British Academy Small Research Grant SG-49361

Pilot project to assess effects and develop experimental research protocols related to marine inundation of archaeological soils and sites, employing Wallasea Island, Essex ahead of flooding by the RSPB in 2010.

By
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with
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Synopsis

Four sampling locations were selected in association with the RSPB from areas flooded by DEFRA in 2006 and ahead of planned flooding in 2010. These were control arable and grassland (3 locations) and flooded grassland (Profile 3) sites. Bulk soil and micromorphological analyses were successfully combined with studies of foraminifera, ostracods and pollen. Control grassland Profile 4 provided insights into potential influence of saline groundwater which results from rising sea levels, and the following effects were identified: increased soil wetness and specific conductance (organic matter accumulation and ferruginisation, local colonisation by ‘saltmarsh’ molluscs and foraminifera). Profile 3 recorded marine flooding and soil burial by estuarine clay (soil sealing, rapid sediment weathering; introduction of tidal flat foraminifera, ostracods and exotic regional pollen). The pilot study indicates potential for an expanded study (employing the above-listed techniques) to investigate the threat of sea level rise and improve interpretation of previously inundated archaeological sites.

Report

i. account of research carried out

A small British Academy grant was received in order to examine the effects of marine inundation on soils in Essex caused by recent (2006) flooding of the northern part of Wallasea Island, Crouch River estuary by DEFRA. These flooded soils were to be compared to (‘control’) dryland soils within the modern sea walls. Moreover, these dryland soils were characterised because the whole of Wallasea Island will be flooded from 2010 by the Royal Society for the Protection of Birds (RSPB). The methods employed were fieldwork and laboratory analyses of the soils and new marine sediments (soil micromorphology, chemistry, magnetic susceptibility and particle size, molluscs, pollen, foraminifera and ostracods).

Fieldwork: Sampling areas were selected with Mark Dixon (RSPB) during a reconnaissance visit (access kindly granted by Wallasea Farms Ltd). These were to include flooded arable and grassland areas and dryland ‘control’ areas within the extant sea walls. Mark Dixon identified dryland arable (Profile 1) and grassland (Profile 2) areas that he would ‘protect’ from landscaping ahead of planned flooding in 2010, but which would be affected by flooding first – i.e. in the NE corner of Wallasea Island; these sites were therefore also potential locations for any future archaeological site inundation experiments. Site testing, soil pit digging and sampling
(Appendices 1-2) were carried out by Richard Macphail (UCL), Mike Allen (Allen Environmental Archaeology), G. M. Cruise (UCL research assistant) and Peter Murphy (English Heritage); site coordinates and their elevations were recorded using a GPS (supplied by the Institute of Archaeology) and a LIDAR ‘map’ supplied by the RSPB. Although the flooded area was accessed at low tide, only flooded grassland (Profile 3) could be sampled because flooded arable land was too deeply buried by mud to permit safe access. Instead, and in order to examine the planned number of four profiles, a 4th control profile was dug in grassland (Profile 4) from the lowest ground within the current sea walls, in a position by the ‘borrow’ dyke that corresponded to Profile 3. This proved to be an extremely useful choice.

**Laboratory Studies:** Selected monolith samples were subsampled for 8 pollen and 18 thin section analyses; others were retained in a cooler. 8 bulk samples (6 others retained) were analysed for grain size, chemistry and magnetic susceptibility. All 14 mollusc samples were assessed. After an assessment had found unexpectedly good pollen preservation, full pollen counts (minimum 200 pollen grains) were carried out; soil micromorphology focused upon Profiles 3 and 4, including microprobe studies, and because very few molluscs were present, all 14 mollusc samples were then assessed (gratis) for foraminifera (already noted in the thin sections) and ostracods by John Whittaker (Natural History Museum).

**ii. advances in knowledge or understanding resulting from the research**

**Results** These are presented in Appendices 3 (soil micromorphology and microprobe), 4 (bulk analyses), 5 (molluscs), 6 (pollen) and 7 (foraminifera and ostracods). The control arable (Profile 1) and grassland (Profile 2) sites produced expected results (‘agricutans’ [Jongerius, 1970], pollen of arable plants, poorly preserved foraminifera, and low LOI and specific conductance (a measure of ‘saltiness’) associated with agricultural soils formed in saltmarsh sediments (Wallasea soil series, Wallasea soil association 1; Jarvis *et al.*, 1984, 281-286, 391); Profile 2 although ‘grassland’ is essentially an arable soil variant.

Laboratory studies focused upon Profiles 3 and 4, the flooded grassland and its unflooded control, respectively. 22 contexts were identified in 10 thin sections and analysed in detail. The chief characteristics of the unflooded grassland (which was influenced by vegetation management – burning – and ‘borrow’ ditch cleaning events) are: a grass and herb litter layer with ‘peaty’ organic matter, strong leaching of cations and phosphorus but with instances of ferruginisation that increase down-profile (microprobe data); in addition to herbs, grasses and wetland plants (Cyperaceae), anomalous amounts (14%) of tree (mainly *Pinus*) pollen are present; specific conductance is high (Na and Cl present throughout); examples of brackish/salt water molluscs and ostracods and abundant well-preserved saltmarsh and mudflat foraminifera occur, which is also presumably a reflection of the fauna in the nearby ‘borrow’ ditch. This profile provides both clear information on the flooded grassland profile before sea wall breaching in 2006 (see Profile 3), and yields insights into potential effects of saline groundwater resulting from rising sea levels (see Hazelden and Boorman, 2001). Inundation of Profile 3 led to: burial of the grassland soil by finely laminated estuarine sediments, with muds infilling voids around the surface plant litter and roots; the sediment seals the Litter-mineral soil boundary. Calcareous laminae include algae which contribute to the detrital organic
matter content; partial decalcification and plant material ferruginisation occur even after only 2 years of sediment ‘ripening’. Microprobe mapping of the soil-sediment interface confirmed the presence of salt (NaCl) consistent with a very high specific conductance and the presence of sodium carbonate. Foraminifera reflect the sediment-buried topsoil sequence (mudflat deposits over developing ‘high salt marsh’ prior to flooding), and have the potential to show in detail the state of preservation and species associated with the different buried soil and sediment types. High grass pollen frequencies as well as other herbaceous types in flooded Profile 3 occur both before flooding and in the immediately overlying flood clays. Higher arboreal percentages (36%) recorded in the overlying estuarine muds cannot be linked to an increase in trees locally and probably reflect the massive change in pollen catchment from local to one of regional or even extra-regional scale (Prentice, 1985), consistent with palynological studies of Holocene intertidal sediments in Essex (Wilkinson and Murphy, 1995).

Conclusions: Soil micromorphology (including microprobe), bulk chemistry, foraminifera, ostracods and pollen analyses recovered the most information and produced the clearest results; the potential of other methods (diatoms) was also noted. The research provides clear insights into the following progressive effects: a) increased soil wetness and influence of saline groundwater, and b) marine flooding and burial by estuarine mudflat deposits. This pilot study already identifies some of the taphonomic complications affecting archaeological sites, including the short timescales involved; the understanding of the foraminifera, pollen and sediment micromorphology at Lower Palaeolithic Boxgrove, West Sussex, being a case in point. The pilot study indicates potential for an expanded study to investigate the threat of sea level rise and improve interpretation of previously inundated archaeological sites.

Appendices 1-7: Marine Inundation and Archaeology: pilot study at Wallasea Island, Essex 2008

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By
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Dissemination
16th-17th September 2008
24th-26th September 2008
Coastal site inundation: effects on archaeological features, materials, sediments and soils (by Macphail, Allen, Crowther, Cruise and Whittaker), Table Ronde “Géoarchéologie et Taphonomie”, Aix-en-Provence, France (CNRS).
7th-9th January 2009
Effects of sea level rise and site inundation based upon short term events recorded at Wallasea Island, Essex, UK and extrapolation of results to archaeological sites such as Lower Palaeolithic Boxgrove (by Macphail, Allen Crowther, Cruise and Whittaker)
Workshop I: “Singular events viewed in the archaeostratigraphic record: a complementary perspective to high resolution continental and marine archives” in “The cultural-environmental view of long archaeostratigraphic records”, Taragona, Spain (INQUA-IPHES).
Appendix 1a - Field work and other preliminary results July-August 2008 (Figures 1-17)

Fig. 1: RSPB LIDAR base elevations and locations of soil sampling sites: Profile 1 - Control Arable Pit 1 (CA1), Profile 2 - Control Grassland Pit 2 (CG2), Profile 3 - Flooded Grassland Pit 3 (FG3) and Profile - Control Grassland Pit 4.

Fig. 2: Locations of Control Arable Profile 1 – CA1 (accessed via tramline) and Control Grassland Profile 2 – CG2 – in grassland strip between arable and drainage ditch.

Fig. 3: CA1

Fig. 4: CG2
Fig. 5: Location of Flooded Grassland Profile 3 – FG3 – between sea wall (breached by DEFRA July 2006) and the borrow ditch.

Fig. 6: FG3 – sea weed-covered estuarine muds over grassland soil profile; borrow ditch, flooded arable fields and DEFRA breached sea wall in background, respectively.

Fig. 7: Location of Control Grassland Profile 4 – CG4 – between borrow ditch and sea wall (foreground), and on grassland undisturbed by recent vehicle activity, but seemingly affected by borrow ditch cleaning/maintenance in the past. This is the closest equivalent soil profile to FG3.

Fig. 8: CG4 in grassland; borrow ditch, grassland strip and arable fields in background, respectively.

Fig. 9: CA1 (Control Arable Profile 1) samples for soil micromorphology and pollen/microfossils; in addition bulk samples were collected for chemistry, grain size and mollusc analyses (see Fig 14).

Fig. 10: CG2 (Control Grassland Profile 2); sampling as in Fig 9.
Fig. 11: FG3 (Flooded Grassland Profile 3); sampling as in Fig 9. Note sea weed covered estuarine mud, and ground water seepage into the soil pit (see Figs 16-17).

Fig. 12: CG4 (Control grassland Profile 4, West Face); sampling as in Fig 9.

Fig. 13: CG4 (Control grassland Profile 4 North face) – sample M10 across probable relict grassland surface buried during previous borrow ditch cleaning/maintenance episode(s) (see Fig 15).
Fig. 14: Control Arable Profile 1 (CA1); scan of ~13 cm-long resin-impregnated block; note compact but moderately finely structured uppermost Apg1 horizon with wheat roots, over compact Apg2 horizon with coarse prismatic structures.

Fig. 15: Control Grassland Profile 4 (CG4) between borrow ditch and sea wall; scan of ~16 cm long resin-impregnated block. This is a complicated profile because of ditch cleaning, with a current strongly rooted and humic Ah horizon, a mixed/dumped Ahg/Bg1 horizon, a buried ‘surface’ (arrow) that varies in depth laterally, and buried bAhg/Bg1 horizon. Note strong ochreous mottling and inclusion of blackened organic matter, reflecting the lower elevation and wetter environment of CG4 compared to CA1. (Compared to CA1 [115 µmho] this location has a much higher specific conductance at 5580 µmho – implying saline water effects; J. Crowther University of Wales, preliminary chemistry)(see Fig 16).
Fig. 16: Flooded Grassland Profile 3 (FG3); scan of ~11 cm-long resin-impregnated block, showing algae (a) coated estuarine clay laminae (Est) over buried Ahg and Bg horizons. (Estuarine clay: 8950 µmho specific conductance; bAhg: 4750 µmho specific conductance; J. Crowther University of Wales, preliminary chemistry).

Fig. 17: Flooded Grassland Profile 4 (FG4); scan of ~14.5 cm-long resin-impregnated block, ~24-40 cm depth. Gley colours and massive/prismatic structure apparently not unlike subsoils found at CA1, CG2 and CG4 locations.

