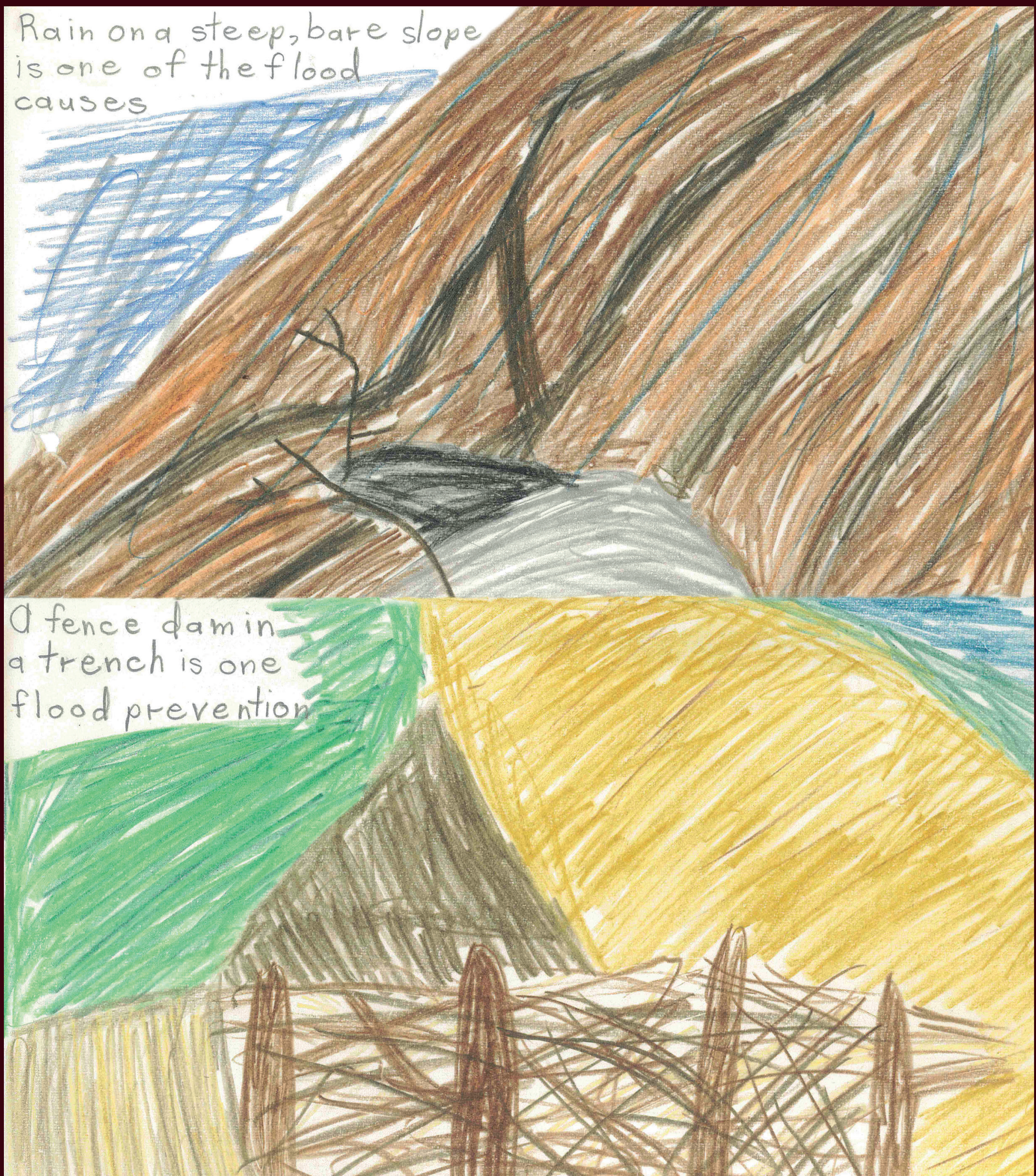
McDONALD INSTITUTE CONVERSATIONS

Inspired geoarchaeologies: past landscapes and social change

Essays in honour of Professor Charles A. I. French

Edited by Federica Sulas, Helen Lewis & Manuel Arroyo-Kalin



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with contributions from
Michael J. Allen, Andrea L. Balbo, Martin Bell, Nicole Boivin, Christopher Evans, David Friesem, Kasia Gdaniec, Lars Erik Gjerpe, Michael Gill, Martin Green, Ann-Maria Hart, Robyn Inglis, Martin Jones, Gabriella Kovács, Helen Lewis, Johan Linderholm, Roy Loveday, Richard I. Macphail, Caroline Malone, Wendy Matthews, Cristiano Nicosia, Bongumenzi Nxumalo, Innocent Pikirayi, Tonko Rajkovaca, Rob Scaife, Simon Stoddart, Fraser Stuart, Federica Sulas & Magdolna Vicze

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On the cover: *Hand drawn illustration by Charly French, aged around 10 years old. Courtesy of Kasia Gdaniec.*

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Martin began a fieldwalking survey as a lad on Cranborne Chase in the latter 1960s. Following experience gained on a number of field projects, he began excavating independently in the region in 1976. He joined Richard Bradley's and John Barrett's Cranborne Chase Project the following year, contributing four site excavations to *Landscape, Monuments and Society* in 1991. He continued independent fieldwork in the early 1990s in collaboration with Mike Allen, in particular on the Fir Tree Field shaft which revealed a remarkable sequence of deposits dating from the late Mesolithic to the Beaker period, and worked with Charly French on the Upper Allen Valley Project 1998–2003, contributing four further site excavations to *Prehistoric Landscape Development and Human Impact in the Upper Allen Valley, Cranborne Chase, Dorset* (2007). Since that time, he has continued independent research, also in collaboration with Josh Pollard and Southampton University, on the Dorset Cursus, on Down Farm and in the Knowlton environs whilst continuing to increase the biodiversity on his small farm. He was made an FSA (Fellow of the Society of Antiquaries) in 2004 and received an honorary Doctor of Science degree from Reading University in 2006.

