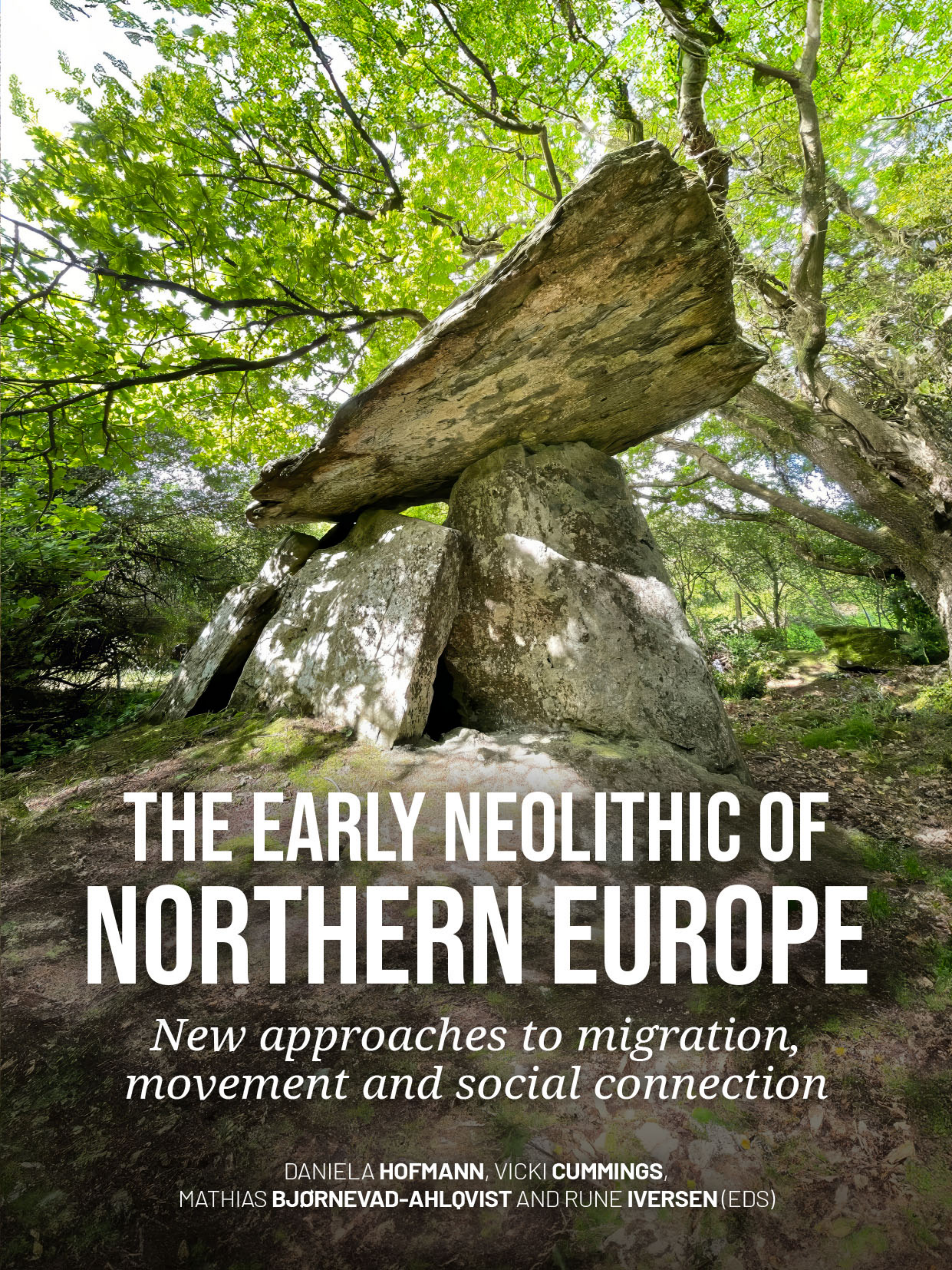

THE EARLY NEOLITHIC OF NORTHERN EUROPE

New approaches to migration, movement and social connection

DANIELA **HOFMANN**, VICKI **CUMMINGS**,
MATHIAS **BJØRNEVAD-AHLQVIST** AND RUNE **IVERSEN** (EDS)

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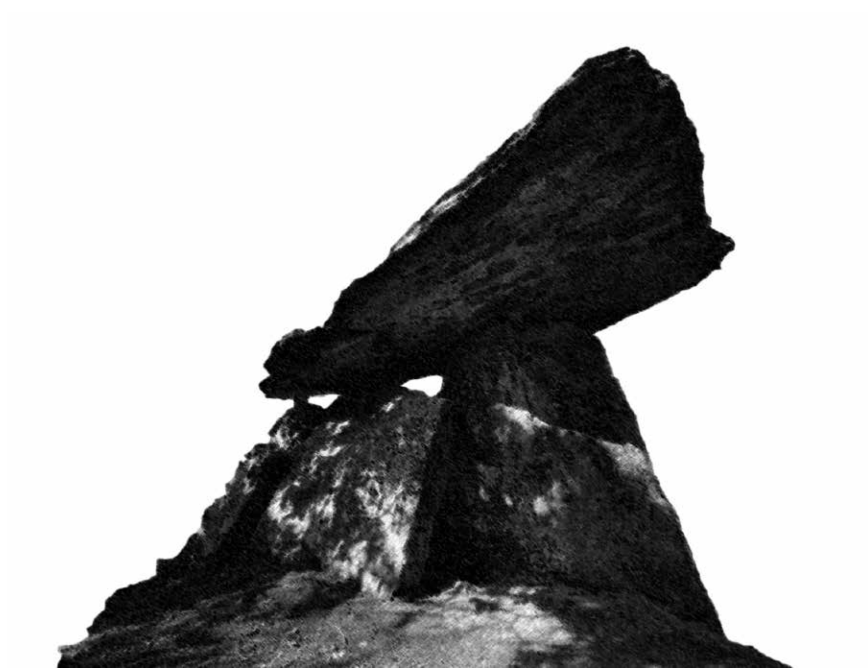

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Hugo Anderson-Whymark is a Senior Curator of Prehistory in the Department of Scottish History and Archaeology, National Museums Scotland, Edinburgh. He is responsible for the Museum's European Palaeolithic to Neolithic collections and specialises in flint and stone tools.

