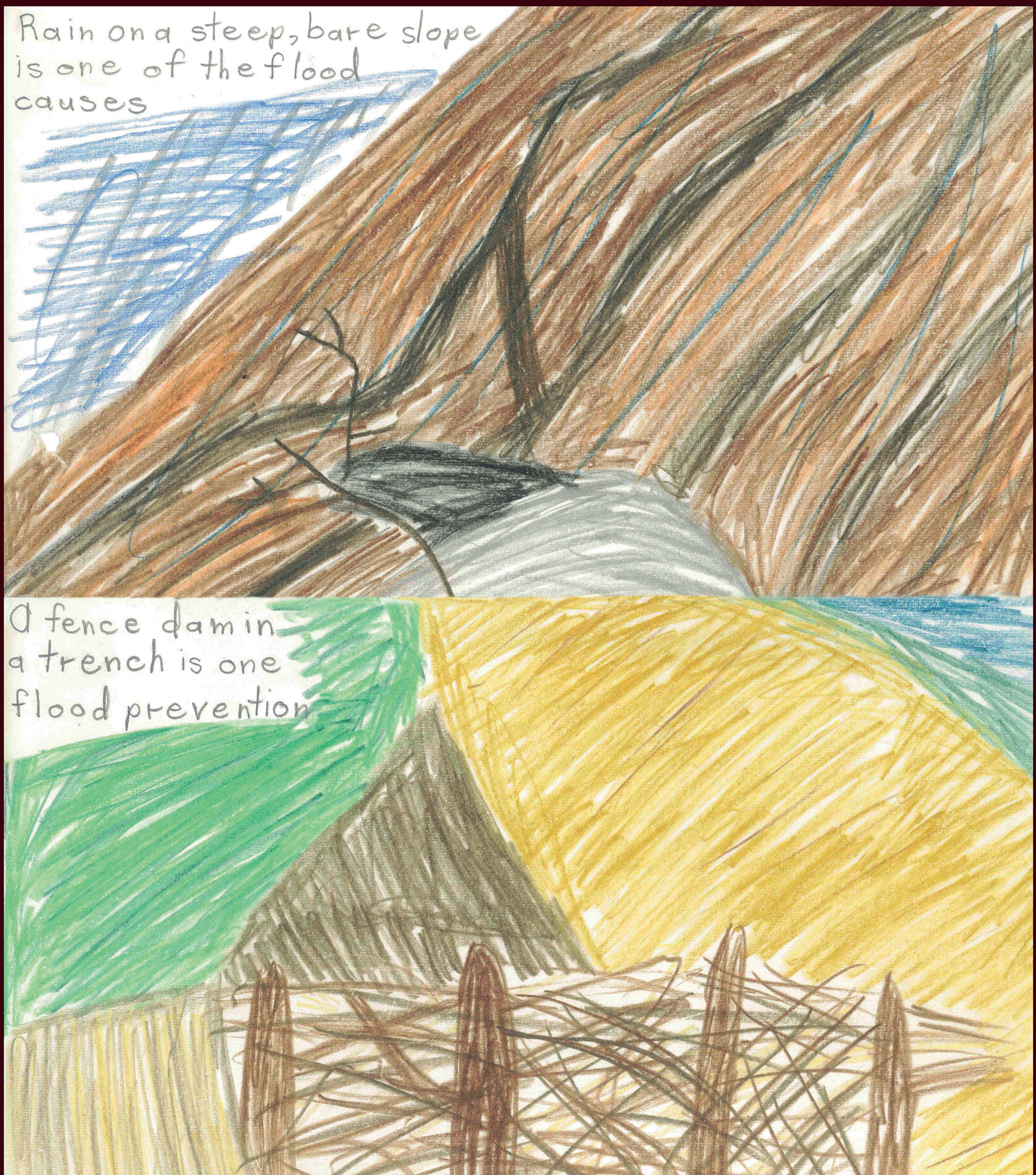
McDONALD INSTITUTE CONVERSATIONS

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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Essays in honour of Professor Charles A. I. French

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

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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Mike's (BSc, PhD, MCIfA, FLS, FSA) research and geoarchaeological interest was originally based around the analysis of colluvium and land snails, including in the South Downs, Dorchester, Cranborne Chase, Stonehenge and Avebury in particular; these were the subject of both his undergraduate and PhD research. He has combined a career dominated by commercial archaeology with involvement in university research projects and as a staff lecturer at Sussex, Bournemouth and Oxford Universities. He was Environmental Manager at Wessex Archaeology for twenty years and for fifteen years has run his own geoarchaeological consultancy from a purpose-built bespoke lab, where he is involved in research designs and coordination of environmental archaeology from fieldwork to publication. Projects have been as diverse as intertidal zone research and Maltese prehistoric temples. His interests now lie principally in landscape archaeology and the development and creation of landscapes through prehistoric human intervention. He has worked with – and still is working with – Charly French in Cranborne Chase, the Stonehenge Riverside Project, and both recent Avebury landscape projects. He is vice-president of the Conchological Society, and as founding editor of the Prehistoric Society Research Papers has seen ten peer-reviewed volumes through to publication.

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Christopher was the executive director/director of research of the Cambridge Archaeological Unit (CAU), University of Cambridge until 2021. Having worked in British archaeology for over forty years – with his initiation to Fenland archaeology coming at Fengate – following on from the Haddenham Project, he co-founded the CAU with Ian Hodder in 1990. He has directed a wide variety of major fieldwork projects, both abroad – Nepal, China and Cape Verde (the latter sometimes involving Charly) – and in the United Kingdom. A fellow of the Society of Antiquaries of London, in 2018 he was elected a fellow of the British Academy. He has published widely, including monographs arising from both his own landscape projects and those of earlier-era practitioners in the CAU's 'Historiography and Fieldwork' series (e.g. Mucking in 2016). Together with Tim Murray, he edited Oxford University's *Histories of Archaeology: A Reader in the History of Archaeology* (2008).

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Lars has a Masters and PhD in archaeology from the University of Oslo, with a thesis on Iron Age settlement and property rights in southeastern Norway. He has directed several large-scale heritage management excavations for the Museum of Cultural History at the University of Oslo, mainly targeting Iron Age burials, settlements and agricultural remains, while including other periods and relics. As a result, he has been editor and main author of publications on cemeteries (*Gravfeltet på Gulli*, University of Oslo 2005) and Iron Age settlements. Interdisciplinary cooperation and environmental archaeology, including archaeometric analysis (e.g. seeds, charcoal and soil), have been an integrated part of these projects. He has also been editor for the journal *Primitive tider* and academic editor of Trond Løken's 2020 *Bronze Age and Early Iron*

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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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Wendy is a specialist in Near Eastern Archaeology and geoarchaeology, focusing on micromorphology of the built environment and long-term perspectives on sustainability (MA Edinburgh 1984; PhD Cambridge 1992, 'Micromorphology of occupational sequences and use of space in a Sumerian city'). She was a research associate and fellow of the McDonald Institute (1993–2000) and is an associate professor in Archaeology at the University of Reading, following a semester as visiting lecturer at UC Berkeley. She was a member of the *Çatalhöyük* team and steering committee, Turkey (1993–2017). She co-directs the *Central Zagros Archaeological Project* investigating the Neolithic of the Eastern Fertile Crescent, Iraq, Iran (2007–), and has conducted research in Syria and Bahrain. She has co-supervised twenty-two PhD students and teaches modules on past, present and future sustainability; micromorphology; and Mesopotamia. She co-designed a new prehistory gallery at the Slemani Museum with Iraqi and Reading colleagues, with sustainability as a central theme.