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Richard trained in geology and geography, specializing in soil science (BSc Swansea University). An MSc in pedology and soil survey (Reading University) prepared him for a soil science PhD on podzol development on heathlands (Kingston Polytechnic). An English Heritage-funded archaeological soil contract at the Institute of Archaeology (University College London) provided further training and international research opportunities were developed, including working with the Soil Survey of England and Wales and Macaulay Institute, UK, the CNRS, France, and the Soprintendenza, Italy. This led to the publication of *Soils and Micromorphology in Archaeology* (with Courty and Goldberg; Cambridge University Press 1989), the founding of the International Archaeological Soil Micromorphology Working Group, and training weeks at UCL. As a result, *Practical and Theoretical Geoarchaeology* (Blackwell 2006; Wiley 2022) and *Applied Soils and Micromorphology in Archaeology* (Cambridge University Press 2018), both with Goldberg, were written. Macphail is a recipient of the Geological Society of America's Rip Rapp Award for Archaeological Geology (2009), and is a fellow of the Geological Society of America. He is also the 2021 co-awardee (with P. Goldberg) of the International Union of Soil Sciences Tenth Kubiëna Medal for Soil Micromorphology. The paper included here also reflects more than two decades of research across Scandinavia.

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Francis has studied the archaeology of the Fens since 1971. His major excavations in the region took place near Peterborough at Fengate, Maxey and Etton. In 1982 his team's survey of fenland drainage dykes revealed the timbers of a waterlogged Bronze Age timber platform and causeway at Flag Fen, which was opened to the public in 1989. He was a member of Channel 4's long-running series *Time Team*. He has written many popular books including *Seahenge* (2001), *Britain BC* (2003), *Britain AD* (2004), *The Making of the British Landscape* (2010), *Home* (2014), *Stonehenge* (2016) and *The Fens* (2019). His most recent book is *Scenes from Prehistoric Life* (Head of Zeus 2021).

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Figures

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Chapter 5

Challenges of geoarchaeology in wetland environments

Cristiano Nicosia

Wetland environments are extremely important in terms of heritage and ecology. Even today they play a crucial role in carbon sequestration dynamics, influencing current environmental trends. But wetlands are also very fragile entities, endangered by exploitation, mismanagement, drainage, and agricultural practices. These risks can also strongly affect the precious archaeological record that wetlands hold, an archaeological record that, by virtue of the wet or waterlogged conditions in which it formed, has a unique degree of preservation. Geoarchaeology faces several challenges when addressing the stratigraphic sequences of wetlands. These challenges, nevertheless, are rewarded with the possibility of extracting from wetland sediments a vast amount of data about the lives of past individuals and about the environment in which they lived. This contribution reviews a series of examples from archaeological contexts in northern Italy to stimulate discussion on the challenges, issues, and many open research perspectives in the geoarchaeology of wetlands. The variety of geomorphic settings in which wetland sediments of relevance to archaeology occur are briefly discussed. Attention is then paid to the sediments forming in such settings. In particular, the peculiar anthropic sedimentary facies resulting from human activities in wetland contexts will be addressed. To conclude, the chapter highlights the many future lines of research for the archaeology and ecology of these unique environments.

Anyone acquainted with archaeology in wetland environments, especially with excavation of wetland sites, can immediately visualize the challenges that such settings entail (see Murphy & French 1988; French 2003, especially 59–72; 2017). Muck, water pumps, Tolkienesque fog in the winter and sub-tropical heat in the summer, along with the iconic plastic boot stuck forever in the mud (unless a willing King Arthur comes to its rescue). But with any challenge up to this name, also great opportunities come along. In wetland archaeology, in fact, we face the fact that almost *everything* is preserved: wood, textiles, seeds, fruits, insect remains, mushrooms, coprolites, sometimes whole human bodies. And this unique level of preservation imposes on archaeologists excavating wetland sites a peculiar form of strain. They, in fact, confront themselves with the necessity to record, extract, preserve and consolidate the plethora of eco- and artefacts that emerge, sometimes at an extremely fast pace, from the ground. These finds can give an otherwise unattainable degree of detail when used to reconstruct the lives of past individuals and past environments. However, they are at the same time very fragile.

This contribution aims to describe some of the challenges that geoarchaeologists face when working in wetland contexts and, specifically, when working with 'wetland sediments'. This is a definition employed in this chapter simply for lack of a better way to address 'the sediments occurring in wetlands'. It will be clear further in the text that, in fact, almost *any* sediment type is found in wetlands, although organic sediments constitute an important specificity of such contexts. Wetland sediments can be encountered during excavations, therefore, as intra-site sediments that encase anthropic structures and materials. They make up the matrix of the deposits that formed when past individuals inhabited an area, those very deposits that archaeologist excavate in order to distil an historical or environmental narrative. In these 'anthropic horizons', wetland sediments become intimately commixed with materials resulting from human activities at a site, such as ash, bone, pottery, excrements, charcoal, etc. They constitute a peculiar anthropic facies within wetland stratigraphic sequences, of great interest to archaeologists, and will be discussed more in depth below ('anthropic accumulations').