Tom Booth has a BSc in Archaeological Science (2007), an MSc in Human Osteology and Funerary Archaeology (2008) and a PhD in Bioarchaeology (2014), all from the University of Sheffield. He has spent the last 10 years working on projects mainly concerned with sequencing DNA from ancient human skeletons from Britain to understand human population history and evolution. He is currently a Senior Laboratory Research Scientist in the Skoglund Ancient Genomics Laboratory at The Francis Crick Institute.

Peter Bye-Jensen has obtained his PhD from Southampton University and is now a curator at Vejlemuseerne, where he heads ArchaeoLab, a centre for artefact research. Specialising in use-wear analysis and prehistoric flint artefacts, Peter's work combines experimental archaeology with analytical techniques to uncover the technological and functional aspects of prehistoric stone tools. His research provides critical insights into the activities associated with Early Neolithic monuments, exploring prehistoric craftsmanship, structural depositions and subsistence strategies.

Alfredo Cortell-Nicolau finished his PhD at the University of València (Spain) in 2020. After a post-doc extension there, he obtained a MSCA-IF at the University of Cambridge, where he then worked as Senior Teaching Associate on Computational Methods. He currently works at the Max Planck Institute for Evolutionary Anthropology as a Humboldt Fellow. Adopting a computational approach, his research is based on the transition to farming in the western Mediterranean. Additionally, he is particularly focused on methodological development and how the poor quality of archaeological data can undermine the inferential power of the discipline.

Vicki Cummings is Professor of Neolithic Archaeology at Cardiff University. Her research has focused on the start and spread of the Neolithic in Britain, Ireland and north-west Europe. She has a particular research interest in Early Neolithic monumentality, especially chambered tombs, and has excavated sites in Wales, Scotland and Ireland. More recently her work has focused on the Early Neolithic of Orkney as well as Early Neolithic kinship. She is the author of *The Neolithic of Britain and Ireland* and *Monuments in the making: raising the great dolmens in early Neolithic northern Europe* (with Colin Richards).

Stephen Davis began his career as a specialist in insect remains, studying raised mires, lowland river systems and Irish burnt mounds from an environmental archaeology perspective. Since his appointment at University College Dublin in 2006, he has expanded his interests to include remote sensing, geophysical survey and digital recording, undertaking fieldwork amongst others at Brú na Bóinne in Ireland and in Attica, Greece.

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Daniela Hofmann is Professor of Archaeology at Bergen University, where she teaches and researches mainly on the Neolithic of Europe. Her current interests include migration, kinship, ritual, social inequality and resistance to it, as well as social contacts and change. In her projects, she tries to combine theoretical approaches with a variety of methods, including bioarchaeological information, in an effort to write narratives that take into account different perspectives. She hopes that knowing about diversity in the past could help us create a fairer society today, but has doubts on whether this is actually working.

Rune Iversen is Associate Professor of Archaeology at the University of Copenhagen. His research focuses on the European Neolithic, including migrations, cultural interactions, art and iconography. He is currently PI of two research projects, one of them (*Deep histories of migration: the early Neolithic around the North Sea*) financed by the Independent Research Fund Denmark (IRFD, Grant 0132-00022B) and co-led with Daniela Hofmann and Vicki Cummings. He is also principal editor of the *Danish Journal of Archaeology*.

Luc Laporte is a Senior Researcher (DR CNRS, HDR, UMR 6566 CReAAH) in Rennes (France). He is a specialist of the Neolithic on the Atlantic coast of Europe and more broadly in megaliths in other parts of the world. His fieldwork has focused on the establishment of reference sites for the Neolithic period, particularly on the island of Oléron, Poitou-Charentes and Brittany; large projects have amongst others concerned the study of Tumulus C at Péré at Prissé-la-Charrière and a settlement of the Middle Neolithic. He has also directed an archaeological project in Senegal for the past twenty years. His research has been published in more than 160 articles and book chapters, as well as monographs and edited collections.

Chris Scarre is Emeritus Professor of Archaeology at Durham University. His principal research focus is prehistoric monumentality in Atlantic Europe, and he has directed and co-directed excavations at prehistoric sites in France, Portugal and the Channel Islands.

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Alasdair Whittle is an Emeritus Research Professor and Fellow of the British Academy. He taught and researched at Cardiff University for nearly 40 years. He has specialised in the study of the Neolithic period in Britain and across Europe, working at varying scales ranging from continent-wide synthesis to detailed site examination. He has excavated in Scotland, England, Wales, Hungary and Germany. His involvement over the last 20 years and more in formal chronological modelling in a Bayesian framework (principally with Alex Bayliss and Frances Healy) now enables the production of much more precise sequences for the remote past, which has led to his advocating a more historical approach to our narratives.

