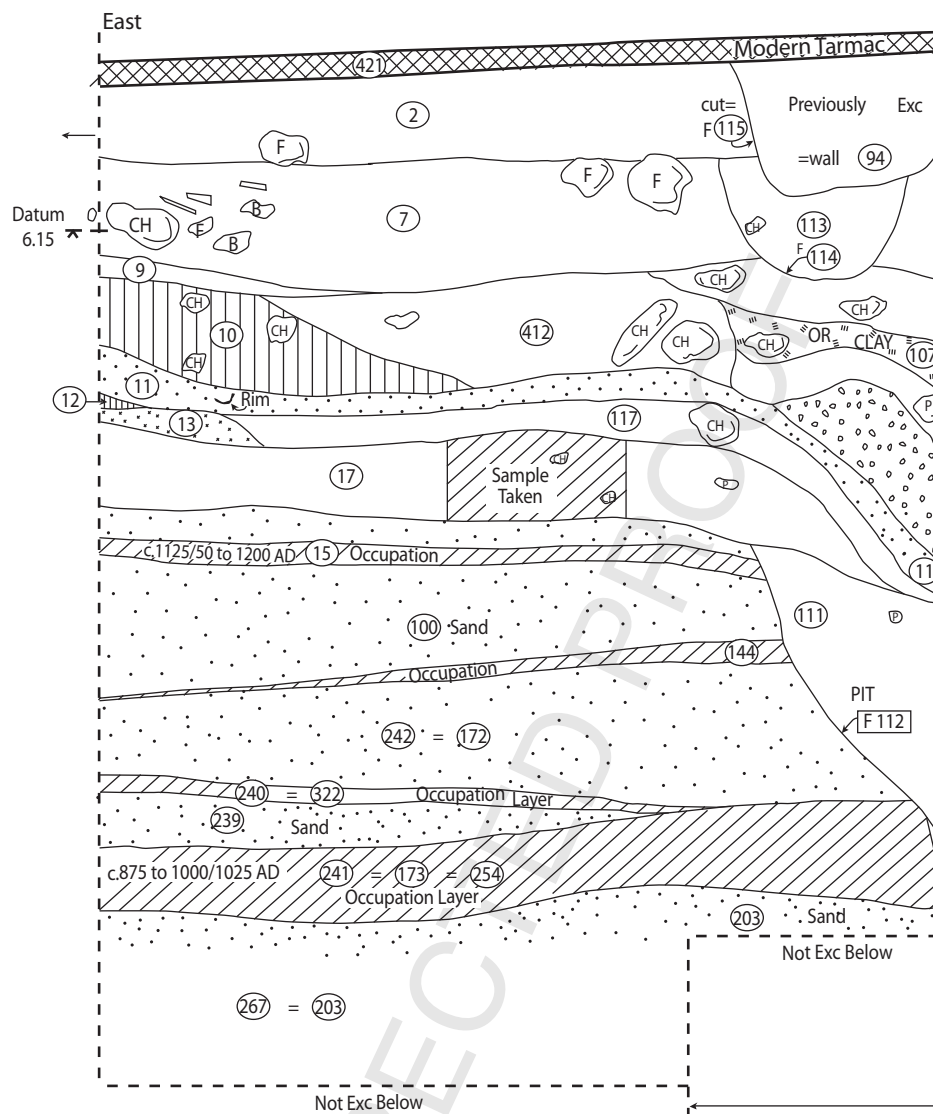


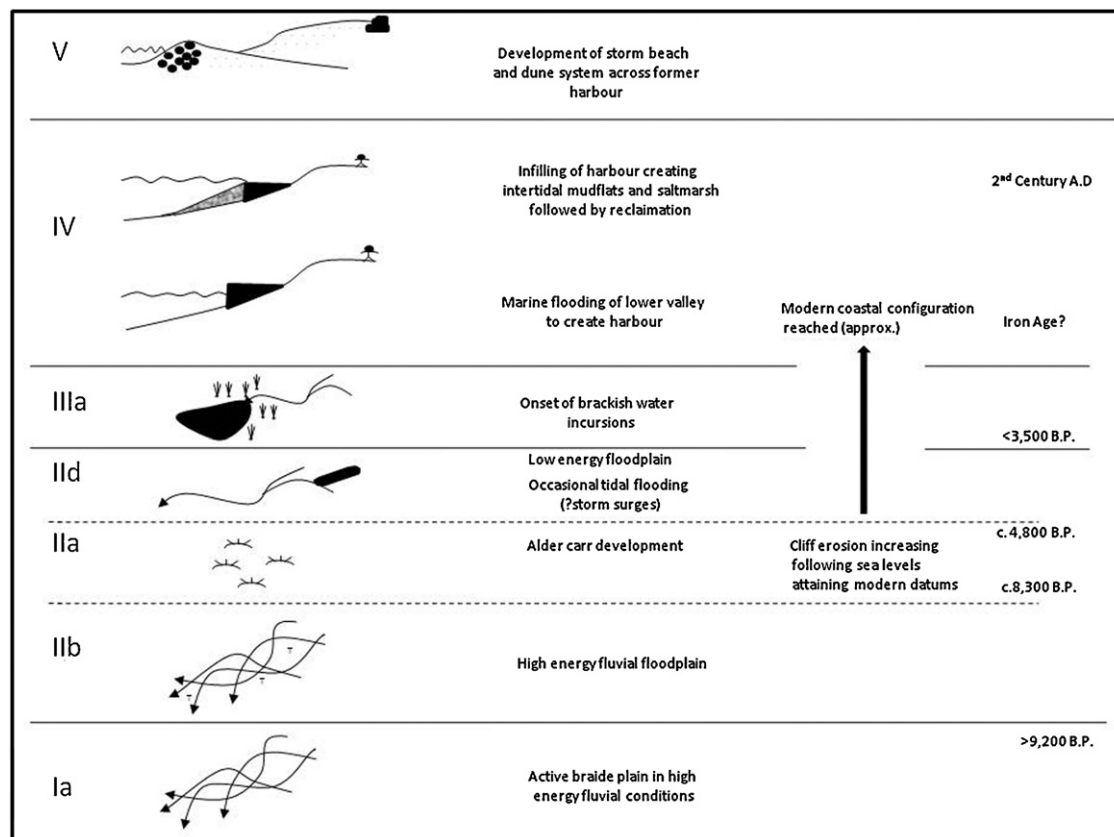
Fig. 14. Sketch section through upper parts of sand sequence at Crypt site showing deposits dated to the late Saxon period based on dates derived from analysis of the contained pottery fragments.

8). However, when attempting to retrodict cliff erosion rates into the prehistoric past other factors also need to be taken into account. For example Duperret et al. (2004) suggest that rainfall patterns and associated ground saturation are important triggers to cliff collapse while Mortimore et al. (2004) suggest that further influences include storms and frost. This has important implications when considered in conjunction with potential phases of climate change in the past. For example the well known cold period of the Little Ice Age in the 17th century (Grove, 2002) or the late Bronze Age climatic deterioration noted by van Geel and Renssen (1998) are likely to have enhanced cliff erosion rates in the area over periods of warmer/drier climate. It is interesting to note that, although within a totally different system, Allen (2002) has considered the degree of erosion on the Severn Levels over the last 1000 years and argues that significant variations in long, medium and short term erosion rates can be postulated where the variations are a function of a variety of factors operating at local and regional levels and similar differences through time in erosion rates are likely for the Channel coast.

Thus, it is clear from the discussion that there is strong circumstantial evidence that considerable coastal erosion has taken place since the end of the last cold stage. Most of this erosion