Wetland sediments can also enter the radar of geoarchaeological practice when working *away* from archaeological sites. This is the case, for example, with

Figure 5.1. *Wetlands are particularly suited for hand auger observations. This low-cost technique permits us to reconstruct the vertical stacking of peat (pictured) and other wetland sediments, such as organic or carbonatic muds or clastic sediments. This picture was taken by Sabrina Bianco during the University of Padova campaign in the Fimon lake area (Berici hills, Veneto, northeast Italy) in 2019. Image: Sabrina Bianco.*

cores, auger observations (Fig. 5.1) and environmental trenches used to gather information on the palaeoenvironmental evolution of a given area. It is also the case when extra-site features, such as trackways or other, sometimes mysterious, isolated human structures are investigated. In these latter cases the anthropic signal is much more diluted with respect to intra-site stratification, with micro-charcoal, pollen, micro-particles from early atmospheric pollution – among many other proxies – echoing the impact of human activities in the broad surroundings. The examples presented in this contribution all come from northern Italian archaeological sites. In this area, several wet environments with archaeological sites can be found, in a variety of different geomorphological settings.

Wetland sediments

The term 'wetland' is already in itself a very broad umbrella under which a variety of sedimentary environments and geomorphological settings is grouped. Consequently, wetland sediments can be found in several terrestrial, transitional, and even shallow marine environments (e.g. coastal mangrove swamps). Terrestrial systems hosting wetland sediments include, for example, mires, a general term for all types of areas where peat accumulates *in situ* (i.e. from plants growing and decaying in a basin, see Moore & Bellamy 1974, 84). Mires are differentiated further between bogs (rainwater-fed systems, acidic and nutrient poor, comparable to moors; French 2003, 18) and fens (groundwater-fed systems, neutral to alkaline and with higher nutrient status; Evans & Warburton 2010, 6–7). Swamp (low lying, raised, floating) is another term to indicate areas with wetland characteristics in floodplains, normally very acidic and characterized by Sphagnum moss in temperate areas (McCabe 1984).

Lacustrine environments also host sediments that can be regarded as wetland sediments. These are of great relevance to archaeology, as, for example, in the framework of research on Neolithic and Bronze Age circum-alpine pile dwellings in Italy, France, and Switzerland. In such research, the analysis of stratigraphic sequences and of facies architecture of lacustrine sediments is key to reconstructing variations of lake levels and of palaeoshores (Morhange *et al*. 2017). These ultimately depend on climate-induced variations, as, for example, in terms of rainfall and evaporation rate, and therefore shed light on the links between human dwelling and environmental conditions. In lacustrine systems, peat occurs in the emerged littoral zone, whereas organic muds (among which gyttja) and carbonate muds (or lake marl) are found on the submerged platform bench, talus, and in the deep zone. Their stratigraphy reflects complex bio-geochemical mechanisms and associated environmental processes (Fig. 5.2; Magny 2007; Verrecchia 2007). Allochthonous clastic sediments can also be

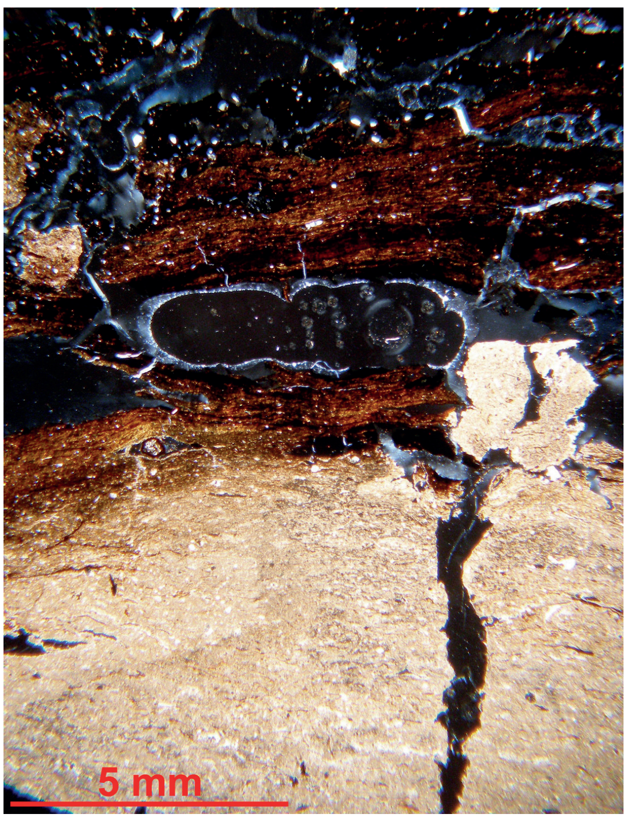

Figure 5.2. *Transition from carbonate muds to foliated peat, viewed in thin section. The rather abrupt passage between these two sedimentary facies suggests a rapid lowering of the water level in the basin, prior to the establishment of a late Neolithic pile dwelling. The sample comes from a lacustrine-palustrine basin formed after the retreat of a Piave Glacier branch in the narrow Lapisina Valley, Veneto Prealps (Revine lake area, Treviso-Pordenone provinces, northeast Italy). Image: Cristiano Nicosia.*

found in lacustrine stratigraphic sequences. They can occur as discrete units intercalated to peat, organic or carbonate muds, or they can lead to the formation of intergrades and mixed organo-mineral facies. Allochthonous clastic inputs derive, for example, from water courses flowing into a lake or from colluvium generated along the surrounding slopes, such as in response to vegetation clearance and cultivation.