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THE EARLY NEOLITHIC OF NORTHERN EUROPE

New approaches to migration, movement and social connection

Vicki Cummings, Rune Iversen and Daniela Hofmann

Abstract

This volume is the outcome of a two-day conference held at the University of Copenhagen in 2023 on connections across Early Neolithic north-west Europe. Participants discussed a broad range of issues surrounding monumentality (with a particular focus on early monument types, such as dolmens), ritual practices like structured deposition, and theoretical and methodological developments. Their papers are presented in this volume and briefly summarised here, drawing out some central themes for future migration studies, notably the identity-building role of artefacts and practices, the relationship between individual journeying and larger patterns of connectivity, and the influence (if any) of initial migration routes on how contact networks developed in the longer term.

Keywords: Early Neolithic; depositional practice; monuments; migration; mobility

Background

The Neolithic saw one of the most dramatic changes in European prehistory as agriculture and its associated practices spread into and across the continent. Ancient DNA data have revealed that this process took place primarily, although not entirely, via the migration of people (Allentoft *et al.* 2024; Brace *et al.* 2019; Cassidy *et al*. 2016; Fernandes *et al*. 2018; Rivollat *et al*. 2020). However, the simple fact that migration has taken place does not in itself provide all the answers. Amongst others, questions that have come to the fore as part of the debates surrounding aDNA data concern the speed and modalities of migration, how newcomers and resident populations interacted, and how material culture and practices changed and creolised as a result (see, for example, Whittle *et al*. 2022a). One of the less explored questions concerns the longer-term connections between potential source and destination areas or indeed between different destination areas settled by possibly connected populations, although such later movements have been flagged up as relevant even in early works on the topic (e.g. Anthony 1990). To address one such possible case, a project was initiated by the authors (*Deep histories of migration: the Early Neolithic around the North Sea*, supported by the Independent Research Fund Denmark) in order to uncover the longer-term social impact of migration into northern and north-western Europe in the fourth millennium BC. We sought to explore the relationship between different forms of contact and material culture change. The overall

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aim of the project is to reveal how these connections developed and changed during the Early Neolithic, a period of some 700 years.

Elsewhere we have provided an overview of the kinds of issues that considerations of migration face (Cummings *et al.* 2022). There we note that because mobility and migration are social processes, they will not simply proceed along the shortest possible routes in limited, one-off events and/or in just one direction of influence. Instead, there is potential for continued mobility and migration over the longer term, depending on how different groups perceive their relations with others around them or with now-distant kin. Perceptions of migration as a social strategy will also influence how likely people are to continue moving, at what scale and over what distances. In order to trace whether such communication routes existed, and whether they were direct and frequent, or more rare and diffuse, our project focuses on sets of complex, but connected practices, specifically details of monument construction and depositional practice. These practices were chosen because they were important to people, forming a recurrent component of Neolithic life, but also because there is the potential that gatherings at such sites would involve many people, including visitors, who could tell others about innovations and changes they witnessed. Monuments and depositional events are central for the creation of community identities, social cohesion and world views and as such they can help us to tease out multiple possible links between areas by comparing whether (and how far) details of such practices 'travelled'. One main question therefore also concerns how similarities between areas can be interpreted — which indicate direct links, which can rather be seen as divergence from a common root, and which may even be coincidental?

In order to explore our research questions, the project has selected micro-regions within southern Scandinavia, Britain and Ireland (Figure 1). This part of north-west Europe was chosen as a relevant study area as it was influenced by comparable Neolithisation processes at roughly the same time, around 4000 BC, including the arrival of central European farmers and the introduction of agriculture and animal husbandry, succeeded by large-scale monument building and associated ritual depositions. A detailed comparison of the selected micro-regions will allow an assessment of whether initial migration routes as suggested in the literature (e.g. Whittle *et al.* 2011) had a long-lasting after-effect in structuring contacts, and whether there were points at which such contacts changed, diversified or were even no longer sought at all. These regions have been selected on the basis of their archaeological signatures as those most likely to provide rich sources of evidence for comparison, as well as an even geographical spread across the study area. They are:

- Northern Jutland
- Funen
- West Wales
- North-western Ireland
- Central-eastern Ireland
- Central-western Scotland
- South-eastern England

Material from these case study areas has been collected in a database which is currently being analysed using network analysis and various other statistical approaches to try and tease apart different modalities of contact, or indeed its absence. It is still relatively rare within megalithic studies to compare architectural detail in this formal way, testing

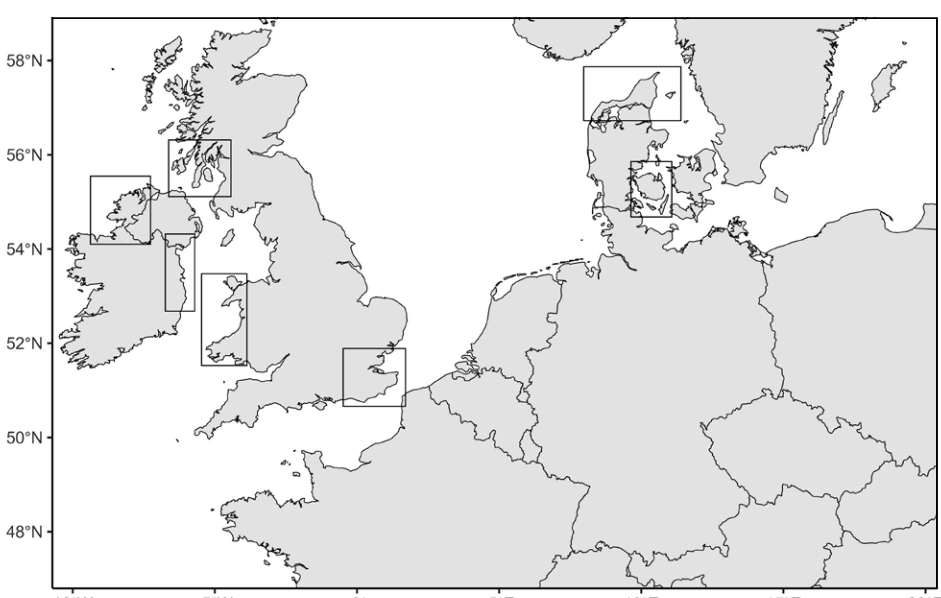

Figure 1. Map of northern Europe showing the case study areas selected for the *Deep histories of migration* project (mapping: Mikkel Nørtoft, Vicki Cummings).