would have occurred following sea level rise to near modern datums in the area and would have varied through time. It is therefore argued that the shape of the valley (and the distance up valley of the modern town centre area) prevented flooding of the area by marine waters until sufficient valley foreshortening and erosion of the east side of the Dour valley had occurred. Evidence for this foreshortening and the reduction in flow velocities of the river in the town centre area consequent with backing up of river waters as the estuary approaches up stream may be seen in the change in nature of the tufa deposits above and below the boat. Higher energy oncoid-rich gravels (11b) dominate the environment through much of the earlier part of the Holocene (Fig. 9) while finer grained micritic muds and low energy stromatolitic growths (11c/d) dominate conditions following boat abandonment (Fig. 9; Table 7). This scenario also has implications for the palaeogeographic position of the Langdon Bay hoard (a large quantity of bronze axes, of c. 1100–1000 BC, recovered from the sea floor to the east of the Eastern Docks) some 600 m from the present cliff line (Coombs, 1976; Muckelroy, 1981). If significant coastal erosion has taken place in this region then the position of the find relative to the contemporary coast would have been different (Table 8).

Table 7
Summarised history of landscape changes in the western part of the town centre area in Dover based on combined geological and archaeological evidence.



6.2. Roman activity and the infilling of the harbour

The onset of brackish water conditions in the lower Dour is recorded within the bedded silts overlying the tufa deposits in the town centre area (Table 7). These deposits remain to be fully investigated and no age estimates are currently available on the timing of this change. However this is likely to have begun sometime after 1500 BC and have been completed by the time of the Roman invasion of Britain.