There are several other terrestrial sub-environments that are subject to wetland sediment accumulation. These are often of high interest for archaeological research, as they were ecological niches suitable for human settlement. This is the case, for example, of intra-morainic basins, small topographic lows within nested moraine ridges formed at the mouths of alpine valleys, home to several Early Bronze Age pile dwellings (e.g. in the Garda Lake region, see Balista & Leonardi 1996; Dalla Longa *et al*. 2019). Such settings are occupied by topogenous mires, fed by water infiltrating laterally through permeable till and resting on impermeable, i.e. cemented or consolidated, basal layers. The sedimentation in such basins is comparable to that of lakes, with peat, gyttja, and carbonate muds reflecting water level variations (Ravazzi *et al*. 2018).

These basins have been systematically drained in the last few centuries and, with few exceptions, no watershed is visible today. Other glacial-derived wetland contexts, such as ponds dammed behind terminal moraines or hollows of glacial origin, are settings in which lacustrine or palustrine sedimentation takes place. These basins, especially smaller ones, are normally progressively filled by plant growth and by detrital inputs (i.e. colluvium). In northern temperate areas, the facies succession begins with muds (either organic or calcareous), detrital gyttja, reed peat and finally forest peat (derived from alder carrs or alder swamps) (Taylor *et al*. 1998, 22). This can be regarded as a typical sequence indicating the progressive filling of a basin.

Topographic lows with wetland sediments occur also in portions of floodplains that underwent a lower sedimentary accretion than the surrounding zones. These areas therefore grew less than the plain around them and resulted in 'differential' lows. The resulting topogenous basins are frequently found adjacent to isolated hill complexes, as in the Euganean and Berici hills in the Veneto region of north-eastern Italy (see Balista & Leonardi 1996).

As mentioned above, peat and organic muds, along with intercalated fluvial deposits, occur also in transitional environments. This is the case of deltaic/estuarine environments, salt marshes, or tidal basins, as for example in the Holocene sequences of The Netherlands. Here, the juxtaposition and evolution of such wetland environments, strongly influenced by marine transgressions and regressions, had important bearings on settlement distribution patterns from the Neolithic onwards (Vos 2015). Transitional settings are also of particular relevance for coal studies, as large fossil deposits of economic value originated in them. This profitable field of research has generated a specific body of literature on the reconstruction of past environments based on organic sedimentary facies (see McCabe 1984; Taylor *et al*. 1998). The non-profitable field of research of geoarchaeology can find a wealth of useful information in it.

From this brief overview it appears clear that in wetland settings we encounter sediments belonging to all three sediment types or sediment classes, i.e. clastic, chemical and organic. What makes these settings – and the associated wetland sediments – peculiar and challenging is their high or dominant organic content. This is the result of the fact that sediment build-up in wet environments takes place in relatively stagnant and oxygen-poor waters. This slows down or completely stops the decay of organic matter, introducing a form of disequilibrium between how much organic material accumulates (from plant remains in peat to particulate or colloidal organic matter in organic muds and organo-mineral intergrades) and how much is weathered away.

Wetland sediments in archaeological contexts

Several structures created by humans behave like small-scale counterparts of the natural sedimentary environments described above. Ditches, canals, moats, or wells can in fact become waterlogged basins where peat, peat-like sediments (see below for a discussion) or organic muds accumulate. As the sedimentation within such contexts takes place in an anthropic environment, the resulting sedimentary facies are somewhat specific to archaeological sites (Fig. 5.3). They therefore differ from the purely natural ones described above, although the two share several formation mechanisms. Little systematic attention was devoted to anthropic sedimentary facies in wetland contexts, which are in fact scarcely, if at all, systematized and codified. But this specificity in terms of facies and sedimentary characteristics is not

Figure 5.3. *Section through the fill of a small ditch in the medieval settlement of Nogara (see Saggioro 2011). The fill is composed of plant detritus, organic muds, and organic sands, containing abundant archaeological material. In such a structure the sedimentation is almost exclusively anthropic (i.e. it derives from the dumping of waste). The degree of mixing of eco- and artefacts of different ages is therefore very high. The waterlogging derives from the site's setting within a spring-fed river valley downcut into a late Pleistocene alluvial fan (Nogara, Verona province, northeast Italy). Metre stick equals 1.4 m. Image: Cristiano Nicosia.*