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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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Tonko is chief research laboratory technician in geoarchaeology at the University of Cambridge. Involved in archaeology since his childhood, he held posts of archaeological site director and museum curator in Serbia (pre-1994) before moving to the UK to specialize in the late Upper Palaeolithic archaeology of ex-Yugoslavia via an MPhil (2004) at the University of Cambridge, and a PhD at the University of Ljubljana (2017). After four years at the Cambridge Archaeological Unit, he took up the post of geoarchaeology technician at the Department of Archaeology in 2008, and since then he has been working at the McBurney Laboratory of Geoarchaeology. He has directed and managed several archaeological projects, field and laboratory training in the UK and eastern Europe. He has authored several volumes and articles, including a monograph on preventive archaeology in ex-Yugoslavia published by Belgrade's Institute of Archaeology (2019) and a manual of archaeological excavation (co-authored with J. Appleby, 2015).

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Figures

Tables

Chapter 9

Speculations on farming development during the early Iron Age of southern Norway (500 BC–AD 550), focusing on the Dobbeltspor Dilling Project

Richard I. Macphail, Johan Linderholm & Lars Erik Gjerpe

British and international geoarchaeologists, with major practitioners such as Professor French at Cambridge, have developed a worldwide reputation for innovative interdisciplinary study. Such workers have been privileged to be involved with expert teams around the globe. Here, representatives of a large multi-national archaeological and paleoenvironmental team present an interdisciplinary thematic case – the prehistoric development of mixed farming in Norway. A decade of research, including a two-year investigation of the c. *5.5-hectare site of Dobbeltspor Dilling, Østfold, has produced a large database for improving our modelling of early Iron Age (500 BC–AD 550) mixed farming in southern Norway. At Dilling, 137 houses/different house phases (e.g. three-aisled buildings), and other settlement features such as fields, trackways and pit houses were excavated, with environmental archaeology samples undergoing geochemical, macrofossil, and soil micromorphological analyses. This new dataset, archaeological stratigraphy and finds recovery allow speculation on the development of sustainable farming during this early Iron Age period, which is not only relevant to Norway but appears to be consistent with findings from western Europe as a whole.*

Ever since becoming involved in the wetland archaeology of the Fens, Professor French at the University of Cambridge has developed a centre of excellence in the field of geoarchaeology both in the UK and internationally (French 1998; 2003; French & Lewis 2005). A basis for much of this has been an experimental and research centre developed at Cambridge (Milek 2006; French & Milek 2012; Lewis 2012; French 2015). In fact, there are significant results which are both intercontinental and multicultural in scale and which involve important aspects of geoarchaeology that deal with ancient urban developments, a wide variety of cultivation types, and patterns of water management, just to note few examples (Matthews *et al*. 1997a; Arroyo-Kalin 2008; Lee *et al*. 2014; Zhuang *et al*. 2014; French *et al*. 2017; Sulas 2018). It is in the spirit of these global investigations that this paper on Norwegian Iron Age farming is offered.

Later prehistoric manuring practices employing dung for sustainable agriculture in Western Europe have not been investigated in enough detail over the last decades. Manuring has long been practised in Europe (Jones 2012), and certainly the latest compilation of dated fields in Norway indicates that mixed farming got underway *c*. 1000 BC (Mjærum 2020). The use of organic manures during prehistory has been recorded from the Neolithic onwards (Troels-Smith 1984; Bakels 1997; Bogaard *et al*. 2013), but studies into the management of this manure have been few and largely associated with medieval plaggen soils in The Netherlands (Pape 1970; Bakels 1988; van de Westeringh 1988; Mücher *et al*. 1990), with research in Denmark, Belgium and Germany possibly taking plaggen soil methods back to the Late Bronze Age (Blume & Leinweber 2004). Similarly dated plaggen-like soils have also been investigated in Ireland, Scotland and the Northern Isles (e.g. Papa Stour, Shetland Isles; Davidson & Carter 1998; Adderley *et al*. 2006).

Experiments in prehistoric manuring practices and associated cultivation of crops, for example for the British Iron Age and Romano-British periods, have used 'raw' dung – e.g. dung taken to the fields direct from the byre at Butser Experimental Farm, Hampshire, UK (Reynolds 1979; 1981; 1987). That experiment was monitored by soil micromorphology and chemistry at both the byre (Moel-y-gar roundhouse) and cultivated field sites (Macphail *et al*. 2004; 2006). Parallel experiments were carried out at Bagböle Experimental Farm, Umeå, Västerbotten, Sweden (Engelmark & Linderholm 1996; Linderholm 1998; Macphail 1998; Viklund 1998b). Manured soils in the experimental fields at both Bagböle and Butser had enhanced levels of organic matter and phosphate as well as fragments of 'raw' dung. At Butser, organic chemistry (biomarkers) linked these field soils to the byre (Evershed *et al*. 1997).

In many cases in Western Europe organic manuring residues (which are visible under the microscope) are lost through oxidation and biological activity (Adderley *et al*. 2018), and as such have been less considered in the literature compared to inorganic residues (pottery, burnt rocks, bone, phosphate nodules and 'night soil') and charcoal (Adderley *et al*. 2006; Goldberg & Macphail, 2006, 202–9; Deák *et al*. 2017). Phytolith remains from manuring cross this organic-inorganic boundary (Devos *et al*. 2009; 2013). In fact, the most recent reviews, although noting the occurrence of organic remains in manured soils, do not discuss what pathways may have been involved in improving the organic manuring of cultivated soils associated with prehistoric and protohistoric sites (Deák *et al*. 2017; Ismail-Meyer 2017; Adderley *et al*. 2018; Macphail & Goldberg 2018a,b). Although manuring in ancient soils is recognized, it can be noted that the heightened biological activity associated with this is not explicitly mentioned in Deák et al. (2017). Manured agricultural forms of dark earth are well-recognized (Nicosia *et al*. 2017).

These pathways have best been considered in the formation of plaggens – which are generally deemed to be a medieval phenomenon (Bakels 1988; Mücher *et al*. 1990). Essentially, can we identify a time when dung (rather than 'raw' dung) was systematically 'composted' on a dung heap before being put onto the fields? Are there settlement structures that can be associated with this process? Are there artefacts, local and wider cultural aspects, and organizational trends that can be linked to them? With these questions in mind, this paper focuses on what may be an innovative development in farming during the Early Iron Age of Norway, one which can possibly be traced to the Low Countries at a similar time (Mikkelsen *et al*. 2003; 2019).

The generally cooler climatic conditions found in north-west Europe, for example in Norway, sometimes aid the preservation of organic remains on archaeological sites, even in dryland areas. Occasionally, of course, phosphate-enriched organic remains preserve well, with for example anomalous concentrations of pollen being preserved in organic byre floor materials (Macphail *et al*. 2004; 2007). Equally, humified amorphous organic remains of probable dung origin have also been clearly recognized in amended soils in Norway, consistent with enhanced levels of organic matter and organic phosphate (Engelmark & Linderholm 1996; Viklund *et al*. 2013; Macphail & Linderholm 2017; Linderholm *et al*. 2019). Organic phosphate data, cited in the form of PQuota (ratio between inorganic and organic phosphate after fractionation), is therefore an important measure of manuring with dung when PQuota is >1.0. This paper considers recent results from the Early Iron Age settlement of Dobbeltspor Dilling, Østfold, Norway (Gjerpe, forthcoming), and other analogue sites and experiments.