The research team of Dr Richard Macphail (University College London), Dr Mike Allen (Allen Environmental Archaeology), Dr Gill Cruise (UCL) and Dr John Crowther (University of Wales, Lampeter), aided by Peter Murphy (English Heritage), acknowledge funding by the British Academy and thank the Mark Dixon and the RSPB and Wallasea Farms Ltd for access and collaboration.
Appendix 1b - Wallasea Island Soils July 2008: Soil pit locations and brief soil descriptions (west face of soil pits)(Elevations based upon RSPB lidar base elevations)

| Control Arable Pit 1 (CA1) | CA1 | 0-40 cm (Apg): Very dark greyish brown (10YR3/2) firm to very firm silty clay with common yellowish brown (10YR5/6) mottles; moist 0-4 cm; massive with very coarse prisms; few very fine roots; very few very small-stone size tile/brick, flint pebble, chalk and an example of pulverised fuel ash; rare examples of woody root/stem material; dark grey (10YR4/1) burrow and fissured soil to 35+ cm; gradual, irregular boundary. |
| Location: TQ97939/40 : 93825 Elevation: 1.01-1.25 m ODN | Arable (wheat) field. |
| Arable Pit 1 (CA1) | 40-60+ cm (Bg1): Mottled grey (2.5Y5/0)(75%) and yellowish red (10YR5/8)(25%) firm silty clay; common very fine roots; massive with fissuring forming very coarse prisms, with some sandy prism faces; traces of 2-3 mm size indurated CaCO₃ nodules; traces of Fe-Mn staining; rare coarse inclusions as above. |

| Control Grassland Pit 2 (CG2) | CG2 | 0-5 cm (Ah1g): Dark greyish brown (10YR4/2) moderately firm silty clay, with few brown (7.5YR5/4) fine mottles; massive with deep coarse fissuring; rare very small ‘brick’, flint and chalk; traces of CaCO₃; clear horizontal boundary. |
| Location: TQ98032 : 93827 Elevation: 1.01-1.25 m ODN | Grassland strip between wheat crop (arable) and drainage ditch. |
| Grassland Pit 2 (CG2) | 5-24+ cm (A1g&Bg1): Dark greyish brown (10YR4/2) moderately firm silty clay, with common brown (7.5YR5/4) coarse mottles, becoming more common down-profile; massive with deep coarse fissuring frequent CaCO₃; rare very small ‘brick’, flint and chalk; few fine to coarse root channels/traces; diffuse irregular boundary. |

<p>| | 24-41 cm (Bg1): Distinctly coarsely mottled brown (10YR4/3) and yellowish red (5YR4/6) moderately firm silty clay; massive with deep coarse fissuring rare very small ‘brick’, flint and chalk; diffuse irregular boundary. |
| | 41-65+ cm (Bg2): Prominently coarsely mottled grey (2.5Y5/0)(70%) and yellowish red |</p>
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<thead>
<tr>
<th>Location</th>
<th>Description</th>
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<tr>
<td>Flooded grassland Pit 3 (FG3)</td>
<td>1 mm thick, patchy algal cover. On higher, drier surfaces <em>Salicornia</em> spp., <em>Sueda maritima</em>, <em>Beta vulgaris</em>.</td>
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<td>Control grassland Pit 4 (FG4)</td>
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**Flooded grassland Pit 3 (FG3)**

**Location:** TQ98419 : 94310

**Elevation:** 0.76-1.00 m ODN

Between ‘borrow ditch’ and sea wall, flooded/sea wall breached in July 2006.

- **0-3(6) cm (Humic estuarine clay):** Black (5Y2/1) soft and wet organic silty clay; massive; sharp smooth boundary.
- **3(6)-11(15) cm (bAhg):** Olive grey (5Y3/2) and fragmented/patchy dark greyish brown (2.5Y4/2) and dark grey (5Y4/1) wet silty clay; massive; very abundant black fine roots; sharp irregular boundary.
- **11(15)-33 cm (bBg1):** Distinctly mottled greyish brown (10YR5/2) weak and moist silty clay with frequent fine grey (2.5Y5/0) mottles; rare root traces; diffuse irregular boundary.
- **33+ cm (bBg2):** Prominently mottled reddish brown (5YR5/4)(70%) and grey (5Y5/1)(30%) moderately weak to moderately firm silty clay; massive with relict prisms; ochreous root traces; marked ground water seepage.

**Control grassland Pit 4 (FG4)**

**Location:** TQ98257 : 93620

**Elevation:** 0.51-0.75 m ODN

Between ‘borrow ditch’ and sea wall.

- **0-3(5) cm (Ah):** Very dark greyish brown (10YR3/2) moderately weak silty clay; massive; moderately humic; fine pot/brick present; very abundant fine roots; sharp, irregular boundary.
- **3(5)-15(20) cm (Ahg&Bg1/ditch cleaning dump):** Mixed black (2.5Y2/0)(Ah) and distinctly mottled light grey (5Y6/1) and brown (7.5YR5/4) moderately weak silty clay; massive; rare fine living roots, few strongly blackened fine roots; possible buried turf line at 15 cm depth on north face, marked by 0.5 cm thick blackened organic matter; sharp to clear irregular or smooth boundary.
- **15-20 cm (bAh/Bg1):** Distinctly mottled light grey (5Y6/1) and brown (7.5YR5/4) moderately weak silty clay; rare fine living roots, few strongly blackened fine roots; massive with weak fissured to prismatic structure; clear, irregular boundary.
- **15(20)-37+ cm (Bg2):** Distinctly mottled light grey (5Y6/1)(50%) and brown (7.5YR5/4)(50%) moderately firm silty clay, with few distinct yellowish red (5YR4/6) mottles (iron-stained...
channels/root traces?); massive with weak fissured
to prismatic structure, some sandy ped faces; fewine roots; minor ground water seepage.

(The RSPB and Wallasea Farms Ltd are thanked for their cooperation)
(Soils occur as Wallasea soil series and Newchurch soil series variants within the
Wallasea 1 soil association; Jarvis et al., 1983, 1984, 281-286, 386, 391)

References:
Survey and Land Research Centre, Silsoe.
Ordinance Survey.
—, 1984, Soils and Their Use in South-East England: Harpenden, Soil Survey of
England and Wales.
### Appendix 2: Wallasea Island Samples July 2008

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<th>Location</th>
<th>Pollen Cores</th>
<th>Pollen Depths of cores (cm from surface)</th>
<th>Pollen Samples sent to Lampeter</th>
<th>Soil Monoliths</th>
<th>Soil Depth</th>
<th>Soil Impregnated Block</th>
<th>Soil Thin Section</th>
<th>Soil Bulk Sample (analysed)</th>
<th>Molluscs</th>
<th>Forams</th>
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<td><strong>Control Arable Profile 1</strong></td>
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<td>CA1</td>
<td>P1(a)</td>
<td>0-15 cm</td>
<td>1 cm, 3 cm</td>
<td>M1</td>
<td>0-37cm</td>
<td>M1A 0-15cm</td>
<td>M1A1 0-75mm</td>
<td>0-4cm</td>
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<td></td>
<td>P1(b)</td>
<td>16-32 cm</td>
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<td>M2</td>
<td>44-48cm</td>
<td>M2 44-48cm</td>
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<td>M2 445-480 mm</td>
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<td>CG2</td>
<td>P2(a)</td>
<td>1-16 cm</td>
<td></td>
<td>M3</td>
<td>0-15cm</td>
<td>M3 0-15cm</td>
<td>M3A1 0-75mm</td>
<td>0-5cm</td>
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<td>P2(b)</td>
<td>16-32 cm</td>
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<td>M4</td>
<td>34-41cm</td>
<td>M4 34-41cm</td>
<td>M4 340-410mm</td>
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<td>P3(a)</td>
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<td>M5</td>
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<td>M5A 0-15cm</td>
<td>M5A1 0-75mm</td>
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<td>P6</td>
<td>1-14 cm</td>
<td>1.5cm, 3cm, 5cm, 7cm</td>
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<td>M10</td>
<td>12-20 cm</td>
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<td>12-20cm</td>
<td>M10 12-20cm</td>
<td>M10 120-215 mm</td>
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NB: *=additional samples used for Foraminifera assessment;
Appendix 3a - Soil Micromorphology Illustrations
(Richard I Macphail and G. M. Cruise, Institute of Archaeology, UCL)

Wallasea Island: **Control** (2008) grassland (0-50mm [Ahg]), 50-75mm [bBg]; 240-320mm [bBg2 with relict saltmarsh laminae]; **Flooded** (in 2006) grassland – after two years (40-0mm [estuarine mudflat laminae]); 0-65mm [bAhg]; 65-90mm [bBg]. 75mm long

Control grassland: already affected by high water table including saline water (5580µm ho spec. cond.); slow organic matter turnover (26.7%LOI). Grass stems; root mat; very humic Ahg with patchy iron-staining (frame= ~4.62mm). (Grass and sedge pollen, with included cereal and ‘saltmarsh’ types)

Grass stems (left) 
Ageing root mat (right) with browning and ferruginisation

Humic Ahg with patchy iron impregnation (intermittent waterlogging)
2006-2008 Flooded grassland impregnated block (A=algae); estuarine mudflat laminae [8950 µm ho spec. cond.] over bAhg – grassland soil; middle laminae, coarse silt-very fine sand and calcitic silty clay; iron-staining of detrital organic matter (algae?) in lower laminae (height=4.62mm; PPL, OIL) – not dissimilar to Boxgrove ‘ironpan’

Wallasea flooded grassland (now mudflat); junction of estuarine laminae and buried soil; Microprobe maps of Ca, Cl, Na and Si (from Kevin Reeves)(width is ~50mm)
Wallasea Island: **Control** (2008) grassland (thin section M8A1): Litter layer (0-8[15] mm), Ahg (8[15]-50mm), Bg (50-75mm); Microprobe maps of Si, Al, Na and Cl, Si (from Kevin Reeves)(width is ~50mm)
Foraminifera in mudflat laminae and iron impregnation of detrital organic matter, e.g., algae.

Example of typical Mudflat and sandflat Foraminifera

But how long would this calcareous fossil be preserved?
PPL, XPL frame=\~0.90mm.

Wallasea: Grass litter (L) layer of bAhg, with mudflat inwash around soil peds and grass roots; note (whitish) sodium carbonate impregnation (OIL). This basal inwash layer apparently seals buried mineral Ah – the only other inwash clay occurs as a thin (1mm) laminae between the bAhg and bBg.

Clayey inwash laminae in Litter of bAhg ‘sealing’ lower buried soil PPL, OIL frame=\~2.38mm

Lower bAhg – no evidence of inwash. PPL Frame=\~4.62mm

Junction of bAhg and bBg Inwash laminae OIL Frame=\~4.62mm

Junction of bAhg and bBg Inwash laminae OIL Frame=\~4.62mm
Appendix 3c: Wallasea Island: Soil Micromorphology (Microprobe)
(Richard I Macphail, G. M. Cruise and K. Reeves, Institute of Archaeology, UCL)
(Profile 3, Flooded Grassland: Microprobe analysis [vertical line counts 0-99] of M5A1 [junction of new estuarine mud flat sediments and 2006 buried grassland topsoil - bAhg horizon].

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Wallasea Island, Profile 4, Grassland Control (by borrow ditch): Microprobe analysis (vertical line counts 0-100) of M8A1 (‘peaty’ L1, litter layer L2, Ahg horizon, Ahg/dump (ditch clearance) and bBg subsoil).

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<td>42.55</td>
<td>2.09</td>
<td>3.20</td>
<td>0.37</td>
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<tr>
<td>Count</td>
<td>31</td>
<td>31</td>
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<td>31</td>
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</tbody>
</table>
### Appendix 3c: Wallasea Island: Soil Micromorphology (Descriptions and preliminary interpretations)
(Richard I Macphail and G. M. Cruise, Institute of Archaeology, UCL)

<table>
<thead>
<tr>
<th>Microfacies type (MFT)/Soil microfabric type (SMT)</th>
<th>Sample No.</th>
<th>Depth (relative depth)</th>
<th>Soil Micromorphology (SM)</th>
<th>Preliminary Interpretation and Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pit 1 – Control Arable (CA1)</td>
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</table>

- **M1A1**
  - 0-75 mm
  - Ap(g): Assessed only
  - Moderately open, massive, earthworm-burrowed, silty clay with coarse modern roots, rare charcoal and trace amounts of other anthropogenic inclusions (chalk and clinker), with very abundant textural intercalations, void coatings and infills (that include fine charcoal and amorphous organic matter) – consistent with modern arable land use and biological activity in surface few cms.

- **M1A2**
  - 75-150 mm
  - Ap(g): Assessed only
  - Very compact, massive, with few coarse modern roots, rare charcoal and other anthropogenic inclusions (coarse clinker and fine burned clay and soil), with sometimes silty infilled burrows, abundant textural intercalations, void coatings and infills – consistent with modern arable land use and surface compaction.