Evidence for conditions associated with the initial infilling of the Roman harbour area are now available from the three boreholes examined. The simplest explanation linking observations in these boreholes with those at sites such as Stembrook (Fig. 2, site 7) and beneath the Market Square is that a major phase of aggradation took place in the western part of the harbour sometime in the 2nd to 3rd century A.D. This resulted in the creation of saltmarshes and intertidal mudflats in the western part of the former harbour that become increasingly removed from tidal influence inland towards the Market Square (Fig. 12). Higher energy sediments do appear to be found intermittently in Bench

Street and may represent the main outfall for the Dour through this area at low tide.

Longshore drift and the infilling of harbours is well documented in the Dover area since at least the time of Henry VIII when a newly constructed harbour (the Paradise Basin) rapidly became clogged with sediments (Biddle and Summerson, 1982). The net movement of sediment along the south coast is likely to have brought substantial quantities of sand eastwards into the mouth of the harbour as soon as flooding of the lower valley had occurred. Consequently there is undoubtedly a natural tendency for the mouth of the Dour to fill with sediment. In addition the size of the river Dour would make it extremely unlikely that sufficient discharge was routinely channelled down the valley to flush sediment out of the harbour area. However two additional factors need to be taken into consideration when discussing harbour infill. These are the major timber structures known to exist within the harbour area thought to have been constructed by Roman engineers as moles for shelter/protection or mooring (Fig. 2, sites 2 and 3). While the extent of neither the Dolphin Lane structure (Elsted, 1856; Knocker, 1857; Rigold, 1969) nor the more recently

Table 8
Postulated cliff recession rates, sources, calculated positions of the coastline seawards of the present coast at 3500 B.P. (approx. age of Bronze Age Boat) and 3000 B.P. (approximate age of Langdon Bay bronzes and the estimated distance from the cliff or coast edge for the bronzes) (note the highest retreat rates place the bronzes 300 m from the coast on dry land).

Retreat rates	Source	Maximum seaward position of cliffs at 3500 B.P.	Maximum seaward position of cliffs at 3000 B.P.	Distance from cliffs of Langdon Bay bronzes (based on this data, approximate 3000 years since deposition)
0.014	McDakin (1900)	49 m	42 m	558 m
0.07	Dornbusch (2005a)	245 m	210 m	390 m
0.12	May and Heeps (1985)	420 m	360 m	240 m
0.30	Dornbusch (2005b)	1050 m	900 m	–300 m (i.e. 300 m from cliff top on dry ground)

found Townwall Street structure (Parfitt, 1993) is known, their position within the harbour mouth would certainly have slowed drainage at times of low tide and acted as barriers behind which slower moving water at high tide would have encouraged deposition of sediment. As a consequence these structures may have provided additional impetus to a pattern of sedimentation already likely to have been important in the valley. If accretion of sediments in the western part of the harbour did occur in a single phase of infilling during or after the 2nd century A.D. then as an operational port the western part of the harbour would have ceased to function at this time. This infilling would also have provided the impetus for constructing the later Shore Fort wall across an area already partially infilled and only requiring minimal levelling up in order to create a construction platform.

6.3. Saxon activity and the creation of a beach and dune system

Deposition of the sands above the Roman harbour infill sequences has been noted across the area between Bench Street and York Street from Townwall Street up to the southern boundary of the late Roman Shore Fort wall. The profile of the sand surface clearly exhibits two trends:

Along Bench Street the elevation of the sand surface dips northwards dropping by 2.5 m along the surveyed profile.

From York Street roundabout to the Saxon Shore Fort wall the surface of the sand rises significantly by up to 6.5 m (Fig. 3).

In the vicinity of Townwall Street the sands appear to be laterally equivalent with coarse, well rounded flint gravels deposited under storm beach conditions (water-rolled Roman tile has been recovered from sands on the BP site at the eastern side of the valley – Parfitt et al., 2006). Inland, these coarse gravels give way beneath the Crypt site to sands with occasional beds of rounded gravel. These gravel beds disappear beneath Bench Street. The evidence suggests that the origin of the sands derives from marine deposition and a storm beach feature present along the line of Townwall Street. Inland along Bench Street the profile of the sands fits that of a back beach profile with finer grained sediments preserved inland of the clastic beach resulting from washover episodes into lower energy dominated back beach environments. By contrast, sands between York Street and the late Roman Shore fort exhibit significant rise in elevations northwards resulting from probable aeolian activity (Table 7). This difference in interpretation appears to be underlain by the subtle grain size differences between sand samples from the two areas (Fig. 13).