Archaeological context of settlement and farming in Norway, with special attention to Iron Age southern Norway

Mixed farming was the main source of calories in southern Norway in the Early Iron Age (500 BC–AD 550). An Iron Age version of an (extended) nuclear family lived on single farmsteads with a lifetime of one or a few generations (Myhre 2003). Most farms had one or two short-lived (25–75 years), three-aisled houses with internal roof support posts dug into the subsoil, and both people and animals sheltered under the same roof. Cattle, sheep, goats, pigs and horses were the main livestock. Small (a few hundred square meters) irregular fields were prepared with hoe or ard (Mjærum 2012a,b), and the sickle was the main harvesting tool from *c*. 200 BC onwards (Penack 1993; Gustafson 2016). Some sickles have a hooked tip, suggesting leaf fodder was collected. Later on, in the late Early Iron Age, the 'snidil', a special knife used to cut twigs from deciduous trees, was introduced (Myhre 2002, 148, 199). This suggests leaf and bark were important winter fodder (Austad 1988; Ropeid 1960). The main cereals were spring-sown barley, wheat, and to some degree oats from the Roman Iron Age period (AD 0–400) onwards – rye was never a substantial part of the produce in Iron Age Norway (Prøsch-Danielsen & Soltvedt 2011; Viklund *et al*. 2013). Flax was grown, probably for both the seeds and textiles, and some plants that are considered weeds today were in all likelihood collected and eaten. Due to climate and topography, just three per cent of Norway is arable land today and only about thirty per cent of this is suitable for growing cereals. Most of the soil substrates suited to growing cereals in southern Norway are clay, sand and silt that were originally deposited in salt water, and which became dry land after post-glacial uplift. The soil is mostly acidic and low in nutrients and needs fallow, manure, or both to give good yield over generations.

Although manuring was an established practice in the Iron Age, little is known about the collecting, treatment or spreading of manure, or exactly what kind of manure was used; however, animal dung seems to be a main source (Bårdseth & Sandvik 2010). Fields were manured from the Neolithic onwards (Soltvedt *et al*. 2007), but why manure was important, and how to maximize the nutrient content of the dung, was probably only fully understood recently, as late as the twentieth century. Composting normally reduces the nutritious value of manure, but was still practised in eighteenth century Norway (Næve 2003 [first published 1767]). On the other hand, composting might kill some of the weed seeds if the temperature reaches a certain level. Bulk chemical analyses do not normally differentiate the phosphate content between raw and composted manured soils. However, we can suggest, based on experimentally composted dung (0.981 per cent P, using XRF) and EDS analyses directly on thin sections of archaeological examples from Scandinavia, that composting of dung raises phosphate concentrations (2.10 per cent P in composted byre dung at Åker gard, Hedmark), compared to raw manure additions to cultivation soils. For instance, raw dung manured soils are less phosphate-rich (0.36–0.46 per cent P) compared to pelletized remains (max 0.75 per cent P) at Foss Lian, Trondelag (Macphail *et al*. 2017b; Macphail 2019).

Although it is possible to keep cattle outdoors through winters with temperatures well below freezing (Zimmermann 1999), snow and frost make winter grazing impossible in most parts of Norway. Thus, fodder needs to be collected. In the Pre-Roman Iron Age, iron reaping tools started to appear in graves. The new tools made it possible for two adults to collect grass and leaf winter fodder for three cattle and thus to increase both food and dung production (Løken 2020). Coincidentally, open forest pastures became reduced at this time (Sørensen *et al*. 2015), and, logically, keeping livestock closer to the settlements and fields meant easier access to manure as a resource.

In seventeenth to nineteenth century western Norway, dried bog soil was spread on the byre floor, soaking up solid and liquid dung – urine contains *c*. 50 per cent of nitrogen in cattle excrement, soaking it up is important. This was trampled by stalled animals into 'talle' (Myhre 2002). More bog soil was added as the talle became wetter; the talle layer could be quite thick by spring. The talle was then mixed with more bog soil and dung, and spread onto the fields in springtime. Mostly talle was produced by sheep, but the technique was also used in cattle-stalls, when cattle were sometimes placed on removable floors or planks (Næve 2003 [1767]). The sheep talle was so packed it was hard work chopping it into pieces. This technique has similarities with the plaggen soil practice of Central Europe dated to the Pre-Roman Iron Age, but the earliest finds of this in Norway are from the Roman Iron Age (Myhre 2002, 141). In the sixteenth to nineteenth centuries, manuring was considered better in western than eastern Norway, probably due to the talle system. At one coastal site (Ørlandet, Trondelag), there is clear evidence of livestock stalling in houses in the Pre-Roman Iron Age, whereas there seems to have been a change in the Roman Iron Age, with dung residues instead becoming accumulated/deposited near the houses (Linderholm *et al*. 2019). In eastern Norway the custom was to leave the dung outside, exposed to rain and general weather, thus losing much of its nutritional value (Lunden 2002). In Medieval northern Norway dung was for the most part not utilized as manure, as animal husbandry and fishing were the main source of calories and income (Bertelsen 1985). Manuring fields was thus considered a waste, as cereals could be bought from the income from fishing. It is thus clear that manuring practice in Norway never was a uniform practice, but rather varied.

The Dilling site

The C14-dated settlement at Dilling, Rygge Municipality, Østfold, southeastern Norway, consisted of one to six contemporary farms (Fig. 9.1; Gjerpe forthcoming). Altogether, more than a hundred houses or phases of buildings were excavated, and most were not concurrent. The main settlement period was *c*. 300 BC to AD 200, but there were also earlier and later occupations, including a Migration Period settlement (*c*. AD 400–550) upslope. Due to modern farming no archaeological features from the *c*. 25 cm-thick topsoil were preserved, thus no floor layers and very few artefacts were found. The acidic, sandy soils at Dilling provide poor conditions for organic material preservation, and next to no Iron Age organic material was found during excavation. The recovered artefacts and ecofacts are thus limited to charred macrofossils, wood charcoal, cremated bones and some ceramics, mostly preserved in features such as postholes, roof ditches and ditches. The settlement was facing south, and spread across a gentle slope composed of beach sands and marine clay loams in the lowest ground (Fig. 9.2). It thus had access to dry soil and to bog-like wetter zones. Today the soils in Rygge are regarded as some of the best in eastern Norway, but this owes much to modern fertilizers, irrigation and watering, none of which was accessible in the Pre-Roman Iron Age. There is not much detailed evidence for yields in eastern Norway before 1800, but various written sources describe the soil in Rygge generally, and sometimes Dilling in particular, as in much need of manure (Opstad 1957). When the railway connected Dilling and Oslo in 1879, trains brought *pudrette* (latrine waste mixed with peat) to Dilling railway station, from where it was spread on the fields (Berggren 1990).

At Iron Age Dilling, three-aisled houses, charred seeds and cereals suggest mixed farming was the main