- **M1B1**
  - 150-225 mm
  - Ap(g): Assessed only
  - Very compact, coarse prismatic structured, with very few roots, rare fine charcoal and other anthropogenic inclusions (fine chalk,
| M1B2  | 225-300 mm | **Ap(g): Assessed only**  
Very compact, coarse prismatic structured, with very few roots, rare trace of fine charcoal and rare other inclusions (e.g., of coarse probable marine shell and clayey fragments of probable saltmarsh sediment origin), with silt-infilled burrows, abundant textural intercalations, void coatings and infills – consistent with modern arable land use, compaction, and traces of saltmarsh sediment origin. |
|-------|------------|------------------|
| M2    | 445-480 mm | **Bg1: Assessed only**  
Moderately compact, massive and coarsely prismatic structured; composed of very coarse silt and clayey sediment fragments with rare traces of charcoal, shell and organic remains; very abundant textural intercalations, void coatings and infills, with very broad burrow infills of humic and/or silty soil; examples of relict iron impregnation (mottling) of clayey sediments as well as examples of modern ferruginous void hypocoatings – all consistent with landscaping of original saltmarsh sediments (physical mixing and disturbance/slaking) and burrowing and soil inwash downwards from current overlying arable Ap(g) horizon. |
### Pit 2 Control Grassland (1) CG2

<table>
<thead>
<tr>
<th>Layer</th>
<th>Thickness</th>
<th>Description</th>
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</table>
| M3A1  | 0-75mm    | **A1g: Assessed only**  
Compact, massive with vertical fissures, heterogeneous with coarse clayey and silty clay soil, moderately humic and poorly humic soil, and saltmarsh sediment fragments; abundant fine and coarse roots, rare fine charcoal and blackened organic matter (e.g., fine clinker and 'iron'); very abundant dusty clay intercalations and both dusty clay and silty infills, including earlier-formed burrows; many inclusions of iron-depleted and iron-stained (including ferromanganiferous nodules) soils and sediments – consistent with a coarsely disturbed (ploughed) arable soil mixed with subsoil and saltmarsh sediments, which only recently was given over to grassland (border between arable and grassland corridor alongside drainage ditch). |
| M3A2  | 75-150mm  | **A12g: Assessed only**  
Compact, prismatic structured, mainly homogeneous moderately humic silty clay (as M1A1), with occasional fine and medium roots and root traces, rare fine charcoal and blackened plant material; many iron-stained clay fragments; very abundant textural intercalations, finely dusty and coarsely dusty void coatings and infills, as well as silt-infilled burrows – all consistent with a recent arable landuse. |
<p>| M4    | 340-410 mm| <strong>Bg1: Assessed only</strong>  |</p>
<table>
<thead>
<tr>
<th>MFT A1/SMT 1a</th>
<th>M5A1</th>
<th>Compact, massive with relict (infilled) vertical fissures (earlier-formed prismatic structure); junction between base of earlier-formed semi-homogenised silty clay arable soil (Apg) and strongly mottled (iron-depleted and iron-impregnated areas) more clayey subsoil; many fine root channels throughout; very abundant textural pedofeatures, including silty burrow fills and earlier-formed fissures which contain microlaminated silty clay, impure clay and dusty clay infills up to 5 mm thick – all consistent with a subsoil affected by modern arable activity.</th>
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</thead>
<tbody>
<tr>
<td><strong>Pit 3 – Flooded Grassland – by borrow dyke (CG4)</strong></td>
<td><strong>Mudflat clays</strong></td>
<td>Discontinuous 0.5mm thick greenish layer of 50-75 µm thick algal strands. Surface seaweed layer (algal strands also found below) Weakly calcareous moderately humic laminated mud, with micritic very fine silt and fine silt-size quartz, intercalated with horizontal plant/algal tissue strands remains (50 µm thick and 1.5mm long) – some showing weak ferruginisation downwards. Deposition of weakly calcareous moderately humic mud along with detrital strands of algae, or partial decalcification of once more strongly calcitic humic mud – highest deposit and exposed probably except for high tides. Upper, middle and lower well laminated, well</td>
</tr>
<tr>
<td>0-30 mm</td>
<td>0-30 mm</td>
<td>SM: essentially homogeneous (but laminated); Microstructure: finely (1mm) to very finely (0.5mm) laminated, 5-10% voids, very fine (75-120 µm) vughs (weak decalcification and/or oxidation of round algal remains); few very fine (0.5) vertical and subhorizontal fissures; Coarse Mineral: Coarse:Fine (limit at 10 µm), 0-0.5(0) mm: discontinuous algal strands 50-75µm thick surface algal tissue layer(s) (SMT 1a: pale green (PPL), isotropic (XPL), dark brown-dark greenish brown (OIL)(algal surface layer);</td>
</tr>
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</table>
| MFT A2/SMT 1b | **0.5(0)-5 mm: Upper laminae** | sorted humic clayey layers and coarse silt-very fine sand-size quartz (with calcite, fossil fragments and mica), characterised by horizontally oriented short lengths of detrital organic matter (algae as above!), often showing browning and iron-staining with occasional sodium carbonate impregnation; occasional Foraminifera present.  
*Well sorted alternating humic clay and silt laminae, recording tidal mudflat deposition, including probable deposition of detrital algae. Iron impregnation of detrital organic matter and humic clayey laminae produced banded laminae; minor secondary sodium carbonate.* |
| --- | --- | --- |
| MFT A3/SMT 1c | **5-18 mm: Middle clay and coarse silt-very fine sand laminae:**  
C:F, associated coarse (1mm) and fine laminae (0.5mm), with C:F of 60:40 (coarse silt-very fine sand-size quartz) and 10:90 (silt-size quartz and mica), respectively (humic and micritic fine fabric SMT 1c: very finely speckled darkish brown, with few dots (PPL), moderately high interference colours (open porphyric [clay laminae], very close porphyric [silt layer], crystallitic b-fabric, XPL), (OIL); humic staining, abundant fine and long lengths of amorphous organic matter and tissue fragments; rare phytoliths, spores and pollen.  
*Probe: very poorly calcareous (mean 0.37% Ca; max 0.83% Ca) silts and clay (mean 3.98% Al, mean 17.57% Si) and iron staining (mean 2.80% Fe; max 11.08% Fe); Ca-depletion zones (Ca map)* |
**MFT A3a/SMT 1c**

**18-30 mm: Lower clay and coarse silt-very fine sand laminae**

As above but darkish reddish brown laminae – more strongly iron stained humic material and plant fragments (horizontally oriented and some up to 3mm long); rare examples of sections through relict grass stems (1-2mm wide);

*Probe*: Weakly calcitic with secondary micrite (mean 0.69% Ca; max 4.61% Ca) silts and clay (mean 4.87% Al, mean 12.97% Si), with minor secondary sodium carbonate and ‘salt’ (mean 0.54% Na, max 6.14% Na; mean 0.85% Cl, max 2.12% Cl), and iron staining (mean 2.24%, max 6.24% Fe). Na and Cl concentrations; Si and Al laminae (maps).

**30-40 mm: Lowermost mudflat clay and intercalated grass litter layer**

Poorly laminated/massive, C:F, 75:25, well sorted fine silt-size quartz, with fine mica and calcite, and few Foraminifera shells and shell fragments; example of 3mm long horizontally oriented mollusc shell fragment; very abundant grass stems, as cross sections and roughly horizontally oriented lengths (2-6mm long); some showing perfect preservation, most others showing loss of parenchymatous cells and general browning and iron-staining; example of coarse 3mm-size charcoal; few soil crumbs (see SMT 2a, below). SMT 1d: finely speckled and dotted darkish to reddish brown or blackish grey (sodium carbonate)(PPL), moderately high interference colours and low (open and close porphyric, crystallitic b-fabric, XPL), darkish brown (OIL); humic staining, abundant fine and long lengths of amorphous organic matter and tissue fragments; rare phytoliths, spores and Intercalated calcitic and sodium carbonate impregnated humic clays and silts (with laminae and stem fills of coarse silt), containing very abundant very fine detrital organic matter and many Foraminifera shells and fragments (example of mollusque shell also present), intercalated with grass stems (cross sections and long horizontal fragments – some showing browning and iron staining).

**Inundation, with both clayey and silt laminae, and massive poorly laminated fills between grass stems and litter layer; sediments particularly rich in Foraminifera – possibly because flow slowed by grass stems and ‘coarse’ Forams became deposited(?); secondary iron-staining of humic clayey laminae and grass stems (some grass stems may already have been iron-stained before**
pollen. 
Probe: weakly calcitic with secondary micrite (mean 0.92% Ca, max 6.13%) silts and clays and soil crumbs (mean 4.38% Al; mean 19.56% Si), with sodium carbonate and ‘salt’ (mean 1.38% Na, max 13.85% Na; mean 1.21% Cl, max 6.83% Cl), and iron soil and grass litter impregnation (mean 2.91% Fe, max 9.70% Fe). Ferruginisation of plant fragments; Al and Si laminae (maps).

Estuarine mudflat laminae: Pedofeatures: Depletion: probable/apparent depletion of highest (exposed) calcareous mud layer); Crystalline: occasional horizontal concentrations of sodium carbonate impregnation; Amorphous: very abundant ferruginisation of detrital organic matter, and impregnation of humic clayey laminae (giving horizontal banding); Fabric: very abundant laminated sedimentary features. 

**40-75 mm buried soil**
SM: essentially homogeneous; Microstructure: fine and medium subangular blocky (with some humic crumbs) with 25-60% voids, poorly to moderately accommodated planar voids, and simple and complex packing voids; Coarse Mineral: C:F, 60:40, well-sorted medium and coarse silt-size quartz, with mica; very few fine sand-size quartz; Coarse organic and anthropogenic: abundant 1-3mm wide roots and very abundant root and other plant fragments and tissues, with and rare fine charcoal; Fine Fabric: SMT 2a: dusty and speckled brown, with some dots (PPL), moderately low interference colours (close porphyric, speckled and weakly strial b-fabric, XPL), pale greyish brown (OIL); very humic, with very abundant fine amorphous organic flooding – see CG4); some layers impregnated with sodium carbonate (note specific conductance is highest in these mudflat clays; Cl concentrations present). 

bAh(g)

**bAhg**
Moderately well structured fine and medium subangular blocky humic fine loam (silty clay), with well sorted silt-size quartz (and mica); abundant in situ grass roots and very abundant finely fragmented grass and root fragments and amorphous organic matter, with rare fine charcoal present; rare examples of oriented clay associated with fabric/burrow intercalations, and iron impregnation; burrowed with humic (mainly very thin) and broad organo-mineral excrements. 

**Humic Ah horizon, with moderately high amounts of biological activity in this rooted horizon, with burrowing causing minor**
matter, tissue fragments; charred organic matter present. Pedofeatures: Textural: rare patch of clayey intercalation (now weakly iron-impregnated); Amorphous: rare patches of iron impregnation; Fabric: abundant 1-2 mm burrows, some with associated oriented clay/intercalations; Excrements: many humic and organo-mineral broad 1mm-size excrements, with occasional very thin (50-250 µm) organic excrements. Probe: silty soil (mean 4.34% Al; mean 18.32% Si) with iron-stained plant material (mean 1.89% Fe, max 4.56% Fe). Plant fragment ferruginisation; Al and Si soil structures (maps).