out the potential of different approaches, and we look forward to interpreting the resulting patterns. Also, while these case study areas can be considered representative of wider regions and practices, and their comparison important for identifying the ebb and flow of wider connections or spheres of influence, we have been aware from the outset that ideally, a much broader geographical area would be included to gain a fuller picture. In order to further understand these areas, and current research projects under way, we organised a two-day conference at the University of Copenhagen in May 2023. At that event we heard from colleagues across Europe, albeit with a northern European focus, and we were able to set our own research project into a wider context.

This volume collects most of the papers presented at that conference. In this introductory chapter we outline some of the key themes that we identified during the event and subsequent discussions. Undoubtedly, readers will themselves find further parallels across wider areas, as well as areas warranting further investigation. What is clear is that investigations of migration, movement and social connection have been at the very heart of many studies for over a century, as we try to understand both the bigger picture of Neolithisation alongside the lived experience of people moving to new places. The conference also revealed that there is still much that we can learn about these issues as new data, methods and interpretations change our view of life in the Early Neolithic.

Key themes from the conference: contacts, connections and vibrant materials

Even the earliest considerations of the start and spread of the Neolithic identified a Near Eastern origin and subsequent transmission into Europe (e.g. Childe 1925). For Britain, Ireland and southern Scandinavia, it has been understood that the Neolithic spread from adjacent areas of the Continent, but the nature of contact and connections was rarely explicitly considered (a notable exception being Case 1969). In the latter part of the twentieth century debate shifted to the mechanisms by which the Neolithic spread (i.e. either by incoming Neolithic peoples or by native hunter-gatherer populations adopting a Neolithic way of life). It has only been in the twenty-first century that the precise nature of contact has been explored more explicitly, even if specific origins have often continued to elude us. Indeed, there may be cases in which migration itself has functioned as a transformative process in which new, composite identities were forged (e.g. Hofmann *et al.* 2024; submitted; Thomas this volume). Even so, the search for contacts has focused primarily on the *initial* phase of Neolithisation (e.g. Callaghan and Scarre 2009; Garrow and Sturt 2011; Sheridan 2010), in spite of further and later connections visible in the form of passage tombs in Britain, Ireland and southern Scandinavia.

Our ability to trace connections and contacts has been enhanced in the last decade or so through a series of different approaches, including various methods such as isotopic analysis and aDNA. Their application to increasingly fine-grained case studies, for example the identification of biological relatedness within and between sites, is opening a rich source for exploring connections and some aspects of (inter-generational) mobility in the future. Similarly, advances in radiocarbon dating, most notably Bayesian modelling, have provided us with much more refined chronologies (e.g. Whittle *et al.* 2011) and this enables us to see patterns of activity, and the spread of practices, much more clearly (e.g. Whittle *et al.* 2022b). Likewise, we now have a much fuller understanding of the source material of stones, and the biography of objects, which enables us to see patterns of trade and exchange, both of the objects themselves and of the techniques used to make them (e.g. Davis and Edmonds 2011). All of these different approaches to the archaeological record document that contacts and connections vary considerably through both space and time, and are clearly in place well beyond the onset of the Neolithic. The question now is whether the history of earlier migrations still had any kind of influence on how these connections panned out. Many different papers in this volume tackle these issues in more detail.

One of the most striking aspects of the Neolithic is how particular forms of material culture are found repeatedly across Europe, so much so that the spread of the material things associated with the Neolithic is often referred to as a 'package'. At one level this is perhaps not surprising: the advent of farming and therefore its associated practices such as dairying and processing cereals are likely to manifest themselves in similar ways, especially now that we know that the influence of existing Mesolithic peoples in various regions of Europe was far less marked than was often thought to be the case (e.g. Thomas 2013; Zvelebil and Rowley Conwy 1984; 1986). People migrating into new areas would have taken traditions of practice with them, although we often see people quickly reimagining those practices when they reach a new area (see, for example, Cummings *et al.* 2022; Thomas this volume)[1].

One element that came out very strongly in the conference is how certain things and practices beyond

1 It should also be noted that at a European scale, there remains significant diversity in how the Neolithic spread. The strong role of migration in the west is opposed to areas east of a cultural border zone with predominantly hunter-gatherer populations, cutting through Europe from the Black Sea to the Baltic. There, local hunter-gatherer ancestry was maintained without any notable admixture with Anatolian-descended farmer populations (Allentoft *et al.* 2024), and any Neolithic things and practices were adopted piecemeal by resident groups. The material culture of these 'Neolithic' hunter-gatherers seems largely unrelated to those of western Europe (e.g. Gronenborn and Dolukhanov 2015).