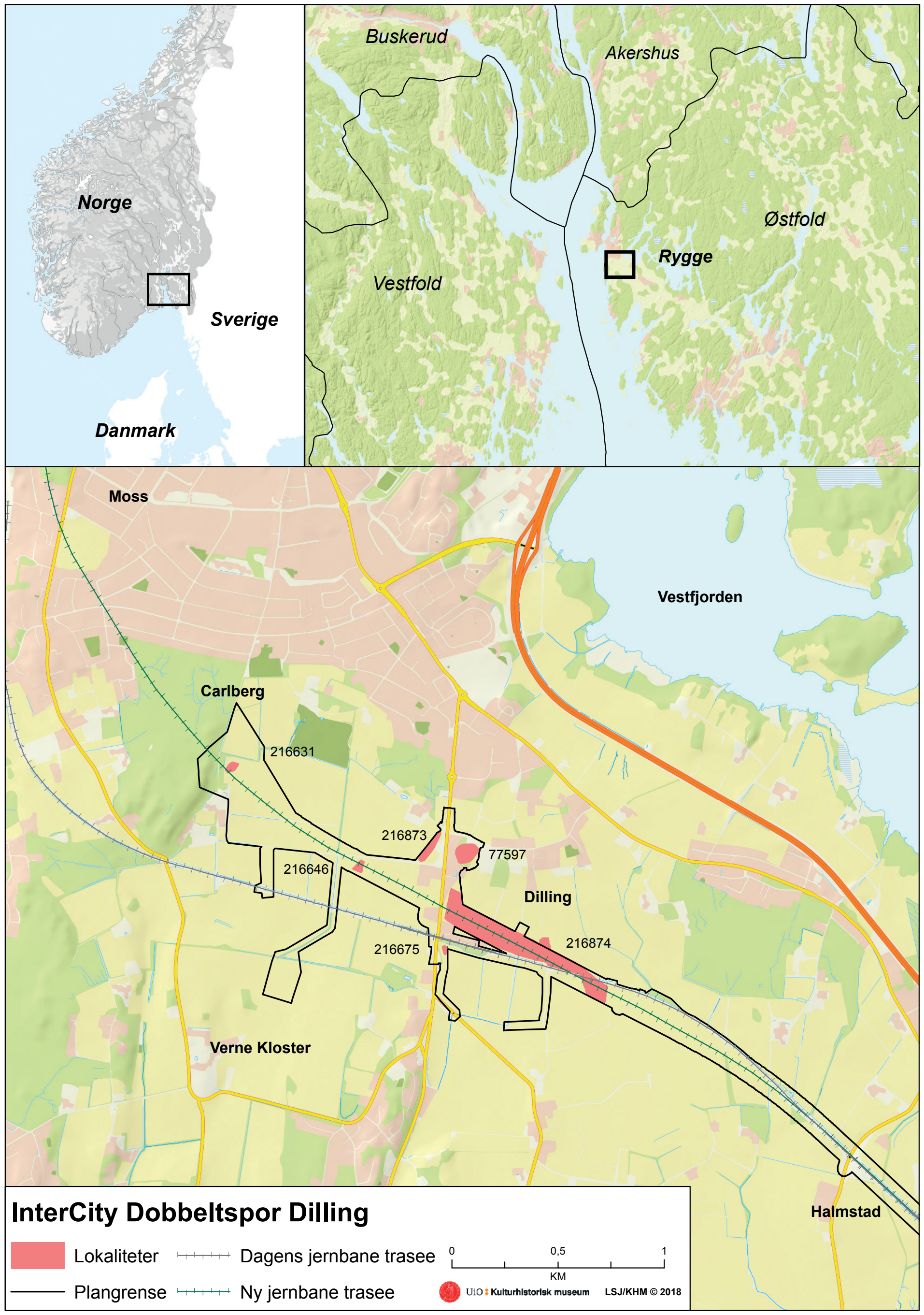

Figure 9.1. *Location of Dilling, Rygge Municipality, Østfold, Norway, showing excavation areas (Lokaliteter) along the new InterCity rail route at Dilling, which is located on a relatively low-lying neck land between Vestfjorden and Oslo Fjord to the west. The Migration Period site is identified as 216973, while the Iron Age settlement spread (Areas 1-6) is labelled 216874. Images: authors.*

livelihood, and a burnt fishbone suggests exploitation of other resources as well (Gjerpe, forthcoming). In the northwest of the settlement, seventeen funerary locations from the last two centuries BC and one from *c.* AD 100, were composed of burials containing mostly cremated bones and charcoal. Three of the graves also included modest grave gifts, including bear claws and three iron sickles (*ibid*.). The fragmented cremated bones could not be determined to sex, but most Pre-Roman Iron Age sickles from eastern Norway are found in female graves (Penack 1993; Gustafson 2016). Thus, women were probably involved in the cereal and husbandry production as the workforce, organizers or distributors; there may well be a link between the introduction of iron sickles and the gathering of fodder and stalling of stock in three-aisled buildings. These houses are of a tripartite character (Engelmark 1985; Engelmark & Viklund 1986; Myhre 2002), with examples of probable house-heating furnaces in domestic areas, and organic waste residues being

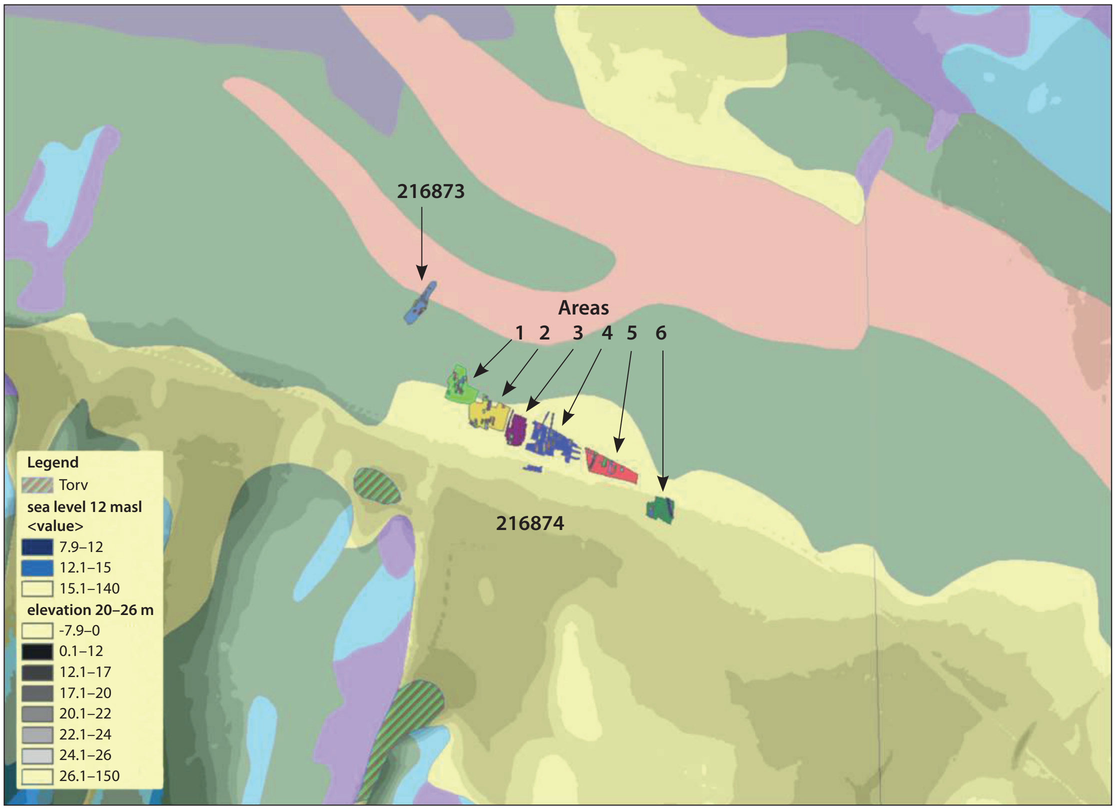

Figure 9.2. *Geological map of Dilling, showing elevations and location on the highest ground of the poorly sorted and coarse end moraine (pink), and, downslope, beach sands (green) and, in the lowest ground, intertidal fine sands and loams (yellow); current areas of peat ('torv'; striped green) are also shown. Migration Period ID Area 216873 crosses the boundary between the end-moraine and beach sands. Pre-Roman Iron Age and Roman Iron Age ID Area 216874 (Areas 1-6) mainly occurs on the fine intertidal sediments, with Area 6 in the very lowest ground. Image: adapted by Johan Linderholm, MAL, University of Umeå, Sweden from The Geological Survey of Norway.*

found in probable byre-associated floor remains and roof ditch fills. The site also involves other features, such as areas of industrial activity (ironworking), pits, wells and waterholes, pit houses, fields and various interconnecting paths and trackways. In fact, all the elements of a functioning settlement are present (Macphail *et al*. 2017a).