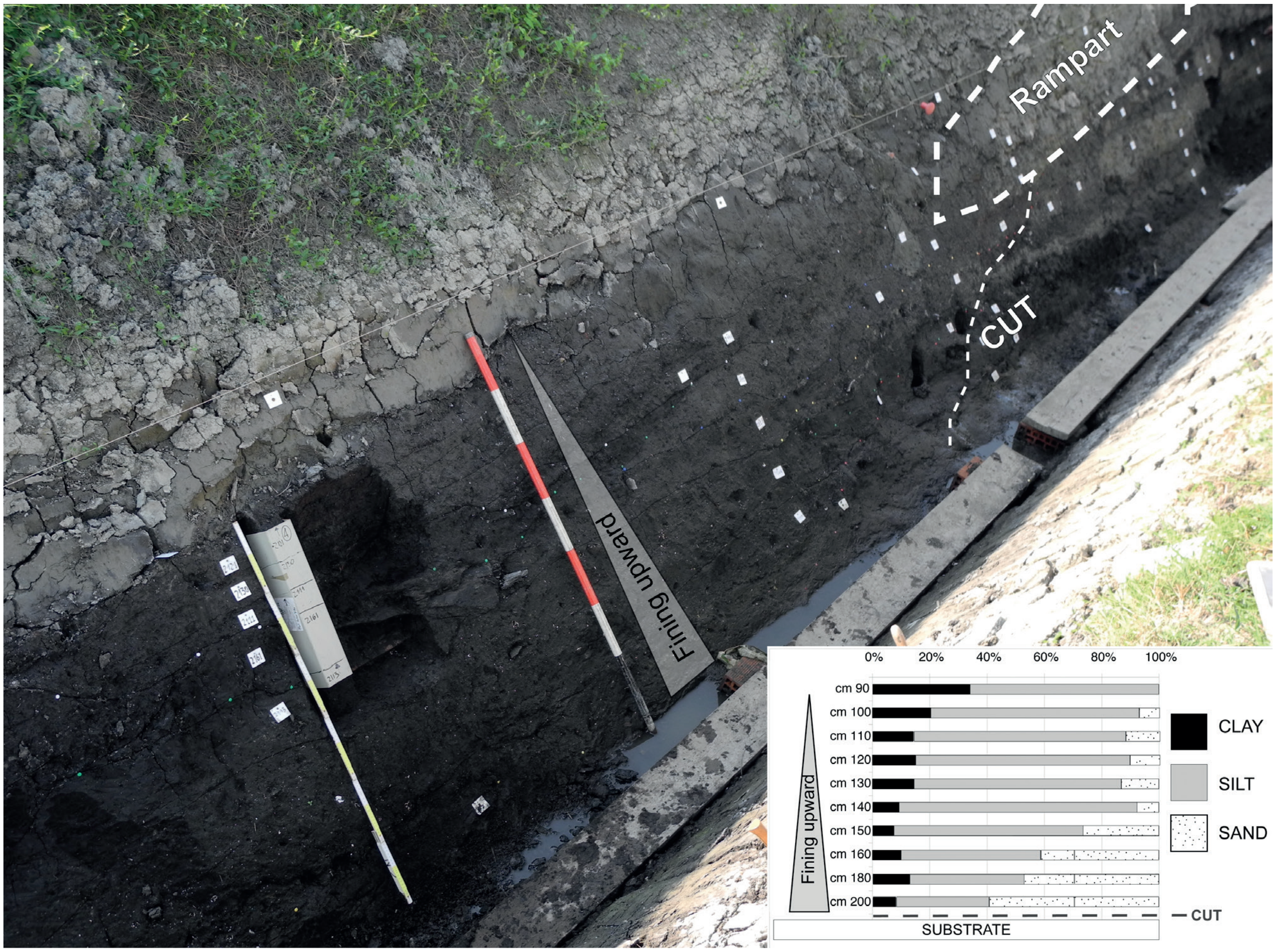

Figure 5.4. *The Bronze Age embanked site of Fondo Paviani (Veneto, northeast Italy) is surrounded by a 'moat' which merges laterally away from the rampart of the site into a wide fen (see Dalla Longa* et al. *2019). The profile consists of an alternating sequence of gyttja, detrital gyttja, and peat. As the basin receives running water loaded with sediments, 'mixed' organo-mineral facies have filled the basin. The clastic component ranges between 40 and 70 per cent by weight. Its granulometry shows an overall fining upward trend, suggesting the progressive lowering of the energy in the environment (i.e. the clogging of the basin). Image: Cristiano Nicosia.*

restricted to the fill of negative features. As outlined in the introduction, anthropic horizons (also known in literature as 'cultural layers' or 'dwelling soils' – a translation of the French *sols d'occupation* and the Italian *suoli d'abitato* – see Moinerau 1970; Butzer 1982; 2008; 2011) or other forms of accumulation (i.e. waste heaps) have peculiar characteristics when formed in wetland contexts.

Fill of negative features

Different processes are involved in the formation of the fill of ditches, canals, moats, or wells. Organic muds with different percentages of clastic material form in standing water bodies (Bos *et al*. 2012), and therefore can characterize larger structures such as moats and even abandoned river channels (oxbow lakes) associated with human settlements. Based on the clastic or minerogenic component, the encountered muds range from fine algal gyttja (almost olorganic), to detrital gyttja (organic with coarser plant remains), to organic silts or clays (predominantly minerogenic with fine interspersed organic material). Laminations can be present, and they also indicate the process of sediment settling within a standing body of water. Their preservation in the sedimentary record reveals a lack of bioturbation. Therefore, sediments were waterlogged at the time of deposition and remained so until exposed, or the accretion rate was very rapid and outpaced bioturbation. In larger structures, like for example the moats of the Bronze Age Terramare