Figure 2. The dolmen at Troldkirken, northern Jutland — a vibrant form of architecture in the Neolithic of north-west Europe (photo: Rune Iversen).

the technological and economic seem to have particularly caught peoples' imagination in the Neolithic. Drawing on the work of Jane Bennett (2010), we would like to evoke the notion of 'vibrant matter' and the idea that some things at particular times possess a vital materiality which sometimes transcends their otherwise quite ordinary nature. There is now for example a significant literature on the importance of specific stones in the Early Neolithic, often, but not always, in the form of axes. The study of jadeitite has revealed the extraordinary networks of transmission of this distinctive green stone, with material travelling from sources in the Alps over hundreds of kilometres (e.g. Pétrequin *et al.* 2012). Other green materials were similarly important in other places and times (e.g. amphibolite in the LBK and variscite in Iberia, Borrell *et al.* 2015; Ramminger 2007), as were other intensely coloured and recognisable rocks, while the colours red and white are also mentioned as particularly meaningfully charged (see e.g. papers in Jones and MacGregor 2002). Beyond colour, the lustre and shine of specific materials (e.g. Chapman 2006), and not least their exotic provenance (e.g. Helms 1988), were likely important. There is no reason to think that specific practices and the knowledge they embodied did not have a similar social impact.

One of us has written elsewhere about how the building of certain monuments in the Early Neolithic similarly evoked senses of awe and wonder in their construction. These were the dolmens of north-west Europe, found in parts of Ireland, Britain and Denmark in particular (Cummings and Richards 2021). These monuments utilised large stones in their construction and in doing so started an interest in large stones that continued, in Britain and Ireland at least, to the end of the Neolithic period. These large stones, lifted and displayed as the capstones on dolmen monuments, could also be considered a vibrant material in the Neolithic world (Figure 2).

The importance of ritual activity, often involving vibrant materials, in the creation of new communities is a central concern of several papers. It was clear that, once established, communities required ritualised practices to create cohesion in what was otherwise quite a fluid world or to provide a focus for expanding populations. There were many different ways in which people could come together and labour (cf. McFadyen 2006) but it is clear that the dead provided a particularly powerful medium through which people could create new social realities.

The importance of the dead in terms of legitimising lines of descent and the use of specific places has recently been illustrated in the example of Hazleton North long cairn, Gloucestershire, England. Here, a long cairn with two opposing chambers was constructed, and the remains of at least 41 people were subsequently buried at the site (Saville 1990). The recent aDNA analyses of these human remains has revealed that the vast majority of those interred within the chambers were biologically related (Fowler *et al.* 2021) as the offspring (children and grandchildren) of a single male and four different women. It appears that this monument may have been constructed by a new lineage seeking to define themselves through monumental construction and subsequent deposition of particular, selected members of that lineage (see Cummings and Fowler 2023). This chimes with ideas that ways of reckoning kinship may have been particularly flexible and open at times of widespread movement and migration (e.g. Hofmann and Bickle in press). We have known the deposition of human remains in chambered tombs since they were first investigated, but using aDNA analysis we can see some of the parameters in the selections of the dead and what this might have meant for social cohesion and ritual practice (see also Rivollat *et al.* 2022). The burial of the dead is just one such arena, but there are others, discussed both in this volume and also within our project, which demonstrate the power of ritual action to unite dispersed individuals and create new social identities.

The papers in this volume are arranged broadly regionally, following an arc from France and the Netherlands to Britain and Ireland and finally southern Scandinavia. However, the themes identified above provide interesting links across regions as well. In what follows, we will draw attention to some of these, but hope readers will identify many more.

The papers in this volume

Dealing most directly with connections and mobility is Bettina Schulz Paulsson's survey on Stone Age boats of Atlantic Europe. She specifically highlights the fact that we have abundant evidence of sea crossings in the material culture, but only limited knowledge on the nautical technologies and the maritime capabilities of the societies involved. The paper focusses on megalithic art and rock art found in Brittany and Fennoscandia, which provides insights into watercraft technologies and the maritime achievements of Stone Age communities during the fifth and fourth millennia BC. Against this background she is able to identify the use of smaller boats characteristic of an early phase of fishing and hunting marine mammals. In later phases boats, presumably made from various materials, grew larger to contain more crew and cargo needed for longer expeditions. This paper thus provides important background on the *how* of contact and the technologies and know-how of maintaining it.

On a similar nautical theme, the paper by Chris Scarre considers the sequences from three island groups — the Channel Islands, the Scilly Isles and the Isle of Man. The archaeological record demonstrates that all three island groups were accessible to both Mesolithic and Neolithic seafarers, but that patterns of contact were very variable. Scarre argues that this variability may have depended on attractiveness for permanent settlement, as well as being influenced by the relative difficulty and danger of making the necessary sea crossings. He makes an important point that island communities will have been dependent on connections for access to the wider social and cultural world — and that these connections will not always be visible via the material record.

Having identified the role of movement across the sea, when and why people embarked on these journeys is an important theme for our authors. Karl-Göran Sjögren uses a database of radiocarbon dates to investigate when and how Neolithic things and practices first reached southern Sweden, an area where preservation conditions are not suitable for the large-scale application of aDNA on human remains. He suggests a leapfrog process of longer journeys interspersed with periods of standstill, rather than a gradual filling-in of the landscape, drawing attention to the event-like character of such episodes and the importance of sea travel. To this we must add the necessity of planning such journeys, for example through interaction with the local hunter-gatherer inhabitants. Overall, a dynamic model emerges, in which prestige, group fissioning and ultimately the politics of small-scale societies play a much greater role than 'big' push factors such as demographic growth or climatic challenges.

Similarly, Alasdair Whittle provides a revised summary of the introduction of Neolithic things and practices to mainland Britain, taking into account recent dating programmes undertaken since the publication of the seminal *Gathering Time* volume in 2011. He summarises the possible contacts between Britain and the Continent on the eve of the arrival of agricultural settlers, and also opens for the possibility of continued influx from mainland Europe as late as the thirty-eighth century BC, although insular developments may also be responsible for further expansion here. Britain and Ireland remain flagship case studies for investigating migration processes, largely because so much ground work has already been done in providing a good chronological framework that offers the potential to isolate specific processes.