Methods

The two-year excavation involved bulk analysis of up to 600 samples from soil survey and selected features, and the study of ninety-two thin sections employing soil micromorphology and SEM/EDS (energy dispersive X-ray spectrometry). Bulk geochemical studies at MAL (The Environmental Archaeology Laboratory, Umeå University, Sweden) and soil micromorphology at UCL (Institute of Archaeology, University College London) were carried out on samples from the 2017–18 excavation seasons at the Dobbeltspor Dilling Project (Fig. 9.1). Details of bulk sample analytical methods (fractionated citric acid extractable P, LOI, MS and MS550) have been published previously (Viklund *et al*. 2013) and reviewed (Goldberg & Macphail 2006, 335–67), while soil micromorphology and associated SEM/EDS were carried out according to long-established standard protocols and current research (e.g. Bullock *et al*. 1985; Weiner 2010; Stoops *et al*. 2018).

Results

It is clear from the macrofossils that soils cultivated for growing barley also had a weed population including nitrophilous fat hen, which is indicative of manuring (Östman *et al*. forthcoming). The importance of animal management in the mixed farming economy is also supported by high PQuotas (i.e. greater proportions of organic P compared with inorganic P; see above) in most contexts, e.g. within houses, in the fields and along trackways (Fig. 9.3). Magnetic susceptibility

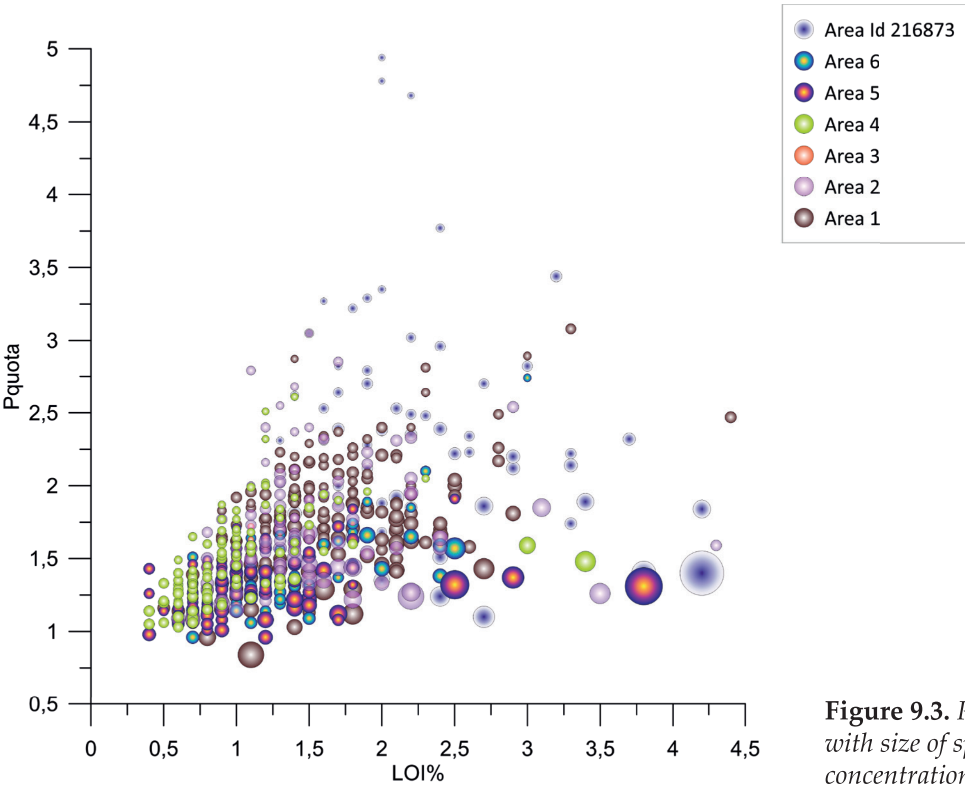

Figure 9.3. *Plot of PQuota and %LOI, with size of spheres indicative of relative concentrations of CitP. Image: authors.*

levels are relatively low, in part due to the poorly ferruginous substrate (range MS=10-30 χlf 10^{-8} m^3 kg^{-1}), while more enhanced MS values, i.e. >80 χlf 10^{-8} m^3 kg^{-1}, are associated with furnace and oven features. Due to high oxidation effects on the terrain, amounts of organic matter, as estimated by LOI, are low (<5 %LOI). Soil leaching results in only small to moderate concentrations of P (normally <400 ppm Cit P).

As an example of animal management in Area 6, at House 60 soil micromorphology suggested animal-influenced domestic space (MS=11-15 χlf 10^{-8} m^3 kg^{-1}; 240-370 ppm CitPOI; PQuota 1.3-1.6; 0.9-2.2 %LOI). This can be compared to a second house-use phase which appears likely to be linked more directly to animal management (MS=14 χlf 10^{-8} m^3 kg^{-1}; 330 ppm CitPOI; PQuota 1.6; 2.4 %LOI). Typically, MS does not become enhanced in byre space (Macphail *et al*. 2004; Viklund *et al*. 2013). Spatial modelling of how the settlement excavated in Area 6 could have functioned is illustrated in Figures 9.4 and 9.5. Byre use in Houses 60 and 75 is supported by geochemical data and soil micromorphology, which also located byre space in House 75. A path/track possibly linking House 75 and Pit House 100, was used by stock: byre residues, including a possible sheep/goat dung fragment were noted. It also records a suspected dung-enriched chemical signature (180-230 ppm CitPOI; PQuota=1.5-1.7). Sunken-feature buildings (including Pit House 100; Fig. 9.6) also have complicated histories of use and disuse. Speculatively, House 100 had a use as byre, possibly for small stock such as sheep and goats, but as the stained bedding and dung fill were removed for manuring, only traces of this use are present. This is in the form of burrow-mixed organic phosphate-stained soil (260 ppm CitPOI; PQuota=1.6; 2.4 %LOI). Later, the disused pit houses became infilled with waterlaid sediments. Following the similarly dated model of Belgium postals ('postallen') or sunken byres, where byre residues seem to have an enhanced PQuota (e.g. 1.5: S14, P1) (Mikkelsen *et al*. 2003; 2019), it can be speculated that these Dilling pit houses may record the beginnings of plaggen cultivated soil innovation, or at least an early episode of such a practice.

What can be more clearly demonstrated, however, is a change in manuring practice. Buried cultivation soils are characterized by an early manuring phase where raw byre waste was employed, and where biological working is marked by increased activity, and by very thin organic excrements consistent with increased soil fertility (Figs. 9.7 and 9.8a–b) (Macphail 1998; Viklund *et al*. 2013; Macphail & Goldberg 2018a, 316–22). In colluvial soils an upper manured horizon has been recognized at both Iron Age and Migration Period fields, where composted, black, pellety manure was employed, and biological activity is common in the form of thin organo-mineral excrements (Figs 9.8c–d and 9.9a–b). The remains of composted dung, forming