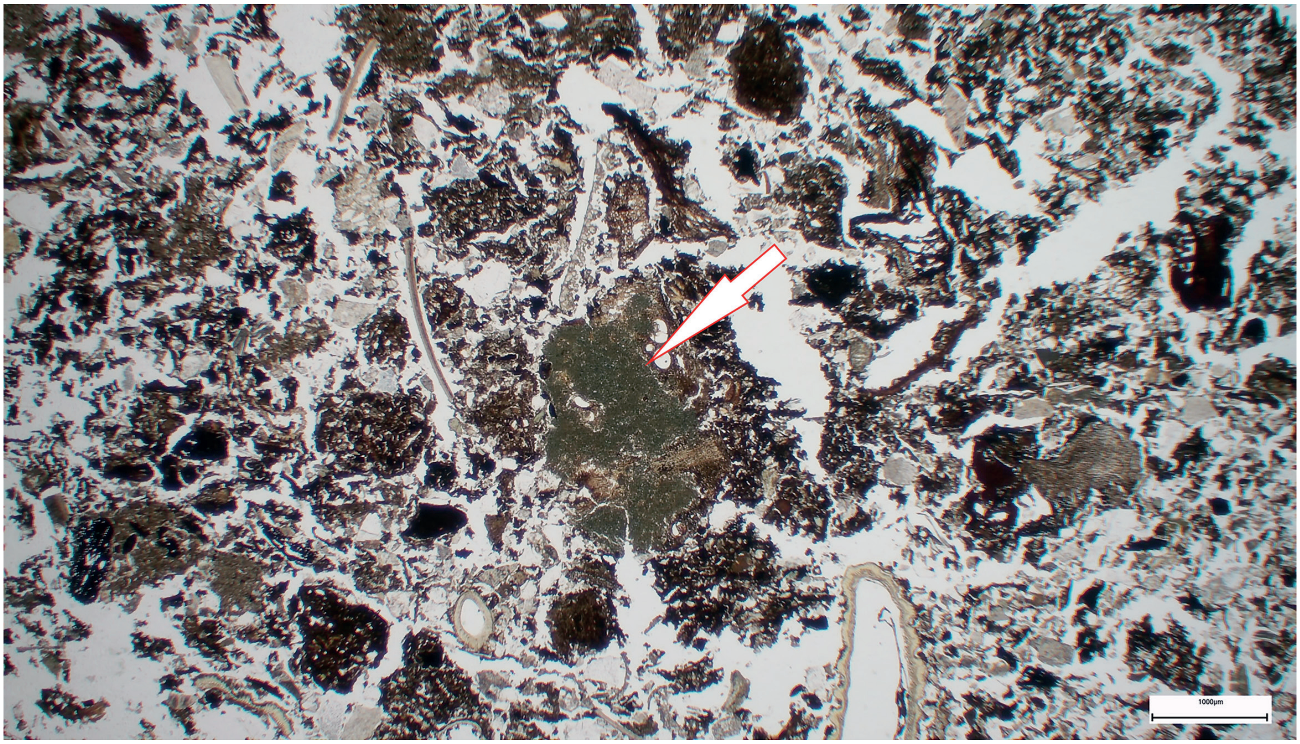

Figure 5.5. *Layer of plant detritus ('detrital peat') as viewed in thin section, showing plant organ and tissue residues without the foliations and fine laminations that characterize in situ peat. The arrow shows a vivianite crystal intergrowth. Such mineral neoformations appear almost instantaneously when a site is drained, or a formerly waterlogged profile is exposed to air for the first time. This process gives rise to bluish colorations of the profile, easily noticeable by naked eye. Bronze Age site of Fondo Paviani (see Fig. 5.4). Scale bar equals 1 mm. Image: Cristiano Nicosia.*

sites in northern Italy, the presence of a feeding channel connected to the active hydrographic network entails a consistent clastic input (Fig. 5.4). This can also be brought about by sediments washed in from the flank of the negative structure, when the latter was dug into a clastic substrate (see Langohr 2000). This process affects larger and smaller structures alike, and is not clearly exclusive to wetland settings.

Peat and 'peat-like' or 'peaty' sediments (Fig. 5.5) is another category that often makes up the filling of negative features, even relatively small ones such as wells or latrines. A clear distinction should be made between peat that derives from plants that grew and died *in situ*, and allochthonous coarse vegetal detritus and plant remains that, once stacked up and compressed by the overburden, resemble peat (hence the 'peat-like' or 'peaty' definition). This distinction is nevertheless difficult to make visually in the field and especially without botanical determinations of the nature of the vegetal detritus. *In situ* peat denotes the final stages of a progressively infilling negative feature. In other words, it forms when semi-terrestrial conditions are established. Here, anoxic conditions are, for example, caused by capillary rise or due to a perched groundwater table fed by rainwater. Instead, the origin of 'detrital peat' (term proposed in Moore & Bellamy 1974) within negative features is often anthropic. This is the case when plant remains, twigs, leaves, herbivore dung, seeds, fruits, animal bedding, wood-working detritus, bark, etc., are discarded in waterlogged or wet basins. The anthropic contribution to the filling of negative features also implies the discard of non-vegetal components, such as bone, pottery, latrine waste, or metal objects. The preservation of organics in wetland archaeological contexts offers therefore a great opportunity to reconstruct past behaviours and environments. At the same time, however, it poses a risk of misinterpretations, unless the mechanisms of formation of the sequence (for example, discriminating *in situ* peat vs. detrital peat) and the level of anthropic contribution to it are understood. For example, pollen or other archaeobotanical analyses must take into consideration the nature of the sedimentary accretion in the sequence they intend to sample, i.e. its processes and pace of sedimentation. Slow, gradual and regular accretion – as for example in a lake basin – is very rare in anthropic contexts. Here, on the contrary, the style of sedimentation is marked by several pulses or 'bursts', as when waste is discarded within a well or a ditch. These are separated by periods of minimal deposit growth, where 'nothing in particular' happens. Residuality is another significant problem when addressing archaeological sequences with laboratory analyses that are based on vertical variation or on the reconstruction of trends through time. Older pollen, older peat, older macro-remains, older charcoal, etc., all end up within the fill of negative features, especially when these occur within densely populated contexts (i.e. in the intra-site). The risk of creating false reconstructions when using such organic remains is therefore significant.