<table>
<thead>
<tr>
<th>MFT C2/SMT 2a, 2b (3a, 1c)</th>
<th>M5A2</th>
<th>75-100mm</th>
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<tbody>
<tr>
<td>SM: heterogeneous with common SMT 2a, dominant SMT 2b and few SMT 3a; Microstructure: fine and medium subangular blocky, 30-40% voids, moderately well accommodated medium (1mm) planar voids; Coarse Mineral: as bAh(g)1; Fine Fabric: SMT 2b: as SMT 2a, moderate interference colours (close porphyric, speckled and weakly striated b-fabric [orientation of clay associated with mica and plant fragments], XPL); pale greyish brown (OIL); as SMT 2a, but comparatively less amorphous organic matter; Coarse organic and anthropogenic: very abundant fine and medium (0.5-1mm) roots and tissue fragments and amorphous organic</td>
<td>formation of intercalations (probably related to soil wetness at times); only minor iron impregnation in comparison to Ahg at CG4, which is a lower and more wet location. Lack of inwash clay may suggest that this buried soil was rapidly sealed by initial clay mud sedimentation.</td>
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<td>As above, mixed humic and minerogenic silty clay soil, including poorly humic SMT 3a (subsoil material), with fine and subangular blocky structure and very abundant root and plant tissue fragments, and traces of charcoal (and burned mineral – see %$\chi_{conv}$) within both SMT 2a and SMT 3a; abundant broad burrows and many humic and organo-mineral broad and very thin excrements. 1 mm thick, discontinuous silty clay laminated fill at base and along junction with bAh(g)&amp; Bg, below. Lower part of buried grass turf Ah horizon,</td>
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MFT D1/SMT 3a, 2a and 2b

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
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<tbody>
<tr>
<td>Matter</td>
<td>Trace amounts of fine charcoal, and example of strongly rubified mineral material; Pedofeatures: Textural: 1mm thick example of SMT 1c humic clayey laminae; Amorphous: occasional patches of iron impregnation; Fabric: abundant 1-2 mm burrows, some with associated oriented clay/intercalations; Excrements: many humic and organo-mineral broad 1mm-size excrements, with many very thin (50-250 µm) organic excrements.</td>
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<tr>
<td>100-125mm SM</td>
<td>Heterogeneous with complex mixing (including burrowing) of frequent SMT 2a-2b and very dominant 3a; Microstructure: massive/coarse prismatic(?) 15-20% voids, mainly fine (0.5mm) channels, with single coarse (3-4mm) fissure; Coarse Mineral: as bAh(g)1, with example of fine sand-size chalk; occasional fine sand-size reddish clay papules and iron-stained nodules; Coarse organic and anthropogenic: abundant fine and medium (0.5-1mm) roots and tissue fragments and amorphous organic matter; example of 1mm-size charcoal; Fine Fabric: SMT 3a: very dusty brown (PPL), moderate interference colours (open and close porphyric, unisintiated with grano-striate b-fabric, XPL), pale brown and pale orange brown (OIL); occasional fine amorphous organic matter and rare fine charred/blackened OM, trace amounts of phytoliths; Pedofeatures: Textural: example of 1 mm thick dusty clay pan between humic bAhg and subsoil; very abundant dusty clay intercalations throughout SMT 3a; Amorphous: abundant moderate iron impregnation of clayey fine material/intercalations, with ferruginous hypocoatings; Fabric: very abundant coarse</td>
</tr>
<tr>
<td>bAh(g)2 &amp; Apg/Bg1</td>
<td>Moderately compact and coarsely heterogeneous with humic Ah(g) and subsoil Bg soil fragments; abundant fine and medium roots and root traces – some partially ferruginised; strongly rooted; very abundant broad burrowing with occasional thin to broad organo-mineral excrements. Biologically mixed junction between compact homogenised saltmarsh sediments (previous borrow-ditch cleaning sediments/arable-grassland soils(?)) and grassland topsoils. Both rooting from now-flooded grassland, and relict root fragments from earlier soils.</td>
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</table>
mixing/burrow and root disturbance of SMT 2a, 2b and 3a; Excrements: occasional concentrations of thin to broad organo-mineral excrements in burrows.

**MFT D2/SMT 3a, 4a, 4b, 5a, 5b**

**M5B1**

**150-225 mm**

SM: extremely heterogeneous (SMT 3a with frequent SMT 4 (clayey soil and sediment fragments) and frequent SMT 5 (silty clay loam soil and sediment fragments); Microstructure: fine prismatic (from massive?), 35% voids, inter-ped: coarse (4mm) moderately well accommodated planar voids, intra-ped: fine closed vughs and mainly medium (1mm) vertical channels (root traces and roots); Coarse Mineral: as above, with occasional Coarse organic and anthropogenic: (coarse charcoal (0.5-3.5mm), coarse coal (4mm) and example of coarse rounded chalk (5mm); occasional 0.5-1mm size roots, commonly vertical, showing browning and faunal activity (very thin organic Oribatid? excrements); Fine Fabric: SMT 4a (C:F, 20:80): very finely dusty pale yellowish brown (PPL), low to moderate interference colours (very open porphyric, recticulate striated and grano-striated b-fabric, XPL), pale greyish yellow (OIL); trace of humic staining and amorphous organic matter: SMT 4b: as 4a with sedimentary laminae; SMT 5a (C:F, 75:25): pale to dark brown (PPL), moderate to moderately high interference colours (close porphyric, speckled and recticulate and grano-striate b-fabric, XPL), pale orange to orange (OIL); moderate once-humic staining and rare to occasional fine amorphous organic matter traces; Pedofeatures: Textural: very abundant relict sedimentary features and dusty and impure void infills (from previous arable activity/mixing – see M1); rare dusty clay infills

**bApg/Bg1**

Once-compact massive, now finely prismatic, extremely heterogeneous soil composed of homogenised and poorly homogenised ‘arable’ Ap soil, with coarse fragments of clayey and silty clay loam sediments and weakly homogenised soil variants. Occasional coarse charcoal with examples of coarse coal and rounded chalk occur (amended arable). Occasional fine and medium roots show 1: faunal working – organic excrements locally abundant; 2: later partial ferruginisation. Lastly, minor dusty clay inwash around this rooting is recorded and perhaps may form rare examples of void inwash.

*Arable upper Bg horizon with mixed and partially homogenised clay and silty clay loam saltmarsh sediments, forming compact soil (due to 1950’s landscaping), which became rooted during both its arable and most recently, its grassland land use phase. Increased site wetness led to partial decay of roots (and faunal working) and their ferruginisation. Lastly, site inundation is recorded by dusty clay inwash along decayed root channels (at 170mm) for example (as in M5A2 above).*
around relict vertical roots and forming closed vugh at 170mm (as possibly related to inundation, cf M5A2 above); Amorphous: many weak to moderate iron impregnation of fine, often clayey included soil; very abundant moderate ferruginisation of relict roots; Fabric: very abundant coarse mixing; Excrements: rare very thin (25-50 µm) humic excrements (Oribatids?).

<table>
<thead>
<tr>
<th>MFT D3/SMT 3a, 4a, 4b, 5a, 5b, 6a</th>
<th>M5B2</th>
<th><strong>225-300 mm</strong></th>
<th>SM: heterogeneous (as above, with very few SMT 6a); Microstructure: massive with medium prisms, 25% voids (well accommodated coarse (1-2mm) planar voids; Coarse Mineral: as above; Coarse organic and anthropogenic: rare trace of charcoal, with examples of burned clay and possible iron fragment; occasional roots and root traces, some integrated in fine fabric, some cutting through mixed soil materials; Fine Fabric: as above, with SMT 6a: blackish brown (PPL), very low interference colours (close porphyric, speckled b-fabric, XPL), greyish with blackish specks (OIL); humic stained with many to abundant tissue and amorphous OM fragments; Pedofeatures: Textural: very abundant dusty and impure clay void infills, some associated with soil/sediment clast boundaries; Amorphous: very abundant moderate ferruginisation of relict roots; Fabric: very abundant coarse mixing; Excrements: rare trace of very thin (25-50 µm) humic excrements (Oribatids?).</th>
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<td></td>
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<td><strong>410-500mm</strong></td>
<td>410-440 mm As M5B2, but extremely and more coarse heterogeneous with SMT 3a, 4a, 4b, 5a, 5b, 6a, and rare traces of roots; massive, 15% voids, fine vughs and channels. 440-500 mm</td>
</tr>
<tr>
<td>MFT D4/ SMT 3a, 4a, 4b, 5a, 5b, 6a</td>
<td>M6</td>
<td><strong>410-500mm</strong></td>
<td>410-440 mm As M5B2, but extremely and more coarse heterogeneous with SMT 3a, 4a, 4b, 5a, 5b, 6a, and rare traces of roots; As M5B2, but extremely and more coarse heterogeneous with SMT 3a, 4a, 4b, 5a, 5b, 6a, and rare traces of roots; masssive, 15% voids, fine vughs and channels. 440-500 mm</td>
</tr>
<tr>
<td>MFT E/SMT 1b</td>
<td>SM: moderately heterogeneous – dominantly very coarse fragment of SMT 1b (MFT A2); <strong>Microstructure:</strong> massive, relict laminated; 10% voids, traces of very thin planar voids along laminae and very few fine root channels; <strong>Coarse Mineral:</strong> as in MFT A2; <strong>Coarse organic and anthropogenic:</strong> trace of root traces; <strong>Fine Fabric:</strong> as SMT 1b. <strong>Pedofeatures:</strong> Fabric: very coarse fabric mixing.</td>
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<tr>
<td>MFT C2/SMT 2c (2a)</td>
<td><strong>bBg2</strong> Compact coarse fragment of laminated silt and clay, with traces of roots. <strong>Weakly disturbed original saltmarsh sediments affected by landscaping.</strong></td>
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<tr>
<td>M8A1</td>
<td><strong>Pit 4 Control Grassland (2) – by ‘borrow dyke’</strong></td>
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<td>0-75mm</td>
<td>Dominantly organic layer, rich in amorphous organic matter, leaf fragments and roots of probable grass and herbs, with possible examples of brackish/salt water molluscs; charcoal, phytoliths and diatoms present; humus stained micritic infills also affected the uppermost part of this layer. Much mesofaunal burrowing and excrement formation; leaching effects but occasional iron impregnation (see microprobe).</td>
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<td>0-8(15) mm</td>
<td>Well rooted litter (L) layer rich in amorphous organic matter (‘peaty’ O layer), with fragmented grass leaves (source of phytoliths) showing working by mesofauna but also browning and blackening from decay and weak ferruginisation from high groundwater. Some burrow mixing upwards from mineral Ahg horizon. Surface also includes possible brackish/salt water molluscs (Allen pers comm.) and micritic calcite sedimentation/impregnation has also</td>
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<td>MFT C3/SMT 2d, with 3b and 2e</td>
<td>Browning and blackening of plant material; Fabric: many thin (0.5 mm) burrows; Excrements: very abundant very thin and thin organic excrements and thin organo-mineral excrements (from Ah below). <em>Probe</em>: Ca, K, Mg, Mn, P and S totally absent from ‘peaty’ L1; Ca, K, Mg, Mn, P and S totally absent or very low from L layer (Fe very low apart from individual concentrations, max 3.13%); low Na and Cl; high Si (sand). 8(15) - 50mm Ahg SM: heterogeneous with dominant SMT 2d, with mixing downwards of frequent SMT 3b and SMT 2e (buried and burrowed); Microstructure: coarse aggregate and fine and medium subangular blocky; 35% voids, curved moderately accommodated planar voids, with simple and complex packing voids; Coarse Mineral: C:F, 55:45, very dominant well sorted coarse silt-size quartz, with few mica and fine sand; Coarse organic and anthropogenic: very abundant roots and root remains, both ‘grass’ (0.5mm) and probable dicotyledonous (2-4mm) roots; patches of abundant charcoal (mainly &lt;1mm); Fine Fabric: SMT 2d: very dark reddish brown to darkish brown (PPL), very low interference colours to isotropic (moderately close and close porphyric, speckled and undifferentiated b-fabric, XPL), very dark brown to greyish brown (OIL); highly humic to humic, with very abundant tissue and amorphous organic matter, fine charcoal locally abundant, phytoliths, rubefied grains and fungal bodies (250 µm – probable vesicular arbuscular mycorrhizae) present; SMT 2e: blackish to blackish brown (PPL), isotropic (open porphyric, undifferentiated b-fabric, XPL), black (OIL); occurred. High groundwater (as also indicated by presence of diatoms) is leading to the formation of a peaty Om horizon. <strong>Ahg</strong> Moderately open subangular blocky structured organic silty clay characterised by very abundant fine ‘grass’ and coarse dicotyledonous roots. Also present are fragments of silty clay loam subsoil (Bg1) and concentrations of charcoal and charred humic soil and probable litter/OM. Examples of probable vesicular arbuscular mycorrhizae also occur. Infills and pans of humic clay containing few silt grains occur; iron impregnation of the matrix and plant material is very abundant (see microprobe). Heterogeneous soil records 1: burning of earlier formed L/Om surface, 2: burial by probable ditch cleaning clay and silts, 3: renewed growth of grasses and dicotyledonous herbs and development of bioworked Ahg horizon, 4: high water table caused stress to plants (hence probable presence of vesicular arbuscular mycorrhizae), death of plants (plants decaying) and moderately strong ferruginisation (cf $\chi_{\text{max}}$).</td>
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| MFT C3/SMT 3b | concentrated charred amorphous organic matter and fine charcoal; Pedofeatures: Textural: abundant pans and infills (1mm) of dark brownish very dusty and impure (silty) moderately oriented clay (pale greyish under OIL), with very abundant blackened and browned fine organic matter (from ditch cleaning?); Amorphous: very abundant moderately strong iron staining of matrix and root material; Fabric: very abundant burrows (up to 5-6mm wide); Excrements: rare thin organic and very abundant thin to broad (2.5mm) organo-mineral excrements. | bBg1
Compact silty clay loam, with abundant roots and root channels – several coarse roots showing charring; very abundant textural intercalations, pans and infills of matrix clay; iron staining of textural pedofeatures and channel hypocoatings especially. Subsoil of earlier-formed grassland/herbaceous soil, with charring of in situ roots from ‘clearance’ fire, ahead of ditch cleaning and dumping. |
<table>
<thead>
<tr>
<th>MFT D2/SMT 3a, 4a, 4b, 5a, 5b</th>
<th>M8A2</th>
<th>75-150 mm</th>
<th>Strongly heterogeneous mixture of clayey and silty soil/sediments-sediment fragments, which show much relict sedimentary infills, pans, iron-staining and iron-depletion (relict of ditch sediments). Upper 30mm contains abundant coarse anthropogenic material – coal, with clinker/pfa, weathered ash(?) clast and iron-stained flint. Occasional iron-stained root traces and example of broad organo-mineral mamilated excrements are present. <strong>Little weathered (mainly just rooted with rare example of probable earthworm burrow)</strong> dumped ditch cleaning clay and silty clay fragments – showing evidence of ditch silting and gleying.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFT D4/SMT 1c, 1e</td>
<td>M8B1</td>
<td>150-225 mm</td>
<td>Mottled compact massive (underlying coarse prismatic) partially and completed homogenised intercalated silts and clay, some still moderately micritic with traces of Forams(?); rooted with iron staining of roots/root channels. <strong>Bg horizon formed of partially plough-homogenised saltmarsh silts and clay, as found in M5A. Gleying effects evident from mottling.</strong></td>
</tr>
</tbody>
</table>
| MFT A4/SMT 1f | M8B2 | 240-315 mm | SM: homogeneous; *Microstructure*: massive (with partially fragmented and contorted bedding (≤1-2 mm silt and clay laminae)) and coarse prismatic; 30% inter-ped voids (coarse well accommodated planar voids) and 20% intra-ped voids (fine and medium root channels); *Coarse Mineral*: as MFT A2 (M5A1); *Coarse organic and anthropogenic*: many very fine to medium roots/root traces; *Fine Fabric*: SMT 1f: (similar to SMT 1e) dusty and finely speckled brown (PPL), moderately high interference colours (open porphyric [clay laminae] or close porphyric [silt laminae], crystallitic b-fabric, XPL), brown (OIL); many strongly browned detrital organic matter fragments (black under OIL) – horizontally oriented, also tissue and organ fragments (very fine roots); *Pedofeatures*: *Amorphous*: abundant iron impregnation; *Fabric*: very abundant broad to very broad (2-6 mm) burrows.