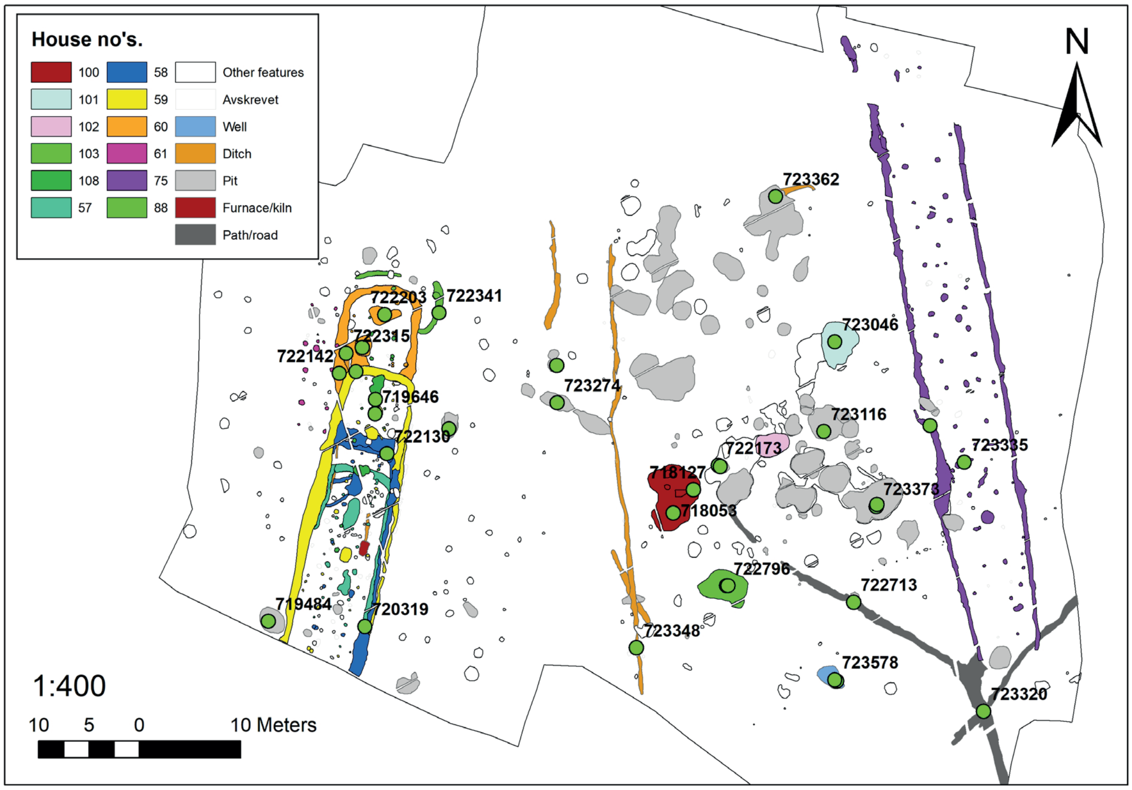

Figure 9.4. *Map of features excavated and sampled for soil micromorphology in Area 6, with overlapping different house phases on the left (e.g. Houses 58, 59 and 60), separated by a N–S ditch from an area of pits, wells, and pit house (House 100). Pit House 100 could be linked to House 75 by a path that also leads off to the south. Image map: Torgeir Winther and Marie Ødegaard, KHM-UiO.*

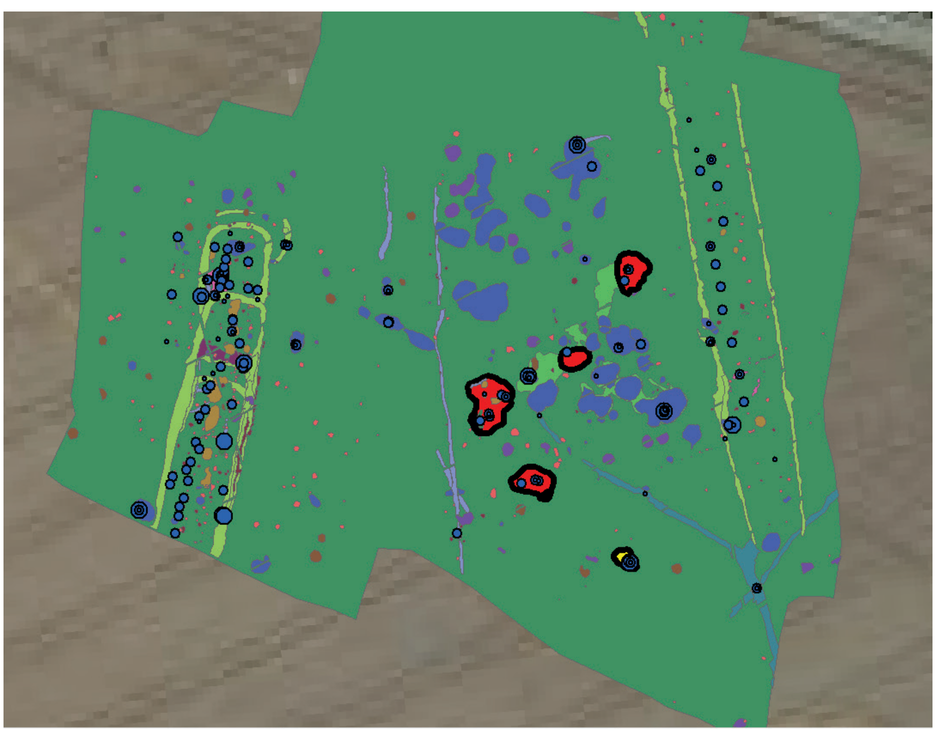

Figure 9.5. *Map of Area 6, showing geochemical sampling, often correlated with soil micromorphology sampling. Relative amounts of CitP are shown by circle size. There is a coincidence of soil micromorphological identifications of CitP concentrations and byre deposits in Houses 60 and 75, and the well. Small amounts of byre/dung residues and enhanced P/PQuota were also recorded in Pit House 100, and along the pathway between House 75 and Pit House 100. Image: authors.*

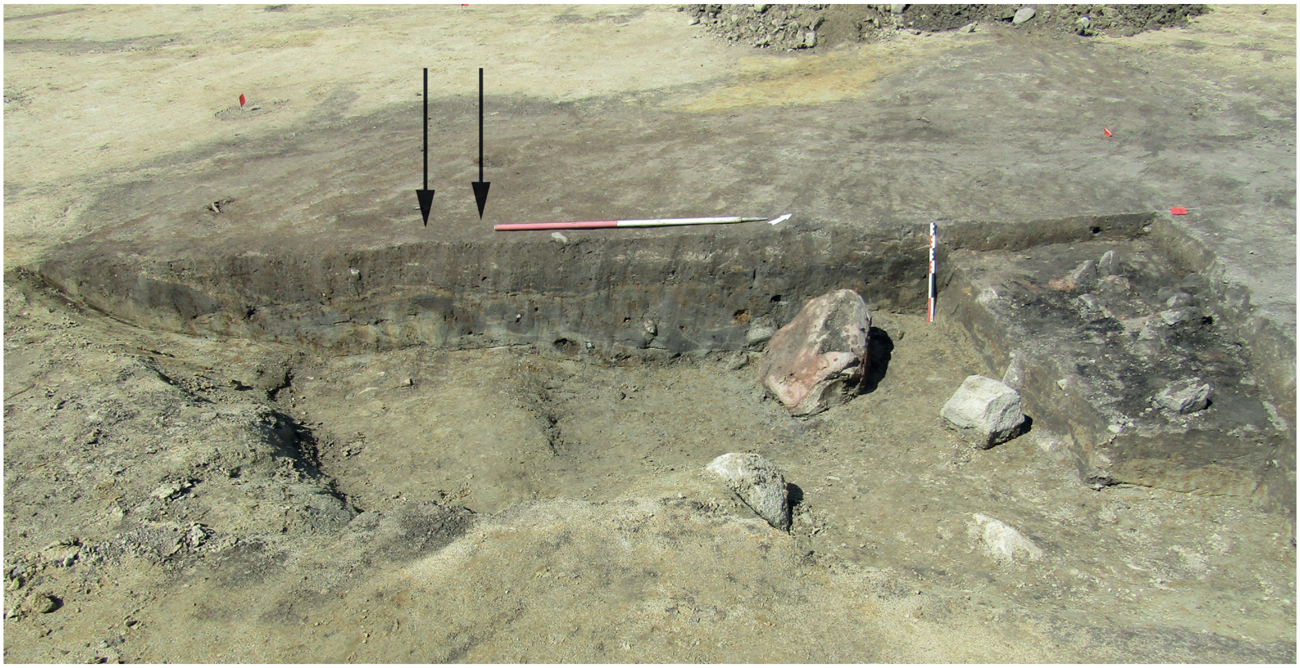

Figure 9.6. *Field photo of Pit House 100, Area 6, showing basal fills, including lowermost layers with subsoil traces of supposed byre-use, post-use waterlaid fills, a later inserted hearth, and uppermost fills. Arrows show monolith and bulk sampling locations. Image: Torgeir Winther and Marie Ødegaard, KHM-UiO.*