It would be reassuring to state that some inter-disciplinary combination of laboratory analyses could *per se* fix the above-mentioned risk of misinterpretations. It is, unfortunately, not that simple. The problem is rooted much more deeply, already at the field or macroscopic stage of the analysis of stratigraphic sequences of wetland archaeological sites. Wetland sediments lie at the intersection between several realms of science: botany, geochemistry, sedimentology, phycology (the science that studies algae), malacology, even coal geology. The description and interpretation of such sediments in the field is therefore inevitably skewed towards one or another specialism. In other words, description and interpretation depend on the lenses through which a sequence is observed. Attempts at providing agreed-upon terminologies for the field description of wetland sediments have been made (e.g. the classification code of Troels-Smith 1955; see Bos *et al*. 2012, 680 and references therein), but do not take into account, for example, archaeological facies. A wide and important field of research in archaeology therefore still has great potential for future systematization. This would allow for more robust field description and interpretation of sedimentary sequences in wetland contexts.

The field stage is the first and mandatory stage of approach to the stratigraphic sequence. It is in fact at the field scale that one formulates proper research questions, chooses laboratory methods, implements the sampling strategy, and integrates the obtained results with excavation-derived data. Involving botany specialists, for example, can already greatly improve the degree of understanding of organic sediments in the field. Several plant remains can be identified by naked eye during excavation or core description, or with the use of a magnifying lens or small binocular microscope. This can already greatly complement the identification of sedimentary facies in wetland contexts, in ways that greatly improve the resolution that could be attained if relying solely on geoarchaeology.

Anthropic accumulations

As mentioned above, anthropic horizons are the outcome of prolonged and intensive human dwelling, as for example within houses, in cities, castles, or inside enclosed settlements. The term (anthropic) 'horizon' is preferred here to the widely used (cultural) 'layer', as it stresses the soil-like characteristics of such deposits. These are in fact characterized by a cumulic character, i.e. by the gradual accumulation of parent material, in this case of anthropic origin, progressively 'digested' in the soil by bioturbation, trampling, and weathering. Similarly to surface soil horizons, anthropic horizons are characterized by the evolution (or degradation, depending on the point of view) of organic constituents that reached the deposit (see Nicosia *et al*. 2011). In wetland environments this set of processes is hampered, slowed down, or even inactive. The anthropic horizons found here, therefore, closely resemble the characteristics of archaeological deposits *before* bioturbation, weathering, humification, etc., intervened to transform them. They are, in other words, closer to the original accumulations that formed under past people's feet.

Anthropic horizons from non-waterlogged contexts can be compared with those from waterlogged (or wetland) contexts in thin sections. Under the microscope, waterlogged anthropic horizons contain large quantities of finely comminuted undecayed plant tissue fragments making up the groundmass. These are brown, dark brown, or reddish brown in plane polarized light. There are also larger plant tissue or organ fragments, such as bark, leaves, stems, twigs (see Ismail-Meyer 2017 for a guide for identifying plant fragments in archaeological thin sections). Herbivore excrements, if present, retain their original shape, as in the case of recognisable goat and sheep droppings (Brönniman *et al*. 2017). Bioturbation is generally low or even absent, especially if the site was drained just before sampling began. Laminations and other sedimentary structures are therefore preserved, as is the imbrication of coarser elongated components, such as charcoal. Often, waterlogged anthropic horizons display an overall 'fibrous' aspect, related mainly to the vertical stacking of elongated vegetal fragments, and their successive compression by the overburden.

In non-waterlogged anthropic horizons, instead, the organic component occurs as fine blackish 'punctuations' dispersed in the mineral groundmass. This is similar to what is observed in urban post-classical deposits (e.g. Nicosia 2018). Thin section analysis alone cannot distinguish such particles from soot or finely comminuted charcoal, and also their degree of humification is undeterminable without specific organic petrology methods. Bioturbation in these horizons is

Figure 5.6. *Waste heap from a pile dwelling phase of the middle Bronze Age site of Oppeano-Palù (Verona province, Veneto, northeast Italy). The arrows indicate peat from the areas surrounding the heap interfingering with its growth, which derives from the repeated disposal of domestic waste. Image: Cristiano Nicosia.*

strongly attested, with several channels obliterating the original sedimentary structures, the original fine layering, and disrupting the fabric of coarser components. If we take into account also the total disappearance of plant residues, dung, and any olorganic components, it appears clear that the transformation from the pristine status of anthropic horizons to what is excavated by archaeologists is very significant. To overcome this unavoidable challenge, soil micromorphology is particularly useful for disentangling the palimpsest of formation processes that have affected any anthropic horizon. This technique is also essential to provide 'context' to any element extracted from anthropic horizons ('micro-contextual approach', see Matthews 2005b; 2012; Goldberg & Berna 2010), such as pollen, phytoliths, diatoms, macrobotanical remains, or even chemical signatures, as revealed, for example, by the GC-MS study of lipids (see Evershed 2008 on this specific topic). For example, thin section micromorphology permits us to ascertain if a certain phytolith assemblage extracted from a bulk sediment sample derives from a concentration of dung pellets within a given layer, or rather from the presence of a vegetal mat, or from a concentration of cereal processing waste, etc.