Tom Booth's paper makes use of these possibilities by questioning why the arrival of the Neolithic in Britain, and a second migration wave towards the end of the period, had a larger demographic impact here than on the European continent, with the haplogroups of the respective resident population being replaced to a much higher degree by incoming ones. There is no easy answer, and the potential role of violence, disease and other 'hard factors' is considered alongside social reasons. Booth also points out that innovations in farming technology (for example postulated by Schier 2017) may have been necessary to settle in Europe's northern and western regions in the first place.

This is also a key aspect for Martin Hinz, who compares Britain, Jutland and Switzerland in terms of the longer-term trajectories of Neolithic settlement. He suggests that the establishment of different economic regimes in these areas, more or less in tune with local conditions, may have influenced the relative resilience of the first agricultural societies. For him, this partly has to do with patterns of hunter-gatherer involvement — introducing the Neolithic in Switzerland, which saw less marked genetic turn-over, may have happened with more local know-how, increasing its adaptation to this specific environment (see also Teather and Sørensen, this volume).

The paper by Julian Thomas also discusses the modalities of how people established themselves in a new area. He contemplates the influence genetic studies have had on the debate on the start and spread of the Neolithic, in some ways enabling a return to theoretically problematic culture-historical models. Instead, Thomas argues, we should explore the Early Neolithic of Britain as the coming together of a diverse set of people, things and practices which were different from what was left behind, with migration as a defining experience binding people into new social networks. Particular material things, architectures and ritual practices were key for bringing people together to forge new identities in this way.

This does not only apply to the Early Neolithic. In his thorough contribution, built on the Bayesian re-analysis of large sets of radiocarbon dates from several regions in France, Luc Laporte identifies an interval of a few centuries, between 3700/3600 and 3400/3300 cal BC, when there is no attested megalith building in France, even though there is considerable construction activity elsewhere. He suggests that two distinct logics of monumentality were active in the two periods before and after this gap, and that these fundamental ideological changes may have been connected with renewed episodes of mobility and migration, with new people bringing with them (and perhaps being united by) new ways of doing things.

In such scenarios, change and continuity must be carefully weighed. Stephen Davis presents a summary of extensive investigations of the landscapes around the River Boyne, Co. Meath, Ireland, focusing on the activities predating the exceptional monumental constructions of the later fourth millennium BC. There is now good evidence for both pre-passage tomb monuments as well as settlement. Both of these forms of evidence are suggestive of broader networks and the similarity of practice as found elsewhere in northern Europe at this time. It is only a few hundred years into the Neolithic that this particular landscape became a place which saw unprecedented, and in many ways unparalleled levels of monument construction. In this case at least, then, early place-making activities were very important in structuring what came later, but this anchoring in local practice did not cut the Boyne Valley off from wider trends — quite the opposite.

Similarly, Luc Amkreutz introduces the Dutch Neolithic monument of Stein, which geographically sits at a crossroads between different monumental traditions and combines influences from many different areas, potentially even including local hunter-gatherer input. It is, therefore, a site that is at once of its place and time — something like this could not have been built anywhere else — but also redolent of connections and inspirations to other areas, encapsulating the kinds of complex fusion processes our *Deep histories of migration* project is also dealing with.

Niels H. Andersen picks up on the similarities between monuments in the Sarup area of south-west Funen, Denmark, and selected sites in Britain. These similarities concern both strikingly visible aspects of monumental architecture, such as the capstones of dolmens, but also details hidden to the casual observer, such as wooden elements. This raises questions of connections, but (similar to Davis, this volume) also of memory and of the ways in which ritual traditions may have been transmitted over time, a point Andersen discusses with reference to causewayed enclosures in Denmark and Britain. In both regions, a concern with the past was evidently an important aspect of Neolithic ritual, but we must also begin to seriously question how practices, ideas and inspirations could have spread.

It seems clear that individual and small-group mobility remained important between bigger migration events. All of these episodes were ultimately based on incentives to keep in contact with specific people, and on knowledge about distant places, and these were often materialised through important objects. In a paper focussed on Orkney, Hugo Anderson-Whymark examines the distribution of artefacts from the Late Neolithic. In particular, he lays out the role of the Stenness-Brodgar monument complex for creating and maintaining wider connections. The concentration of imported artefacts found there indicates that this area was the final destination of many long-distance journeys, showing the ongoing levels of contact, even with more remote areas of the Neolithic world. This also raises the question over which groups of people may have controlled or filtered access to travel or to the materials derived from far away. Was mobility and migration an option open to everyone, and was it equally accessible at different times?

In their contribution, Anne Teather and Lasse Vilien Sørensen highlight the role of existing knowledge for being able to source desired materials, also in new areas. A central point is that the current models of cultural change at the beginning of the Neolithic underestimate the significance of landscapes for specific cultural and symbolic activities. On the basis of deep shaft flint mining, they argue that enacting such activities must have involved embedded landscape learning, including geological knowledge held by Neolithic migrants. Furthermore, communities living in Britain, Scandinavia and Belgium seem to have maintained continuous contacts spanning several hundred years, as similar deposits and artistic expressions are found in mines within these regions. These observations are important as they cast the Neolithisation in Britain and southern Scandinavia as social process of landscape learning lasting several generations. Hence, Neolithisation is not a single event, but rather a lengthy process with several migrations of incoming farmers and involving various degrees of interaction with the indigenous hunter-gatherers.