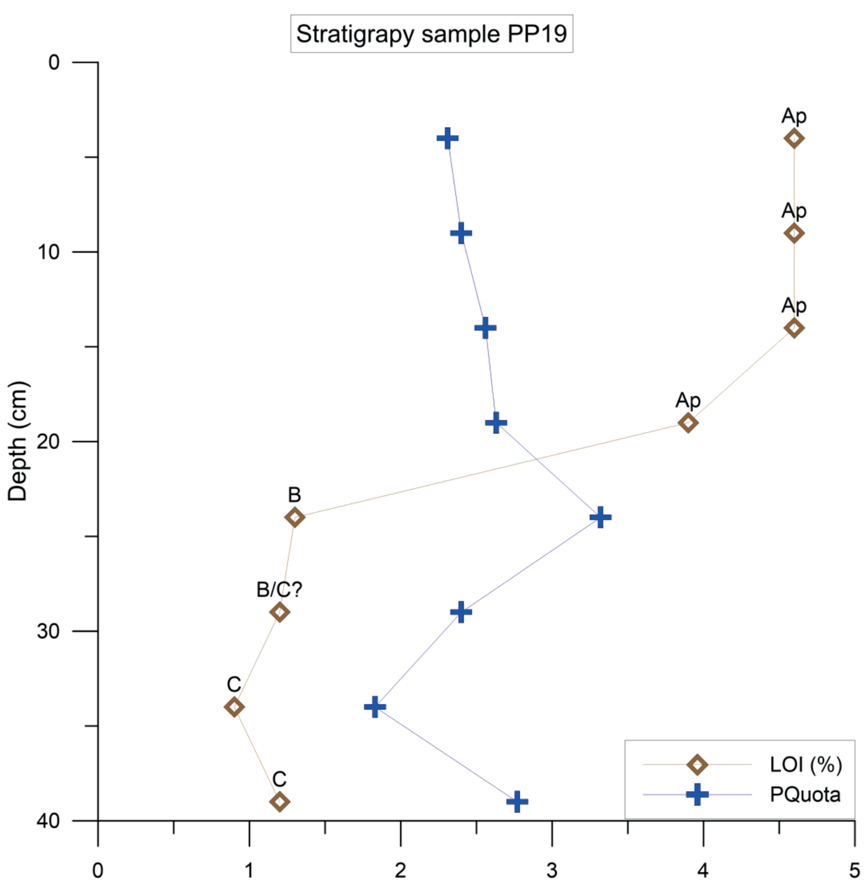

Figure 9.7. *Colluvial soil profile between Areas 3 and 4, showing depth, %LOI and PQuota data. There appears to be a buried manured (cultivated?) soil recording a particularly high PQuota at 25 cm depth, where manuring was by using raw byre waste, and with a more humic recent colluvial Ap (tilled topsoil) above, where composted manure was probably employed, leading to a lowering of the PQuota despite being more humic. Image: authors.*

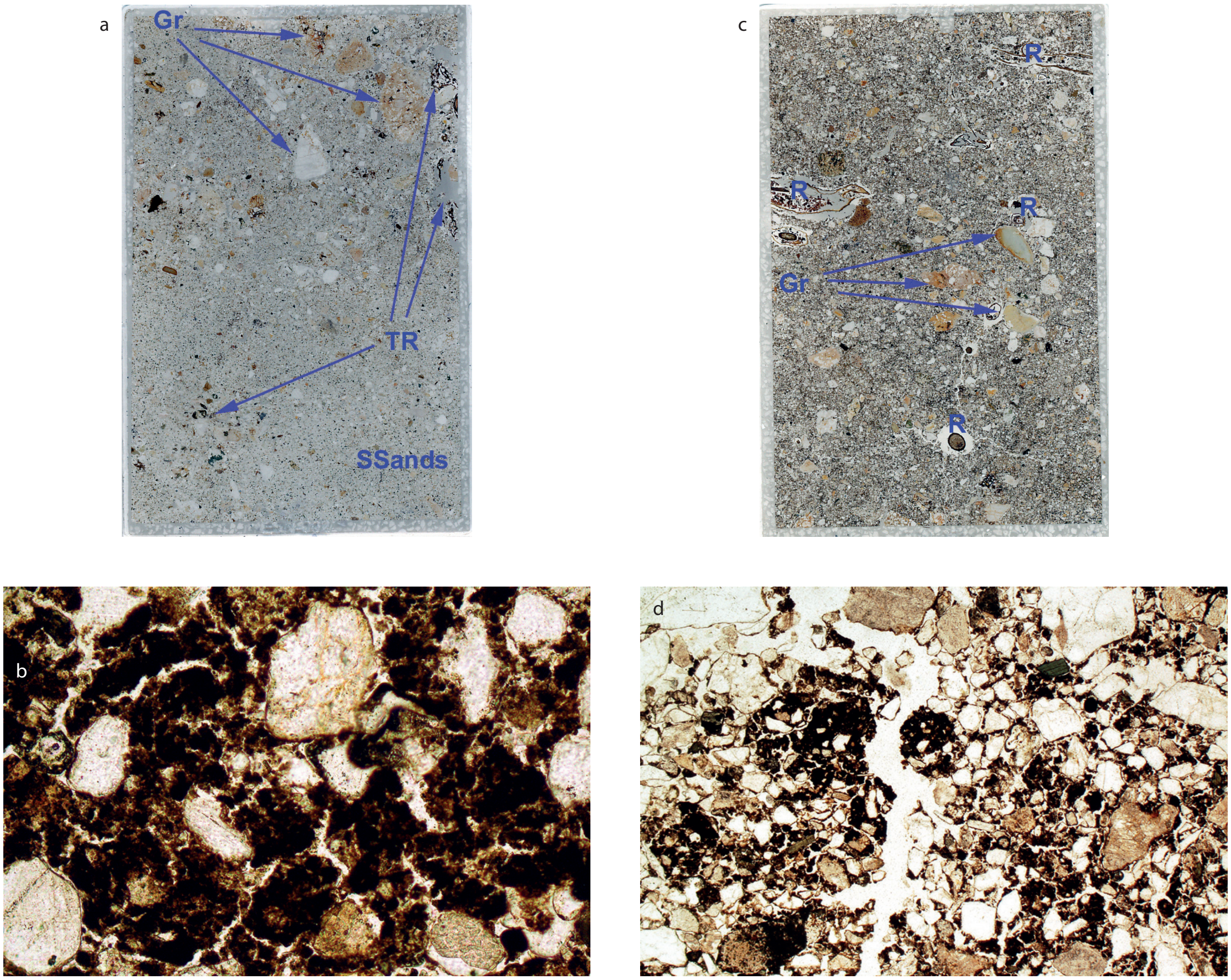

Figure 9.8. *M270909B: (a) scan of M270909B (stone fence buried soil, lower). Ameliorated cultivation soil includes coarser gravel – including probable burnt gravel (Gr) – compared to the subsoil sands (SSands). The manured soil is also more humic and bioactive. Later tree rooting along the fence line is evident (TR). Frame width is ~50 mm. (b) Photomicrograph of M270909B (stone fence buried soil, lower). Organo-mineral fine fabric developed from manuring and bioworking. PPL (plane polarized light), frame width is ~0.90 mm. (c) Scan of M270909A (stone fence buried soil, upper). Humic and organic sandy manured cultivation soil, concentration of gravel and probable burnt gravel (Gr), and more recent tree rooting (R). Frame width is ~50 mm. (d) Photomicrograph of M270909A (stone fence buried soil, upper). Organic sands from inputs of 'composted' dung (?), and evident (FeP) staining from another form of organic matter manuring. PPL, frame width is ~4.62 mm. Images: Richard Macphail.*

the top-most fill of disused pits, presumably acting as dung heaps (cf. Mücher *et al*. 1990), and spillage from dung carts in the form of composted dung is also found in roadway deposits (Fig. 9.10a–b).