A peculiar form of accumulation of anthropic sediments in wetland contexts is the midden heap. These are mentioned, for example, in several early Bronze Age pile dwelling sites at the southern alpine foreland, like the Lucone di Polpenazze (Baioni 2013) and Lavagnone (Degasperi 2007) sites. Midden heaps are dome-shaped features that often 'merge' laterally with the surrounding sediments, causing stratigraphic headaches during excavation (Fig. 5.6). They are laminated and finely stratified, and include alternating sequences of white-coloured carbonatic units (often misidentified as lake marl but in reality composed of wood ash), levels of vegetal detritus, and minerogenic units (sometimes termed 'loam' in Swiss and German pile dwelling studies, see Ismail-Meyer *et al*. 2013) (Fig. 5.7). These are often fragments derived from the dismantling of fireplaces that had clay linings, or from debris derived from architectural earth materials. Midden heaps are extremely precious for reconstructing the lives of the inhabitants of pile dwellings. They are in fact the sole record of the activities that took place on the raised platforms upon which houses stood, as these are normally not preserved in pile dwellings (see Menotti & Leuzinger 2013). Combined micromorphological and phytolith study on the midden heaps of the Lucone di Polpenazze pile dwelling (Lake Garda, Italy) has confirmed that these features are the result of the

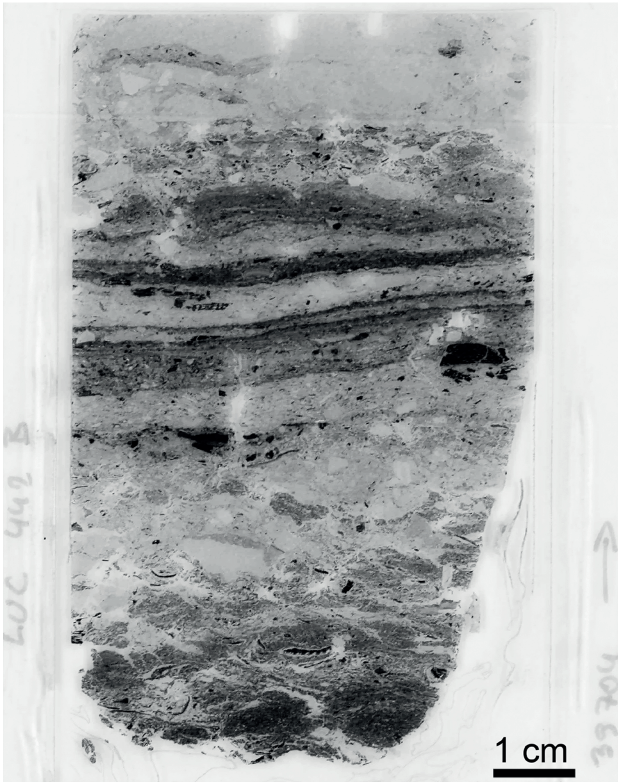

Figure 5.7. *Scanned thin section collected from a waste heap in the early Bronze Age pile dwelling of Lucone di Polpenazze (Garda Lake, northwest Italy). Alternating sequence of light-coloured levels (fragments deriving from dismantled firing structures mixed with ash) and dark-coloured levels (vegetal detritus and cereal processing waste). The preservation of the fine layering and laminations is due to the absence of bioturbation. The latter indicates that the heap accumulated on wet ground. Image: Cristiano Nicosia.*

repeated accumulation of domestic waste on the same spot (Baioni *et al*. 2021), similar to ethnographic and archaeological examples mentioned by Pétrequin in his research on pile dwellings (e.g. Pétrequin 1995). The waste at Lucone di Polpenazze consists of a mixture of cereal processing residues, fragments of hearth linings (quarried from the surrounding soils formed on till), excrements, and large quantities of ash from wood, chaff, grasses, and herbivore dung (Baioni *et al*. 2021). This multiplicity of components confirms the unique potential of midden heaps to reconstruct the daily lives, the diet, and the interactions with the landscape of pile dwelling inhabitants.

Conclusions

This brief outline on the challenges of geoarchaeology in wetlands is intended to stimulate debate on these environments, so precious for archaeological research. The challenges for geoarchaeologists are indeed many, but at the same time such challenges constitute research lines that can be developed in the future. Improving the description and interpretation of organic sediments in the field is one of these. Devoting specific attention to anthropic or anthropic-related sedimentary facies in wetlands is another. Providing robust background information on formation processes to avoid inaccurate reconstructions from ancillary techniques is also an important one. Overall, wetland environments are a particularly ideal (wet) ground to integrate different realms of knowledge. This does not only apply to archaeological or geoarchaeological research. Integration of knowledge is essential to properly manage, preserve, and valorize these fragile environments that hold such unique value in terms of ecology and heritage.

Inspired geoarchaeologies

Geoarchaeological research captures dimensions of the past at an unprecedented level of detail and multiple spatial and temporal scales. The record of the past held by soils and sediments is an archive for past environments, climate change, resource use, settlement lifeways, and societal development and resilience over time. When the McDonald Institute was established at Cambridge, geoarchaeology was one of the priority fields for a new research and teaching environment. An opportunity to develop the legacy of Charles McBurney was bestowed upon Charles French, whose 'geoarchaeology in action' approach has had an enormous impact in advancing knowledge, principles and practices across academic, teaching and professional sectors. Many journeys that began at Cambridge have since proliferated into dozens of inspired geoarchaeologies worldwide. This volume presents research and reflection from across the globe by colleagues in tribute to Charly, under whose leadership the Charles McBurney Laboratory became a beacon of geoarchaeology.

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