| bbG2(C) | Massive, slightly contorted laminated silts and clay, cracking into prisms, with calcitic fine fabric containing often horizontally oriented detrital fine organic matter; fine to medium roots also present. *Bg(C) horizon formed in laminated saltmarsh sediments (silt and clay laminae containing detrital fine organic matter), showing in situ fine and medium rooting.*

| MFT D5/SMT 1e | M10 | 120-200 mm 120-135 mm | SM: moderately homogeneous (homogenised silt and clay of SMT 1e) with laminae of organic matter; *Microstructure*: massive, compact, 10% voids, fine and medium root channels; *Coarse Mineral*: as SMT 1e; *Coarse organic and anthropogenic*: abundant charred

| Dump (and spread of Ahg/Bg1) | Massive, moderately organic moderately calcitic silts and clays, with laminae of charred monocotyledonous fragments. In situ roots and very abundant burrows/burrow mixing (intercalations). *Spread of dumped calcitic ditch silts and* |
| MFT C3/SMT 2d, 4a, 5a | fine organic matter fragments including monocotyledonous stems, sometimes in laminae; *in situ* fine and medium roots and root traces; *Fine Fabric*: micritic homogenised SMT 1c; *Pedofeatures*: *Amorphous*: Many weak iron impregnations; *Fabric*: very abundant burrowed intercalations, with abundant 1-3mm broad burrows, some calcitic. 135-140 mm SM: homogeneous – plant fragments (with very few SMT 1c and 1e); *Microstructure*: structureless and semi-laminated; 45% voids, simple packing voids; *Coarse Mineral*: very few scattered silt grains; *Coarse organic and anthropogenic*: very abundant (very dominant) charred (browned, blackened) mainly monocotyledonous stem fragments and leaves and charcoal fragments of this material; rare charred root fragments; *Fine Fabric*: SMT 1c and 1e; *Pedofeatures*: *Amorphous*: many patches of strong iron impregnation. 140-180 mm SM: heterogeneous (silty and clayey SMT 2d, 4a and 5a); *Microstructure*: fine subangular blocky, with fine prisms and channels; 35% voids, poorly accommodated planar voids, chambers and channels (of roots); *Coarse Mineral*: as SMT 2d; *Coarse organic and anthropogenic*: many fine and medium (0.5-3mm) roots, some charred, some browned and others as traces; *Fine Fabric*: as SMT 2d; *Pedofeatures*: *Textural*: very abundant thick clayey pans below L, and forming coarse infills; *Amorphous*: very abundant moderate to strong iron impregnations especially of clayey material; *Fabric*: abundant broad (1-3mm) burrows; *Excrements*: many thin to broad organo-mineral excrements. |

| MFT C4/(with SMT 1c and 1e) | included burned monocotyledonous plants. |

**L (Buried dump/spread of Litter)**
Very abundant charred monocotyledonous stems and leaves with charcoal and some charred root fragments; patchy strong ferruginisation. (Very dominant Cyperaceae pollen)
*Spread of in situ and locally burned wetland vegetation* (Cyperaceae), which has become ferruginised in places.

**bAhg**
Heterogeneous silty clays with ‘surface’ clayey pans and infills and areas of clayey sediment, all moderately burrowed (mixing of charcoal-rich material) and showing blocky and fine prismatic structure formation; strong iron mottling. ‘Surface’ soil formation in Ahg horizon formed of mixed ditch cleaning silty clays and clayey dumps; biological and structural formation and mixing of burned organic matter layer (occurred prior to later dumping and burial of these layers).
SM: moderately homogeneous – homogenised SMT 1c and areas of 1e; Microstructure: massive with patches of relict sedimentary layering, and coarse prisms; 15% voids, fine to medium root channels; Coarse Mineral: as M8A2; Coarse organic and anthropogenic: many medium (1 mm) root residues (iron-stained); example of coarse sand size chalk; Fine Fabric: as M8A2 (bBg1); Pedofeatures: Textural: abundant clayey intercalations (very abundant clayey pans of original sedimentary origin); Amorphous: occasional moderate iron impregnations; Fabric: abundant fabric mixing.

References:

Methods

Background


Appendix 4: Report on particle size, chemistry and magnetic susceptibility of soils from Wallasea Wsland

For: Dr Richard Macphail (British Academy grant)

By: J. Crowther (October 2008)
Archaeological Services, University of Wales, Lampeter, Ceredigion, UK SA48 7ED

INTRODUCTION
Chemical and magnetic susceptibility analysis was undertaken on eight bulk samples from selected soil horizons in three of the test pits sampled at Wallasea Island in July 2008: control arable pit 1 (CA1), flooded grassland pit 3 (FG3) and control grassland pit 4 (CG4). The properties analysed are routinely used in general soil characterisation and/or in investigating possible anthropological signatures in soil and sediment contexts from archaeological sites: loss-on-ignition (LOI, which provides an estimate of organic matter concentration); pH; specific conductance – which provides an indication of salinity; particle size; phosphate – phosphates are present in all organic material (plant tissue, excreta, bone, etc.) and as they are released by decomposition processes tend to form insoluble compounds and become 'fixed' within the mineral fraction of soils and sediments (see reviews by Bethel and Máté, 1989; Crowther, 1997; Heron, 2001); and magnetic susceptibility – enhancement of which is particularly associated with burning (see reviews by Clark, 1996; Scollar et al., 1990).

METHODS
Analysis was undertaken on the fine earth fraction (i.e. < 2.00 mm) of the samples. LOI (loss-on-ignition) was determined by ignition at 375° C for 16 hours (Ball, 1964); pH (1:2.5 water) using a combination electrode; specific conductance (1:10 water) using a conductivity meter, after stirring and leaving overnight; and particle size using the pipette method on < 2.00 mm mineral (peroxide-treated) soil (Avery and Bascomb, 1974). Phosphate-Pi (inorganic phosphate) and phosphate-Po (organic phosphate) were determined using a two-stage adaptation of the procedure developed by Dick and Tabatabai (1977) in which the phosphate concentration of a sample is measured first without oxidation of organic matter (Pi), using 1N HCl as the extractant; and then on the residue following alkaline oxidation with sodium
hypobromite (P<sub>0</sub>), using 1N H<sub>2</sub>SO<sub>4</sub> as the extractant. These were summed to give total phosphate (phosphate-P), and the ratios phosphate-P<sub>T</sub>:P and phosphate-P<sub>0</sub>:P (expressed as percentages) were calculated.

In addition to \( \chi \) (low frequency mass-specific magnetic susceptibility), determinations were made of \( \chi_{\text{max}} \) (maximum potential magnetic susceptibility) by subjecting a sample to optimum conditions for susceptibility enhancement in the laboratory. \( \chi_{\text{conv}} \) (fractional conversion), which is expressed as a percentage, is a measure of the extent to which the potential susceptibility has been achieved in the original sample, viz: \( \left( \chi / \chi_{\text{max}} \right) \times 100.0 \) (Tite, 1972; Scollar et al., 1990). In many respects this is a better indicator of magnetic susceptibility enhancement than raw \( \chi \) data, particularly in cases where soils have widely differing \( \chi_{\text{max}} \) values (Crowther and Barker, 1995; Crowther, 2003) – \( \chi_{\text{max}} \) being strongly dependent upon the iron (Fe) content of the soil. \( \chi_{\text{conv}} \) values of \( \geq 5.00\% \) are often taken as being indicative of some degree of susceptibility enhancement. A Bartington MS2 meter was used for magnetic susceptibility measurements. \( \chi_{\text{max}} \) was achieved by heating samples at 650°C in reducing, followed by oxidising conditions. The method used broadly follows that of Tite and Mullins (1971), except that household flour was mixed with the soils and lids placed on the crucibles to create the reducing environment (after Graham and Scollar, 1976; Crowther and Barker, 1995).

**RESULTS AND DISCUSSION**

The analytical results are presented in Tables 1–3. Here a broad overview of the results for the individual soil properties is presented.

**Loss-on-ignition (LOI)**

The LOI data confirm the field interpretation of the various horizons sampled. The two subsoil (B) horizons sampled in FG3 and CG4 have very low LOI values of 2.91 and 2.21%, respectively. The Apg horizon in CA1 also has low LOI concentrations (ranging from 4.52% at the top to 4.03% at the base), the relatively low organic matter content being presumably attributable to active decomposition in this soil as a result of the site being quite well-drained and subject to regular aeration through cultivation. In marked contrast, the two grassland Ah horizons are much more organic, with CG4 having a particularly high LOI (26.7%). The overlying estuarine deposit in FG3 is quite organic rich (LOI, 6.95%), which almost certainly contributes to the distinct black colour reported in the field.
pH and specific conductance
The specific conductance data follow broadly the pattern that would be anticipated, with the highest value recorded in the estuarine clay of FG3 (8950 µmho), and high values also being recorded in the Ah horizons of the grassland sites. In marked contrast, the Apg horizon in AP1 has very low values (range, 83.0–115 µmho) as a result of salts having been mostly leached from the plough soil. The pH data tend to mirror specific conductance (i.e. higher pH is associated with higher salinity), except that the two Ah horizons have notably lower pH values (7.0 and 7.4), and the estuarine clay is also somewhat lower than would be expected for such a saline deposit. The lower reduced pH values are almost certainly due to the naturally high base content of the soil being neutralised by sulphuric acid generated within these more organic layers (these samples had a distinctly sulphurous odour).

Particle size
The particle size data (Table 2) show the soils from CA1 and FG3 to be silty clays, with a very small proportion of (mostly fine) sand. The two samples analysed from CG4 have a notably higher sand content, which again largely comprises fine sand. These results suggest that the parent material in CG4 was deposited in a somewhat higher energy environment in which more fine sands were being mobilised and deposited.

Magnetic susceptibility (χ, χ_max and χ_conv)
Magnetic susceptibility data for gleyed or partially gleyed soils/sediments are often difficult to interpret because of the likelihood of Fe being mobilised and leached, possibly after χ enhancement has taken place. None of the χ_max values are particularly high (Table 1), indicating that Fe concentrations are on the whole quite low. The highest values (maximum, 1240 x 10⁻⁸ SI) were all recorded in CA1, which suggests that this site has been less affected by gleying and/or is located on a naturally more Fe-rich parent material. The two lowest values were recorded in the estuarine clay (185 x 10⁻⁸ SI) and bAh horizon (321 x 10⁻⁸ SI) of FG3.