The result of flint extraction activities, including deep shaft mining, is usually manifested in high-quality flint axes of significant size, which were distributed in great numbers from flint-rich areas to regions with shortages of this important raw material. Here, unused or even unfinished oversized specimens could end up being deposited in the landscape. This particular find group is reviewed by Almut Schülke in her contribution on 'ceremonial flint axes'. Her article concerns the inner Oslo Fjord area in south-eastern Norway, a region at the fringe of Neolithic Europe. Here, the deposition of 'ceremonial' thin-butted flint axes from the later fourth millennium BC is argued to have taken place as part of important social and political events in a period of change characterised by the negotiation between different lifestyles. Again, a specific ritual practice concerning very specific materials was crucial in how Neolithic ways of life spread.

In a paper considering flint tool depositions at causewayed enclosures in both Britain and Denmark, Peter Bye-Jensen utilises use-wear analysis to suggest that people deliberately selected tools used in a variety of different ways for deposition at these sites. These tools may well have represented different activities, different people and different places and were brought together and orchestrated with other forms of material culture to create meaningful deposits at these enclosures. This potential history of long-term curation, revealed thanks to detailed attention to taphonomic factors, contrasts with other Neolithic case studies (e.g. Berckhan forthcoming) and could be a tradition specific to northern Europe. What sorts of shared ideas may lie behind its enactment remains to be discussed, but this paper also shows the importance of revisiting old archives and assemblages with new methods to extract relevant information.

Jessica Smyth and her co-authors similarly report on a project which is re-investigating cremated remains from passage tombs in Ireland. Dating from a few hundred years into the Neolithic, passage tombs have seen considerable interest and investigation, generally beginning with antiquaries or early archaeologists, leaving us with an often problematic data set. This paper sets out new work exploring the cremated remains from Carrowkeel, Knockroe and Fourknocks passage tombs, all of which indicate that significant numbers of cremated human remains were being interred. Such work is time-intensive and detailed, but reveals complex sequences of interaction with human remains that may well have a longer history.

Asking the kinds of detailed questions raised by our authors also makes huge demands on the quality of the underlying dataset, a point here raised by Alfredo Cortell-Nicolau. He summarises various kinds of inherent biases that influence archaeological interpretation, with particular reference to the spread of the Early Neolithic in various areas of Europe. For our focus on monuments and depositional practice, this is a timely reminder to reconsider the determining role of monument typologies in trying to establish connections, and how their use may already narrow our investigations to collecting specific types of data only. This partial recording is an issue our project has run up against on multiple occasions.

Long-term connections in the Early Neolithic — where do we go from here?

This collected set of papers from studies and projects across north-west Europe highlight what an exciting time it is to be exploring the spread of the Neolithic in this area. Understanding the movement and migration of people is absolutely central in moving the debate on Neolithisation forward, and genetic studies are crucial for furthering our understanding of this period of time. However, these papers also clearly demonstrate that such data alone are not enough to fully characterise the complex processes underway at this time. Broader, population-level patterns of mobility need to be set against the lived experiences of the people on the ground. Isotopic and genetic studies also have the potential to reveal impressively detailed information at the individual level, demonstrating significantly different life histories, and we must balance the stories of the 'odd ones out' with those of the broader Neolithic population and their lived experiences. A good example is the so-called Vittrup Man, whose complex life history could be reconstructed in high resolution. It revealed that despite growing up far to the north in a hunter-fisher-gatherer setting, he spent half his life as a 'genetic foreigner' in Neolithic Denmark. This constellation has given rise to various interesting interpretative possibilities, including a role as slave or war captive, or a fully-integrated member of the Neolithic community (Fischer *et al.* 2024). In either case, the question also remains what might have induced individuals to travel to radically different places, how they experienced the things and practices they encountered there, and how they decided what to adopt.

Therefore, bioarchaeological data, evidence from across north-west Europe and wider approaches to interpretation need to be placed alongside a detailed and contextual study of things and practices. This set of papers demonstrate the types of insight we can gain when exploring the archaeological record from the start of the Neolithic, and ultimately this is the aim of our *Deep histories of migration* project. As the papers presented here show, this can be achieved in many ways, including a variety of archaeological features, materials and case study regions. As our own project investigates the longer-term social impact of migration into Britain, Ireland and southern Scandinavia via monuments and structured deposits, it will only reveal a fraction of Early Neolithic mobility. Therefore, we are excited to see what new studies, approaches and directions the future will bring. Our conference in May 2023 and the papers presented in this volume are a contribution to this debate.

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FUNERARY PRACTICES ON THE FRINGE

The social dimensions of the Neolithic burial chamber of Stein and its European connections

Luc Amkreutz

Abstract

The Neolithic in north-western Europe is in large parts a more or less clear-cut case where there is an obvious transition between hunter-gatherers and subsequent farming communities. In the Low Countries the situation is somewhat different. It is characterised by a very gradual process of Neolithisation and appears to be at a crossroads of cultural interaction in the Middle Neolithic. This has certain repercussions that colour cultural phenomena such as artefact and burial traditions that seem to harbour combinations of regionally distinct traditions. In this contribution the Neolithic burial chamber of Stein (Limburg, the Netherlands), dating to the latter part of the fourth millennium, is presented as a case study, demonstrating the combination and integration of different regional cultural practices. It is argued that for a better understanding of the developments in the Neolithic we need to think beyond distinct lines of archaeological cultures and material repertoires.