Discussion and conclusions

Dated fields as well as geoarchaeological and botanical studies indicate that there was mixed farming in Norway since *c*. 1000 BC (Viklund 1998a; Myhre 2002; Viklund *et al*. 2013; Mjærum 2020). Some farming developments may also coincide with the introduction of iron sickles from *c*. 200 BC onwards (Penack 1993; Gustafson 2016) and a change from use of forest pastures – woody browse (Sørensen *et al*. 2015) – to animal stalling in three aisled buildings, and more localized grazing, allowing easier management of dung as a resource. As at Dilling (Fig. 9.1), Norwegian settlement sites are characterized by the presence of organic phosphates due to the ubiquity of dung residues in

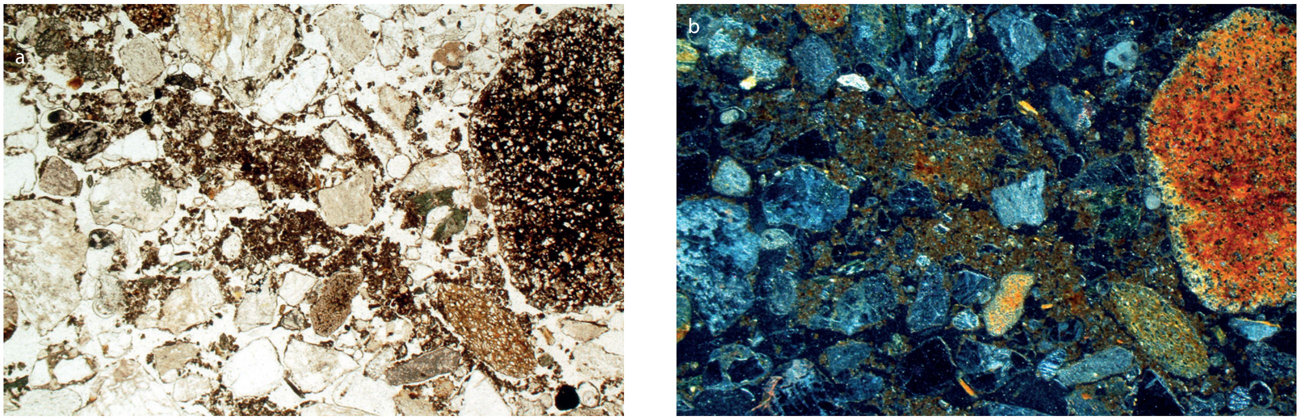

Figure 9.9. *M289442: (a) photomicrograph of M289442 (Migration Period cultivation layer 28733 upper). Formation of thin organo-mineral excrements due to manuring, with burnt rock on the right – settlement waste manuring. PPL and OIL, frame width is ~4.5 mm. (b) as (a), under OIL (oblique incident light), with patchy iron-phosphate staining (?) of humic soil and burnt rock. Images: Richard Macphail.*

buildings and fields. Coincidentally, at Vallemyrene (Porsgrunn, Telemark), a first Iron Age phase of manuring involved the use of dung from stock foddered on woody browse, while a second Iron Age phase (early Iron Age–Migration Period?) employed manure from animals fed on hay and cereals (in part based upon soil pollen analysis); the second phase produced fertilized soils with higher amounts of phosphate (Macphail & Goldberg 2018a, 322).

Another mixed farming variation was found at Ørlandet (Trondelag), with animal stalling in houses in the Pre-Roman Iron Age, while later, in the Roman Iron Age, byre waste concentrations were not located in the houses, but only nearby (Linderholm *et al*. 2019). In addition, we do not know how dung was treated before going onto the fields, although in most Iron Age examples this was in the form of raw dung (Viklund *et al*. 2013; Macphail & Goldberg 2018a, 316–23), and

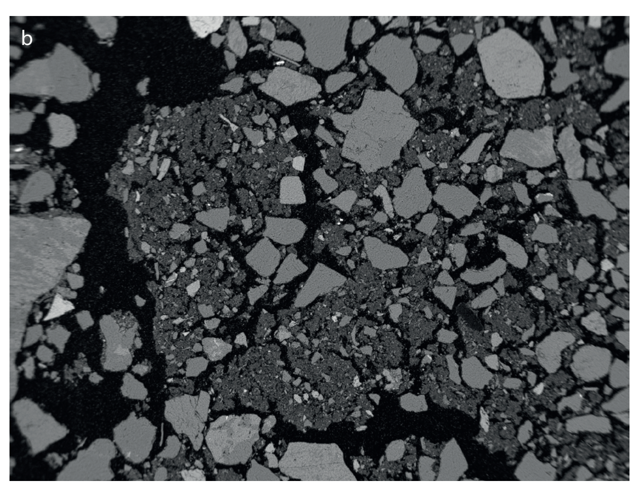

Figure 9.10. *M280000: (a) scan of M280000 (Road 267764, Layers 1/3), compact road fill Layer 3, including an embedded stone (Est), with patches of organic sands of composted dung character (Fig. 9.9b), and upwards fragmented compact wheel track deposits formed of matrix pans. Frame width is ~5 cm. (b) X-ray backscatter image of Fig. 9.10a; 'dung pellet' with concentrated organic matter, S and P (range: 0.90 per cent S, 0.28–0.31 per cent P), which can be iron-stained (max 12.6 per cent Fe, 0.41 per cent Mn and 0.50 per cent P). Frame width is ~3 mm. Images: Richard Macphail.*

not obviously composted via the dung heap as in the plaggen soil model (Bakels 1988; Mücher *et al*. 1990), although exceptions occur at Foss Lian and Åker gard, as noted earlier. Soil evidence at Dilling for the production of barley seems to be hinting at a change from manuring with raw dung straight from the byre to one of composting it first (Macphail *et al*. forthcoming; Östman *et al*. forthcoming). For example, changes from raw dung- to composted-soil manuring of fields through time are illustrated in Figures 9.7 and 9.8, and evidence of dung heaps at Dilling, and the transport of composted dung to the fields also comes from trackway deposits (Fig. 9.10). As in Belgium (Mikkelsen *et al*. 2003; 2019), pit houses in Area 6 (Fig. 9.6) may be linked to this development of plaggen soil manuring. As Area 6 is in the lowest area of the settlement (Fig. 9.2), climate deterioration from *c*. AD 250 (Büntgen *et al*. 2011) may have led to the abandonment of pit house use. The development of plaggen soils for early Iron Age farming in Norway may thus have been sporadic, although there are clear hints of this taking place at Dilling. Although best documented as a Medieval phenomenon, there is now Norwegian evidence of prehistoric plaggen soil cultivation, as already tentatively suggested for Belgium, Denmark and Germany (Blume & Leinweber 2004).

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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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Federica Sulas is a senior research associate at the McDonald Institute for Archaeological Research, University of Cambridge. Her background is in oriental studies and African archaeology (BA Hons, Naples) and geoarchaeology (MPhil & PhD, University of Cambridge). Her main research interests are in landscape historical ecologies and water–food security.
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