The χ values are low and remarkably uniform over the eight samples (range, 13.2–18.6 x 10⁻⁸ SI). Only the two uppermost samples from FG3 have χ_conv values ≥ 5.00% (maximum, 10.1% in bAh), and these are very likely attributable to losses of Fe through leaching rather than enhancement through burning and/or through high levels of natural ‘fermentation’ processes.
Phosphate (phosphate-P, P₀, P, P₁:P and P₀:P)
The phosphate-P (total phosphate) concentrations recorded (Table 3) are all quite low. Notably higher concentrations were recorded in the topsoil horizons (range, 0.668–0.836 mg g⁻¹) and in the estuarine clay of FG3 (0.740 mg g⁻¹), than in the two underlying B horizon samples (range, 0.432–0.493 mg g⁻¹). The higher values recorded in the uppermost horizons and deposits could be attributable, for example, to surface inputs of sediments which are notable more phosphate rich than the underlying strata and/or to preferential uptake and cycling of phosphates by vegetation. As would be anticipated, the highest proportion of organic phosphate (phosphate-P₀:P) occurs in the Ah of CG4 (59.7%) and the lowest in the underlying Bg horizon (18.5%), which have the highest and lowest organic matter concentrations, respectively. Of the remaining samples, consistently higher phosphate-P₀:P values were recorded in CA1 (range 39.4–46.1%) than FG3 samples (range 23.2–37.7%). This pattern, which appears to be largely attributable to the lower phosphate-P₀ concentrations recorded in FG3, is difficult to explain since two of these samples have appreciably higher organic matter concentrations than CA1. [I’ll probably re-run the phosphate analysis at some stage – as these results are puzzling. I’ve not worked on such saline soils before and I wonder if there could be some interference]

Interestingly, the phosphate-P₀:P values as a whole (range, 18.5–59.7%) are much higher than is normally recorded in phosphate-enriched archaeological soils and sediments (typically 10.0–20.0%).

REFERENCES


Table 1: Basic soil characterisation and magnetic susceptibility data

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Depth (cm)</th>
<th>LOI (%)</th>
<th>pH (water)</th>
<th>Spec cond (µmho)</th>
<th>$\chi_{(10^{-8} \text{ SI})}$</th>
<th>$\chi_{\text{max}}_{(10^{-8} \text{ SI})}$</th>
<th>$\chi_{\text{conv}}$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control arable pit 1 (CA1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apg</td>
<td>0–4</td>
<td>4.52</td>
<td>7.6</td>
<td>115</td>
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<td>1190</td>
<td>1.40</td>
</tr>
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<td>4.32</td>
<td>8.0</td>
<td>83.0</td>
<td>18.6</td>
<td>1240</td>
<td>1.50</td>
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<td>8.1</td>
<td>98.0</td>
<td>16.9</td>
<td>1210</td>
<td>1.40</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Est clay</td>
<td>0–5</td>
<td>6.95</td>
<td>8.2</td>
<td>8950</td>
<td>18.4</td>
<td>321</td>
<td>5.73</td>
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<tr>
<td>bAh</td>
<td>5–10</td>
<td>14.2</td>
<td>7.0</td>
<td>4750</td>
<td>18.6</td>
<td>185</td>
<td>10.1</td>
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<td>bBb</td>
<td>20–40</td>
<td>2.91</td>
<td>8.3</td>
<td>1740</td>
<td>13.2</td>
<td>783</td>
<td>1.69</td>
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<td>Control grassland pit 4 (CG4)</td>
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<td></td>
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</tr>
<tr>
<td>Ah</td>
<td>0–5</td>
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<td>7.4</td>
<td>5580</td>
<td>15.0</td>
<td>725</td>
<td>2.07</td>
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<td>Bg?</td>
<td>20–37</td>
<td>2.21</td>
<td>8.5</td>
<td>1610</td>
<td>13.6</td>
<td>776</td>
<td>1.75</td>
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Table 2: Particle size analysis

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Depth (cm)</th>
<th>Coarse sand (600 \mu m - 2.0 \text{ mm}) (%)</th>
<th>Medium sand (200-600 \mu m) (%)</th>
<th>Fine sand (60-200 \mu m) (%)</th>
<th>Silt (2-60 \mu m) (%)</th>
<th>Clay (&lt;2 \mu m) (%)</th>
<th>Texture class</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apg</td>
<td>0–4</td>
<td>0.2</td>
<td>0.2</td>
<td>5.6</td>
<td>48.2</td>
<td>45.8</td>
<td>Silty clay</td>
</tr>
<tr>
<td>FG3</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Est clay</td>
<td>0–5</td>
<td>&lt;0.1</td>
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<td>5.5</td>
<td>56.7</td>
<td>37.7</td>
<td>Silty clay</td>
</tr>
<tr>
<td>bAh</td>
<td>5–10</td>
<td>0.2</td>
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<td>5.9</td>
<td>48.5</td>
<td>44.8</td>
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<tr>
<td>bBb</td>
<td>20–40</td>
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<td>0.9</td>
<td>5.7</td>
<td>51.9</td>
<td>41.2</td>
<td>Silty clay</td>
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<td>CG4</td>
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<td></td>
</tr>
<tr>
<td>Ah</td>
<td>0–5</td>
<td>1.2</td>
<td>1.7</td>
<td>13.5</td>
<td>49.1</td>
<td>34.5</td>
<td>Silty clay</td>
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<tr>
<td>Bg?</td>
<td>20–37</td>
<td>&lt;0.1</td>
<td>0.4</td>
<td>15.6</td>
<td>56.4</td>
<td>27.6</td>
<td>Silty clay loam</td>
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</table>
### Table 3: Phosphate data

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Depth (cm)</th>
<th>Phos-P$_i$ (mg g$^{-1}$)</th>
<th>Phos-P$_o$ (mg g$^{-1}$)</th>
<th>Phos-P (mg g$^{-1}$)</th>
<th>Phos-P$_i$:P (%)</th>
<th>Phos-P$_o$:P (%)</th>
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<tr>
<td><strong>Control arable pit 1 (CA1)</strong></td>
<td></td>
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<tr>
<td>Apg 0–4</td>
<td>0.360</td>
<td>0.308</td>
<td>0.668</td>
<td>53.9</td>
<td>46.1</td>
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<td>Apg 4–20</td>
<td>0.457</td>
<td>0.320</td>
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<td>58.8</td>
<td>41.2</td>
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<tr>
<td>Apg 20–40</td>
<td>0.447</td>
<td>0.291</td>
<td>0.738</td>
<td>60.6</td>
<td>39.4</td>
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<tr>
<td><strong>Flooded grassland pit 3 (FG3)</strong></td>
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<tr>
<td>Est clay 0–5</td>
<td>0.568</td>
<td>0.172</td>
<td>0.740</td>
<td>76.8</td>
<td>23.2</td>
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<td>bAh 5–10</td>
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<td>0.726</td>
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<td>bBg 20–40</td>
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<td>0.493</td>
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<td>31.2</td>
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<td><strong>Control grassland pit 4 (CG4)</strong></td>
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<tr>
<td>Ah 0–5</td>
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<td>59.7</td>
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<tr>
<td>Bg? 20–37</td>
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<td>0.080</td>
<td>0.432</td>
<td>81.5</td>
<td>18.5</td>
<td></td>
</tr>
</tbody>
</table>

Michael J. Allen

Fourteen samples of c. 2kg were taken from the four tespits; all samples were related to the soil stratigraphy as described by Dr Macphail (Appendix 1) and are listed below:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Horizon</th>
<th>Stratigraphy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA1</td>
<td>1</td>
<td>0-4cm Apg</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4-20cm Apg</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>20-40cm Bg1</td>
</tr>
<tr>
<td>CG2</td>
<td>4</td>
<td>0-5cm Ag</td>
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<td></td>
<td>5</td>
<td>30-40cm Bg1</td>
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<td></td>
<td>6</td>
<td>50-58cm Bg2</td>
</tr>
<tr>
<td>FG3</td>
<td>7</td>
<td>0-0.5cm</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>0.5-5cm</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>5-10cm bAh</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>15-25cm bBg</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>30+cm bBg2</td>
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<tr>
<td>CG4</td>
<td>12</td>
<td>0-5cm Ah</td>
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<tr>
<td></td>
<td>13</td>
<td>5-20cm Ahg&amp;Bg1</td>
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<td></td>
<td>14</td>
<td>20-35cm</td>
</tr>
</tbody>
</table>

Samples of 2000g, where possible, were removed and processed following the methodology outlined by Evans (1972). Samples were not air-dried and were weighed moist to wet. Samples were processed without the use of any dissagregant. Samples were of extremely tenacious silts and clays and were processed by continually re-soaking in warm water and gentle stirring. Many were left with large magnetic stirrers for 48 hours. The stone-free nature of the samples is demonstrated by the absence of stones (Table 2). Most flots were very to extremely rooty making microscopic sorting slow and time consuming. The results are presented in table 1, where nomenclature follows Anderson (2005). The sample locations in relation to the soil profiles are given in Appendix 1.

**Results**

Very few shells were present. Even were shells were observed in the field (FG3) few were present in the samples, and all shells were highly fragmentary excepting the two species of *Peringia ulvea* (formerly *Hydrobia ulvae*). The fragmentary marine shells were mainly *Scobicularia plana* observed in the field on the algal surface and in section at FG3.

The lack of shells, even in terrestrial environments, was a feature of all the sampled horizons. In the coastal acid-sulphate alluvial gley soils pH may be as low as pH 3.5 (Avery 1990, 325) resulting in lack of survival of any shells. Elsewhere (eg, CA1) pelo-alluvial gley soils of the Wallasea series are vertisols and shrink and swell significantly (Avery 1990, 307), and despite liming with chalk since reclamation (Murphy pers. comm.), shell survival is negligible. Molluscs were noticed during the sampling; *Cernuella virgata*, *Cochlicella actua*, *Limax cf. maximus*, *Arion cf. ater ater*.

In flooded grassland the present alluvial deposit (FG3 0-5cm) is base rich (pH 8.2), and although 4 valves of *Scrobicultria plana* were present in the field in this almost
thixotrophic deposit, only very small fragments were recovered in the processed samples (see Table 1 vs Appendix 1). Lack of shell survival may be due to higher sulphates resulting from oxidation of sulphides, and particularly strong sulphide small was noted during the mollusc processing of the upper and organic samples from FG3.

Lack of shells in intertidal saltmarsh soils is common and has been recorded on the south coast at Langstone Harbour (Allen in Allen & Gardiner 2000), Brean Down intertidal buried deposits (Allen & Ritchie 2000), the Severn Levels (Allen & Scaife 1998; Gardiner et al. 2002), Goldcliff, South Wales (Bell et al. 2000), and more locally in South Essex (Murphy pers. comm.; Wilkinson & Murphy 1995). Although terrestrial and semi-terrestrial assemblages seem to be rarely preserved (despite recorded living fauna), caches of, in particular, intertidal assemblages are sometimes present in the base of former rhines/creeks, or in strand lines or accumulations in small pools left by flooding. Indeed locally the preservation of shells in the local environs in the Essex coastline is highly variable (Murphy pers. comm.; Wilkinson & Murphy 1995).

Future work
It is clear that molluscan remains may not be one of the better proxy subfossils with which to study the changing burial environments – however where they do occur they are likely to be present in high numbers and could be studies. Some mileage may be gained from more detailed magnetic susceptibility profile signature (see Crowther data); ie, sampling at close intervals to create a profile signature.