The initial onset of sand deposition cannot yet be dated, however it is likely that the conditions created in the town-centre area by the infilling of the western part of the harbour allowed shoreward migration of clastic beach sands and gravels into and across the area previously occupied by the Roman harbour. Such transgressive behaviour must have commenced sometime after the 2nd century A.D. Cessation of sand deposition is also difficult to date although a few sequences have revealed archaeological artefacts interstratified within the upper parts of the sequence. For example, Anglo-Saxon artefacts dated to A.D. 875–1025 have been recovered from the Crypt Restaurant site (Fig. 14) while metallised surfaces in Bench Street contain stray Roman finds (which are probably residual). However the significance of finds within the sands should be treated with caution due to issues relating to migration of artefacts through dune sequences.

7. Conclusions

The evidence presented has significant implications for our understanding of a number of major archaeological finds of late Prehistoric and Roman date. The nature of the evidence for the later Prehistoric environments and the associated calculations of cliff

recession rates are of considerable importance when considering the location and use of the Dover Bronze Age Boat from Bench Street as well as the context of the Langdon Bay bronzes. Our evidence implies that not only was the Bronze Age Dour valley of considerably greater extent (implying a greater distance from the sea to the final resting place of the boat (Table 7)) but that the relationship of the bronzes in Langdon Bay to the cliff line (Table 8) would have been very different at the time of deposition/loss of the bronzes. Today Langdon Bay is little more than the truncated head of a dry valley that would formerly have been significantly more extensive, probably extending a considerable distance seawards during the Bronze Age. These factors consequently have an important impact on our interpretation of the context of the finds. The probability that the coast line was significantly closer to the find spot at time of site creation than at the present day needs consideration. Indeed if the highest rates for cliff recession are used it is possible that the artefacts might have been deposited in a small inlet developed in the base of the dry valley. In both scenarios if the bronzes were lost as part of a wreck (Muckelroy, 1981) the question regarding why no attempt to recover such a valuable cargo in relatively accessible conditions was made must be addressed unless, of course deliberate deposition of the collection occurred. The use and function of the Bronze Age Boat may also require reconsideration. Within the considerably extended valley system argued for here the possibility that the craft may have been used in a riverine rather than marine context may require consideration.

The broader context of the landscape change in the Dour Valley from freshwater to estuarine conditions as outlined here are interesting within the context of the general patterns of coastal change as outlined by Long et al. (2000) for the South-East of England. Regional growth of peat (an estuary contraction) has been recorded at many locations in the SE from the Thames to the Solent between 6850 cal BP and 3200 cal BP (Long et al., 2000) prior to estuary expansion and transgression of marine/estuarine contexts across freshwater ones. Despite the location and local geomorphological conditions described previously the changes present in Dover associated with onset of estuarine conditions in the lower valley broadly fit this model with the shift in environments taking place sometime after the abandonment of the Bronze Age Boat. Dates from the boat suggest an age for the boat of around 1550 BC that is a little older than the ages indicated by Long et al. (2000) for the onset of transgressive tendencies in the SE.

The interplay between human activity and natural processes may also be apparent within the study area. The new evidence suggests that infill of the harbour (western edge) during the Roman period was relatively rapid and, while almost inevitable, may have been exacerbated by Roman engineering creating barriers at the harbour mouth. High energy beach deposits have not been identified within the harbour area and consequently storm beach deposits of Roman date are likely to have been present seawards of the harbour structures (and perhaps built up against such structures near to the mouth of the harbour). Once infilling of the area behind the outer harbour structures had taken place the conditions for landward migration of a storm beach/back barrier system with associated dunes were created. The onshore driving of these sequences subsequently created the topography and landscape within which the Anglo-Saxon occupation of the area occurred.

The evidence described here from the boreholes, coupled with the opportunistic observations made during previous works and the A20 scheme, have enabled a model for sequence development in the town centre area to be articulated (Table 7). Although previous works (e.g. Rigold, 1969) had provided a spatial concept for the distribution of structures and natural topography the present work, for the first time, has fully integrated the archaeological and geological evidence within a process model. The model is however, likely to be overly simplistic at present and

requires additional investigation to refine it. On the basis of the model it is clear that the evolution of the town centre area is complex and that human activity (particularly in the form of Roman harbour activity) may well be intimately linked to processes and patterns of sedimentation.

Uncited reference

Green (2004).

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