References
<table>
<thead>
<tr>
<th>Soil Pit Horizon</th>
<th>CA1</th>
<th>CA2</th>
<th>FG3</th>
<th>CR4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ApG</td>
<td>ApG</td>
<td>bAh</td>
<td>bAh</td>
</tr>
<tr>
<td>M ARINE MOLLUSCA</td>
<td>Cardium/Pecten (Cockle/Scallop)</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Scrobicularia plana (Peppery Furrow Shell)</td>
<td>1 (w)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BRACKISH WATER MOLLUSCA</td>
<td>Peringia ulvae (Pennant) Hydrobia ulvae</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TERRESTRIAL MOLLUSCA</td>
<td>Cepaea spp</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>OTHER REMAINS</td>
<td>Unidentified shell frag A</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Unidentified shell frag B</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Charred seed (?Legume)</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1</td>
<td>0</td>
<td>+</td>
<td>0</td>
</tr>
</tbody>
</table>

w = very weathered

Table 1. Molluscan remains from the Wallasea tespits (July 2008)
<table>
<thead>
<tr>
<th>Sample</th>
<th>Depth</th>
<th>Horizon</th>
<th>Total wt</th>
<th>5.6mm</th>
<th>2mm</th>
<th>1mm</th>
<th>&gt;0.5mm</th>
<th>&lt;0.5mm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control Arable pit 1 (CA1)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0-4cm</td>
<td>Apg</td>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2000</td>
</tr>
<tr>
<td>2</td>
<td>10-25cm</td>
<td>Apg</td>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2000</td>
</tr>
<tr>
<td>3</td>
<td>40+cm</td>
<td>Bgl</td>
<td>1600</td>
<td>6</td>
<td>1</td>
<td>0.5</td>
<td>0</td>
<td>1992.5</td>
</tr>
<tr>
<td><strong>Control grassland pit 2 (CG2)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0-5cm</td>
<td>Ag</td>
<td>2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>20-40cm</td>
<td>Bgl</td>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
<td>1999.5</td>
</tr>
<tr>
<td>6</td>
<td>50-58cm</td>
<td>Bg2</td>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2000</td>
</tr>
<tr>
<td><strong>Flooded Grassland pit 3 (FG3)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0-0.5cm</td>
<td></td>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2000</td>
</tr>
<tr>
<td>8</td>
<td>0.5-5cm</td>
<td></td>
<td>2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>5-10cm</td>
<td>bAg</td>
<td>2000</td>
<td>0</td>
<td>1.5</td>
<td>0</td>
<td>0</td>
<td>1998.5</td>
</tr>
<tr>
<td>10</td>
<td>15-25cm</td>
<td>bBgl</td>
<td>2000</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1998</td>
</tr>
<tr>
<td>11</td>
<td>30+cm</td>
<td>bBg2</td>
<td>2000</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1999.5</td>
</tr>
<tr>
<td><strong>Control Grassland Pit 4 (CG4)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>0-5cm</td>
<td>Ah</td>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
<td>1999.5</td>
</tr>
<tr>
<td>13</td>
<td>5-20cm</td>
<td>Ahg&amp;Bgl</td>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
<td>1999.5</td>
</tr>
<tr>
<td>14</td>
<td>20-35cm</td>
<td></td>
<td>2000</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
<td>1999.5</td>
</tr>
</tbody>
</table>

Table 2. Particle size weights of processed samples. Weights were estimated to ±0.5g.
Appendix 5 - Wallasea Island 2008: palynology (also with brief comments on observed microfossils)

G.M. Cruise

Introduction
The present-day environment of Wallasea Island is mainly intensive arable agriculture (wheat and oil-seed rape at the time of visiting) with narrow coastal areas of salt-marsh. Many drainage ditches bordered by grassy corridors cross the arable areas. No hedgerows or trees were observed on the island. Field visits and samples taken on 8th and 15th July 2008 in advance of the initial breaching of sea-walls (scheduled to begin in 2009) and the beginning of the development of new coastal environments across the whole island. Cores for pollen analyses were taken from the four sample locations alongside those for soil micromorphology, soil chemistry and molluscan studies. The cores were subsampled for pollen analysis, samples being selected from parts of the cores where pollen was most likely to have been preserved (see Table 3).

Table 1.

<table>
<thead>
<tr>
<th>Test Pit</th>
<th>Pollen core</th>
<th>Depths (below surface in cm)</th>
<th>Pollen subsample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Arable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA1</td>
<td>P1a, P1b</td>
<td>0-15</td>
<td>P1(a) - 1 cm, 3 cm</td>
</tr>
<tr>
<td></td>
<td>P2a, P2b</td>
<td>16-32</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Grassland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CG2</td>
<td>P3a, P3b</td>
<td>2-17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P4a, P4b</td>
<td>17-33</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-16</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>16-32</td>
<td></td>
</tr>
<tr>
<td>Flooded Grassland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FG3</td>
<td>P5a, P5b</td>
<td>1-14</td>
<td>P6 – 1.5 cm, 3 cm, 5 cm, 7 cm</td>
</tr>
<tr>
<td></td>
<td>P6</td>
<td>14-54</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-14</td>
<td></td>
</tr>
<tr>
<td>Control Grassland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CG4</td>
<td>P7a, P7b</td>
<td>0-8</td>
<td>P7(a) – 1 cm</td>
</tr>
<tr>
<td></td>
<td>P8a, P8b</td>
<td>8-16</td>
<td></td>
</tr>
<tr>
<td>also M10</td>
<td></td>
<td>0-8</td>
<td>M10 – 1.5 cm on tin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.5-16.5</td>
<td>See micromorphology</td>
</tr>
</tbody>
</table>

Methods
In order to seek an indication of the presence of microfossils, a small quantity of each subsample was, prior to chemical preparations, first placed on a glass slide under a cover slip, and examined under a microscope. The remainder of the subsamples were then sent to University of Wales Lampeter, where the chemical preparation methods and methods for determining pollen concentrations were carried out as described in the published literature (Moore et al., 1991; Stockmarr, 1971). A minimum of 200 pollen grains and spores were counted from each sample. Pollen preservation characteristics were also recorded following Delcourt and Delcourt (1980).
Results

Water observations

The observations made are listed in Table 2. The very high frequency of diatoms in the uppermost layers of the flooded grassland/estuarine mud (Pit 3) is particularly noteworthy, as they appear to both very, very abundant and extremely well-preserved. Their frequency appear to diminish markedly down profile. The control grassland (CG4) and its buried soil appear to contain some microfossils, although fewer than the flooded grassland. Only very few phytoliths were observed in the control arable soil (CA1).

Table 2.

<table>
<thead>
<tr>
<th>Pit</th>
<th>Sample</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Arable</td>
<td>CA1</td>
<td>Rare possible phytoliths</td>
</tr>
<tr>
<td>CA1</td>
<td>P1a 1 cm</td>
<td>Rare possible phytoliths</td>
</tr>
<tr>
<td>CA1</td>
<td>P1a 3 cm</td>
<td>Rare possible phytoliths</td>
</tr>
<tr>
<td>Control Grassland</td>
<td>CG4</td>
<td>Very organic with phytoliths, diatoms, fungal spores and occasional pollen</td>
</tr>
<tr>
<td>Buried soil</td>
<td>M10</td>
<td>Fungal spores, diatoms with occasional pollen and phytoliths</td>
</tr>
<tr>
<td>Flooded Grassland</td>
<td>FG3</td>
<td>Very, very abundant, well-preserved diatoms. Phytoliths and pollen present. Much algal/fungal and other organic material</td>
</tr>
<tr>
<td>FG3</td>
<td>P6 1.5 cm</td>
<td>Similar to above. Diatom assemblage possibly differing from above</td>
</tr>
<tr>
<td>FG3</td>
<td>P6 3 cm</td>
<td>Similar to above. Diatom assemblage possibly differing from above</td>
</tr>
<tr>
<td>FG3</td>
<td>P6 5 cm</td>
<td>Occasional phytoliths: fungal spores</td>
</tr>
<tr>
<td>FG3</td>
<td>P6 7 cm</td>
<td>As for P6 5 cm</td>
</tr>
</tbody>
</table>

Pollen analyses

Pollen percentages, pollen concentrations and pollen preservation characteristics are listed in Table 3. All samples were found to contain countable pollen, although pollen preservation is often extremely variable, even within the same sample. The main results are as follows:

Control Arable CG1. These samples are dominated by high frequencies of Sinapis t. and Chenopodiaceae. Preservation here, however, is extremely variable. 95% of the Chenopodiaceae grains were recorded as being degraded, many being in very poor condition. In contrast 57% of the Sinapis t. grains were recorded as being normal or very well preserved. Many of these were found in clumps of 4-24 grains. Cereal type pollen was also generally well preserved.

Control Grassland CG4. The uppermost sample from this profile (1 cm) contains well preserved pollen whose frequencies are dominated by Veronica t. (32%). Grass (Poaceae) is only 13% of the count. The buried soil from this test pit, was found to be dominated by Cyperaceae (88%) of the count. This last sample contained the highest pollen concentrations of all the samples examined.

Flooded Grassland FG3. The uppermost sample of the flooded grassland profile (1.5 cm) was found to contain the highest frequency of tree pollen types of all the samples examined (36% of the count). The sample below (3 cm) provided the highest grass (Poaceae) frequencies (65% of the count). Grass and herbaceous types are well represented in the lower samples (5cm and 7cm).
**Interpretation**

The recovery of countable pollen from the highly minerogenic and compacted arable soil is very surprising. The source of most of the recorded Cruciferae pollen (*Sinapis t.*) is almost certainly the extensive crop of oil-seed rape (*Brassica napus*) in neighboring fields, that had flowered shortly before sampling. The overall good preservation and the clumps of this type of pollen type are certainly indicative of a local source. Another influence may be the wet summers of 2007 and 2008 that could have been more conducive to better overall pollen preservation than would normally be the case.

The results from the control grassland also provided some surprising results, particularly the lower than expected grass pollen frequencies and more frequent than usual *Veronica t.*. *Veronica t.* includes a large group of herbaceous plants that are mainly insect-pollinated and although this pollen type is common, especially in connection with grassland environments, it rarely occurs in such large numbers as found here. The most likely explanation is that insect activity within the grass litter would have concentrated this pollen type within the layer. The high percentage of Cyperaceae in the buried soil along with a single record of *Nymphaea* (water lily) is consistent with a higher water-table than that of the over-lying grassy soil.

High grass frequencies as well as other herbaceous types in the flooded grassland profile (FG3) are indicative of grassland, both before flooding and, its position next to a grassy bank, immediately after flooding. Higher arboreal percentages (36%) recorded in the newly formed estuarine mud overlying the flooded grassland soil, is interesting. As no trees or hedgerows exist on Wallasea Island, the increase in tree pollen cannot be linked to an increase in trees locally. It is much more likely that the increase in marine influence has resulted in a change in pollen transportation and sources as well as a change in sedimentation. Thus the pollen catchment area would have increased from a rather small local area as found for the control arable and grassland samples to one of regional or even extra-regional scale. Such a change in scale would be consistent with models of relative pollen representation and basin size (e.g. Jacobson and Bradshaw, 1981; Prentice, 1985). It is also consistent with the results reported from palynological studies of Holocene intertidal sediments along the Essex coast (Wilkinson and Murphy, 1995).

**Potential for future work**

Observations of diatoms in water suggest that a specialist study of these would be usefully undertaken.

The palynological results are consistent with the variations that would be expected from differing sedimentary conditions and associated pollen source areas and transportation found in terrestrial and coastal areas. There appears therefore, to be good potential for palynology to contribute to multidisciplinary studies of changing sedimentary environments in association with the planned marine inundation at Wallasea Island.

**References**


Table 1. Wallasea Island 2008: pollen analyses

<table>
<thead>
<tr>
<th>Sample</th>
<th>CA P1a</th>
<th>CA P1a</th>
<th>CG4 P7a</th>
<th>CG4 M10</th>
<th>FG P6</th>
<th>FG P6</th>
<th>FG P6</th>
<th>FG P6</th>
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</thead>
<tbody>
<tr>
<td>Depth (cm)</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1.5</td>
<td>1.5</td>
<td>3</td>
<td>5</td>
<td>7</td>
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<tr>
<td><strong>Taxa</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trees &amp; shrubs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alnus</td>
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<td>2</td>
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<td>0.5</td>
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<td>4</td>
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</tr>
<tr>
<td>Carpinus</td>
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<td></td>
<td></td>
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<td>Fagus</td>
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<td>3</td>
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<td></td>
<td></td>
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</tr>
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<td>Picea</td>
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<td>1</td>
<td>1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Pinus</td>
<td>4</td>
<td>3</td>
<td>10</td>
<td>2</td>
<td>13</td>
<td>3</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Quercus robur t.</td>
<td>0.5</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Salix</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tilia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Corylus t.</td>
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<td>0.5</td>
<td>4</td>
<td>2</td>
<td>0.5</td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total trees &amp; shrubs</td>
<td>6</td>
<td>6</td>
<td>14</td>
<td>2</td>
<td>36</td>
<td>10</td>
<td>17</td>
<td>18</td>
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<tr>
<td>Herb. &amp; dwarf shrubs</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ericaceae undiff.</td>
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<td></td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereal t.</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Poaceae</td>
<td>5</td>
<td>6</td>
<td>13</td>
<td>3</td>
<td>25</td>
<td>65</td>
<td>43</td>
<td>44</td>
</tr>
<tr>
<td>Achillea t.</td>
<td>0.5</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apiaceae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
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Appendix 7: Wallasea Island, 2008: report on the Foraminifera and Ostracods from eighteen soil/sediment samples

by John E. Whittaker

MATERIALS AND METHODS

Samples analysed and weight processed

Samples via M.J. Allen (AEA Warminster)

Control Arable Pit 1 (CA1)  
0-4cm  65g
4-20cm  60g
20-40cm  30g

Control Grassland Pit 2 (CG2)  
0-5cm  40g
30-40cm  40g
50-58cm  60g

Flooded Grassland Pit 3 (FG3)  
0-0.5cm  30g
0.5-5cm  65g
5-10cm  65g
15-25cm  150g
30cm+  60g

Control Grassland Pit 4 (CG4)  
0-5cm  20g
5-20cm  20g
20-35cm  60g

Samples via J. Crowther (UW, Lampeter)

Flooded Grassland Pit 3 (FG3)  
0-5cm  75g
20-40cm  150g

Control Grassland Pit 4 (CG4)  
0-5cm  75g
20-37cm+  75g

Methods

After weighing, each sample was put in a ceramic bowl. The sediment was first broken by hand into very small pieces and thoroughly dried in the oven. Boiling water was then poured on the sample and a little sodium carbonate added to help remove the clay fraction on washing. It was then left to soak overnight. After this soaking the samples usually broke down well when washed with hot water through a 75 micron sieve and the resulting residue was finally decanted back into the bowl for drying in the oven. When dry the sample was stored in a labelled plastic bag. Examination of the residue was undertaken under a binocular microscope. First the residue was put through a nest of dry sieves (>500, >250 and >150 microns) and then sprinkled out a fraction and a little at a time onto a tray. Some foraminifera, ostracods and other organic remains of interest were picked out with a fine camel-haired brush and placed in a 3”x1” faunal slide for archive purposes, although comprehensive picking was not undertaken at this stage of the project. The purpose was rather, mainly just to record the species present and give some semi-quantitative measure of their abundance (present, common, or abundant/superabundant) by eye. Several tables were constructed for each site: the uppermost table giving an indication of the organic remains on a presence (x) or absence basis only and below, semi-quantitative representations of the foraminifera and ostracods present, species by species, on which the environmental interpretations can been made. Some indication of quality of
preservation was also noted. All this information is shown in Figures 1-3, attached to this report.

RESULTS
The results of the samples provided via M.J. Allen are shown in Figure 1 (for CA1 and CG2) and 2 (for FG3 and CG4). Those based on the samples provided by J. Crowther are shown separately (for FG3 and CG4) in Figure 3.

Ecological data on Wallasea Island foraminiferal species (after Murray, 2006)

*Haynesina germanica:* infaunal, widespread in marginal marine environments all along the European seaboard; low marsh and intertidal in estuaries; herbivore on diatoms and cyanobacteria; common in sediments with highly variable mud and total organic carbon contents; salinity 0-35‰; one of the first to colonise “new” estuarine habitats.

*Elphidium williamsoni:* infaunal, herbivore, widespread in marginal marine environments all along the European seaboard; low marsh, intertidal and subtidal (to 5m) in estuaries; common in sediments with highly variable mud and total organic carbon contents.

*Elphidium excavatum:* infaunal; common in sediments with highly variable mud and total organic carbon contents; salinity 15-31‰; intertidal/subtidal in estuaries.

*Ammonia spp.:* infaunal, herbivore, widespread in marginal marine environments; common in sediments with highly variable mud and total organic carbon contents; salinity 10-31‰; marsh and intertidal/subtidal in estuaries; able to tolerate very low oxygen for periods.

*Trochammina inflata:* epifaunal and infaunal down to 60cm; herbivore or detrivore (including bacteria); widespread on mid to high saltmarsh.

*Jadammina macrescens:* epifaunal (sometimes on decaying leaves, and plant material), and infaunal down to 60cm; herbivore and detrivore; widespread on mid to high saltmarsh.

REFERENCE

<table>
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<tr>
<th>John E. Whittaker, “Herbury”, 6A, Ramblers Way, BURNHAM-ON-CROUCH, Essex CM0 8LR</th>
<th>and</th>
<th>Department of Palaeontology, The Natural History Museum, Cromwell Road, LONDON SW7 5BD.</th>
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JEWhittaker06@aol.com; j.whittaker@nhm.ac.uk; October 15th 2008

56
Agreed interpretation of results from the assessment of foraminifera and ostracods

Within sea wall: Current (Control) Arable (CA1) and Grassland (CG2) – both at 1.01-1.25 m ODN

Both agglutinating foraminifera of mid-high saltmarsh calcareous and foraminifera of low-mid saltmarsh and tidal flats present, usually in low numbers. Surface soils (0-4cm and 0-5cm, respectively) have only several poorly preserved specimens present (effects of weathering, biological working, past and present ploughing and use of heavy machinery)

CA1 – generally good preservation of Foraminifera in subsoils, with increased abundance and variety at 20-40 cm (reflecting preservation of intact ‘salt marsh’ sediments, little affected by modern agriculture and pedogenesis)

CG2 – only several poorly preserved specimens present throughout soil profile (perhaps more affected by agricultural disturbance and exposure).

The Foraminifera in these soil profiles (to be flooded in 2010) thus reflect surface weathering in agricultural soils since the 1950’s, and show the possibility of Foraminifera to preserve well in sediments at quite shallow depth in these weakly alkaline silty clay soils.

When these sites are flooded in 2010 there is the potential of being able to differentiate Foraminifera (with likely very good preservation – see FG3) in newly formed mudflat sediments, from the poorly preserved Foraminifera in surface buried soils – a useful analogue for investigating past inundation events, and identifying marker horizons.

Within sea wall: Control Grassland (CG4 – at 0.51-0.75m ODN by borrow ditch)

0-5cm – Foraminifera showing good preservation (perhaps this current fauna is associated with current moist soil saline [5580 µmho specific conductance] and humic [26.7% LOI] conditions, and associated large amounts of herbaceous plant litter that is accumulating here, *Haynesina germanica* and common *Jadammina macrescens* respectively; preservation only good because of surface soil formation processes and neutral pH)

5-20cm and 20-35cm – Poor/good preservation of wider Foraminifera spectra associated with moderate weathering of relict ‘saltmarsh’ sediments, which are still laminated at depth.

The Foraminifera here at 0-5cm are composed of new faunas associated with environmental conditions at this low lying wet and salty grassland site, where herbaceous litter is accumulating. This example has the potential of providing data on the first impacts of sea level rise, where soils become affected by rising saline groundwater (and developing high saltmarsh environment), but are not as yet in the intertidal zone and not affected by marine sedimentation.

Flooded 2006: Flooded Grassland (FG3) - 0.76-1.00m ODN

0-0.5cm (uppermost mudflat sediment) – abundant/super abundant *Ammonia* spp and *Haynesina germanica* showing very good preservation (consistent with weakly
alkaline/calcitic nature of the mudflat sediments, that are saline and muddy and which contain detrital organic matter

0.5-5cm (junction of mudflat sediment and grassland litter layer) - abundant/super abundant *Ammonia* spp and *Jadammina macrescens* and common *Haynesina germanica*, all showing good preservation (consistent with mudflat sediment deposition and inwash around grass stems and litter layer [*Ammonia* spp and *Haynesina germanica*], while the presence of *Jadammina macrescens* may in part be relict of this wet grassland – plant stems and litter – see CG4 0-5cm).

5-10cm, 15-25cm, 30+cm – Foraminifera of low-mid saltmarsh and tidal flats and mid-high saltmarsh showing poor/good preservation (reflecting presence of well preserved ‘saltmarsh’ sediments)

The Foraminifera are apparently showing a spectra consistent with the broad sediment-buried topsoil sequence (mudflat deposits over developing ‘high salt marsh’ prior to flooding), and have the potential to show in detail the state of preservation and species associated with the different buried soil and sediment types (mudflat sediments show three laminae types associated with original material and how it is weathering).

Overall, new studies should include 1) a replicate of CG4 and 2) a new study of a deeper mudflat sequence from the flooded arable area, to monitor sediment-Foraminifera correlations at a higher resolution, and to examine the junction of the mudflat sediment and buried arable topsoil (see CA1, above).
**FIG 1: WALLASEA ISLAND (Mollusca samples)**

**CONTROL ARABLE PIT 1 (CA1)**

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<th>ORGANIC REMAINS</th>
<th>Sample depth</th>
<th>0-4cm</th>
<th>4-20cm</th>
<th>20-40cm</th>
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<td>x</td>
<td>x</td>
<td>x</td>
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<td>insects</td>
<td>x</td>
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<tr>
<td>foraminifera</td>
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<td>molluscs</td>
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**FORAMINIFERA**

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<tr>
<td><strong>Jadammina macrescens</strong></td>
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**FORAMINIFERA**

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**preservation**

|  | p | g | g |

Organic remains are recorded on a presence (x)/absence basis only.
Foraminifera are recorded: x - several specimens; xx - common; xxx - abundant/superabundant.

Foraminiferal preservation: p - poor, mainly damaged (last chamber(s) missing); g - good.
FIG 2: WALLASEA ISLAND, 2008 (Mollusca samples)

FLOODED GRASSLAND PIT (FG3)  
ORGANIC REMAINS

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FORAMINIFERA

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<td>xx</td>
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<tr>
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<tr>
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<td>xxx</td>
<td>xxx</td>
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<td>x</td>
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<tr>
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preservation | vg | g | p/g | p/g | p/g |

OSTRACODS

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CONTROL GRASSLAND PIT 4 (CG4)  
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FORAMINIFERA

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preservation | g | p/g | p/g |

OSTRACODS

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<th>5-20cm</th>
<th>20-35cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loxoconcha elliptica</td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

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

Foraminifera and ostracods are recorded: x - several specimens; xx - common; xxx - abundant/superabundant

Foraminiferal preservation: p - poor, mainly damaged (last chamber(s) missing); p/g - poor to good; g - good; vg - very good (retaining natural colour)

**agglutinating foraminifera of mid-high saltmarsh**
**calcareous foraminifera of low-mid saltmarsh and tidal flats**
**brackish ostracods of creeks and tidal flats**
FIG 3: WALLASEA ISLAND, 2008 (Bulk samples)

FLOODED GRASSLAND PIT (FG3)

<table>
<thead>
<tr>
<th>Sample depth</th>
<th>0-5cm</th>
<th>20-40cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>plant debris + seeds</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>insects</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>molluscs</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>foraminifera</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>ostracods</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

ORGANIC REMAINS

FORAMINIFERA

<table>
<thead>
<tr>
<th>Sample depth</th>
<th>0-5cm</th>
<th>20-40cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haynesina germanica</td>
<td>xxx</td>
<td>xxx</td>
</tr>
<tr>
<td>Ammonia spp.</td>
<td>xxx</td>
<td>xx</td>
</tr>
<tr>
<td>Jadammina macrescens</td>
<td>xx</td>
<td></td>
</tr>
<tr>
<td>Elphidium williamsoni</td>
<td>x</td>
<td>xx</td>
</tr>
<tr>
<td>Quinqueloculina sp.</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

FORAMINIFERAL preservation: p - poor, mainly damaged (last chamber(s) missing); p/g - poor to good; vg - very good (retaining natural colour)

OSTRACODS

<table>
<thead>
<tr>
<th>Sample depth</th>
<th>0-5cm</th>
<th>20-40cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyprideis torosa</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

FORAMINIFERA

<table>
<thead>
<tr>
<th>Sample depth</th>
<th>0-5cm</th>
<th>20-37cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trochammina inflata</td>
<td>xx</td>
<td></td>
</tr>
<tr>
<td>Jadammina macrescens</td>
<td>xx</td>
<td></td>
</tr>
<tr>
<td>Haynesina germanica</td>
<td>xxx</td>
<td></td>
</tr>
<tr>
<td>Elphidium williamsoni</td>
<td>xx</td>
<td></td>
</tr>
<tr>
<td>Ammonia sp.</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

FORAMINIFERAL preservation: p - poor, mainly damaged (last chamber(s) missing); p/g - poor to good; vg - very good (retaining natural colour)

OSTRACODS

<table>
<thead>
<tr>
<th>Sample depth</th>
<th>0-5cm</th>
<th>20-37cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leptocythere castanea</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Leptocythere lacertosa</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

CONTROL GRASSLAND PIT 4 (CG4)

ORGANIC REMAINS

<table>
<thead>
<tr>
<th>Sample depth</th>
<th>0-5cm</th>
<th>20-37cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>plant debris + seeds</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>insects</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>foraminifera</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>ostracods</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

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Foraminifera and ostracods are recorded: x - several specimens; xx - common; xxx - abundant/superabundant

Foraminiferal preservation: p - poor, mainly damaged (last chamber(s) missing); p/g - poor to good; vg - very good (retaining natural colour)

Agglutinating foraminifera of mid-high saltmarsh
Calcareous foraminifera of low-mid saltmarsh and tidal flats
Brackish ostracods of creeks and tidal flats

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