Keywords: Neolithisation; Stein group; Low Countries; hybridisation; Neolithic; TRB; Seine-Oise-Marne culture; Wartberg culture; Vlaardingen culture

Introduction

The process of Neolithisation in continental north-west Europe is diverse and varied. Yet, overall there appears to be a general trend in which the advent of the Linearbandkeramik is followed by subsequent Middle Neolithic groups such as the Rössen, Chasséen and Michelsberg cultures, and a moment, around 4000 cal BC, where there is a more or less defined watershed at which we see a clear development of the Neolithic in both Scandinavia (following the Ertebølle culture) and Great Britain (e.g. Bradley 2007). The situation in the Low Countries seems to distinctly diverge from that pattern in some areas. There is a comparable sequence on the southern Pleistocene soils, while the situation in the north-east of the Netherlands is characterised by the development of the Funnel Beaker culture in the later fourth millennium. In the western wetlands, however, there is a very extended process of Neolithisation which appears to involve a gradual transformation of indigenous Mesolithic communities that sequentially incorporate elements of a Neolithic existence over a period of up to two millennia (see Amkreutz 2013; Louwe Kooijmans 2007; 2022). It is clear that this is a different trajectory that places emphasis on the role played by indigenous communities. In order to understand these extended processes of intra-

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cultural change and contact between farmers and hunter-gatherers-becoming-farmers we need to understand the different modes of movement and interaction that existed and develop a vocabulary that enables doing this (e.g. Hofmann *et al.* 2022; Raemaekers 2022). This has gained an extra pertinent dimension with the advent of aDNA studies within the Third Science Revolution (cf. Kristiansen 2014). These studies have demonstrated the diverse patterns of admixture that exist within hunter-gatherer and farmer communities, reflecting biological interactions that importantly shaped (later) Neolithic populations (e.g. Rivollat *et al.* 2020). It has been argued, however, that we should be wary of imposing top-down and often large-scale genetic patterns on the diverse archaeological record that traditionally is studied from a bottom-up, site-oriented perspective (e.g. Hofmann *et al.* 2022, 285). In the Low Countries, (future) aDNA and most isotopic studies will mainly be limited to the western wetland area with good organic preservation, and therefore to the communities of hunter-gatherers-becoming-farmers. The importance of the correlation of bioarchaeological data and traditional archaeological data from site and material culture studies is therefore of importance if we want to understand the dynamics of this period. This has for instance been noted for the wetland Swifterbant culture (e.g. Raemaekers 2022). At the same time, however, the southern and eastern Neolithic communities that formed the background for the developments taking place in terms of innovation, migration, food economy and material culture, the 'source communities', as it were, are often perceived as largely unchanging (because already Neolithic) and static. This appears to be a remnant of the culture concept that still permeates our thinking of the Neolithic past and essentially has distinct connotations of boundaries and ethnicity (Nyland *et al.* 2023, 21). However, if we want to better understand the developments taking place in the Neolithic we need to acknowledge that there is evidence for interaction and permeability in all the communities involved, so both those 'becoming Neolithic' and those that can be seen as developing from originally Bandkeramik migrations into the area (Louwe Kooijmans 2007). Moreover, we need to be aware that this interaction distinctly not only takes place *between* the communities we culturally define, but also *within* them and that this may have diverged in time, place and intensity. In this small contribution I will highlight an archaeological monument from the Middle to Late Neolithic Stein group (*c.* 3600–2900 cal BC) that is indicative of these ongoing cultural contacts and in itself forms an example of long-distance interaction and mobility. Subsequently I discuss the wider cultural landscape to which the different components characterising the burial may relate. But first of all, I will present a short background sketch of the Neolithic in the Lower Rhine area.

Becoming Neolithic in the Lower Rhine area

The long-term process of Neolithisation in the Lower Rhine area is complex and multi-stranded (see Amkreutz 2013; Louwe Kooijmans 2007) (Figure 1). After the arrival of migrant LBK farmers on the Dutch loess soils around 5250 cal BC we see a southern development that involves the Rössen and Blicquy groups, followed by the Michelsberg culture in the fifth millennium. At the same time, the indigenous Mesolithic communities in the western and northern wetlands see material, economic and social changes that relate to these Neolithic communities on their margins. This starts with the development of indigenous, largely point-based pottery, at which point we speak of the Swifterbant culture. In its first phases this is in fact a ceramic Mesolithic. Ongoing research from amongst others the EDAN-project (the Emergence of Domestic Animals in the Netherlands, 2020–2024; Raemaekers 2022) has indicated that apart from early introductions of sheep and pig around 4500–4300 cal BC at the Hardinxveld site (Dresjhaj *et al.* 2023), all four species of farm animals appear to be present after 4300 cal BC with more solid evidence for animal husbandry after 4000 cal BC. Crop cultivation also seems to be well established after 4300 cal BC (Out 2009). Furthermore, relatively new Swifterbant sites, such as Nieuwegein and Tiel (Ten Anscher and Knippenberg 2022), substantiate the evidence for permanently occupied settlements and an important role for agricultural resources, similar to the slightly younger Schipluiden site of the Hazendonk group. All the while the argument that herewith an 'end date' for the transition to farming is provided (*sensu* Raemaekers 2022, 300; see also Kamjan *et al.* 2020) remains a matter of debate and perhaps semantics (Dusseldorp and Amkreutz 2020; see also Amkreutz 2022), as the focus on individual sites in the light of the broad spectrum of economic, biological and socially diverse aspects that characterise Swifterbant and subsequent Hazendonk sites allows for different answers depending on what is deemed typically Neolithic and when a process is believed to be completed (e.g. Amkreutz 2013; 2022). Recent evidence from aDNA studies, for instance in the German Blätterhöhle, also indicates that from isotopic and genetic perspectives there is much evidence for a continuing Mesolithic component well into the fourth millennium (Bollongino *et al.* 2013). This is also the case for the subsequent Vlaardingen culture, defined for the western and central wetland area between roughly 3500 and 2500 cal BC. Several of its sites exhibit an economic spectrum that comprises abundant wild resources, while evidence of year-round permanency is absent for some sites (Amkreutz 2022). Roughly around the same time (3600–2900 BC) the Stein group is present on the southern Pleistocene soils. This group has either been interpreted as an upland or Pleistocene

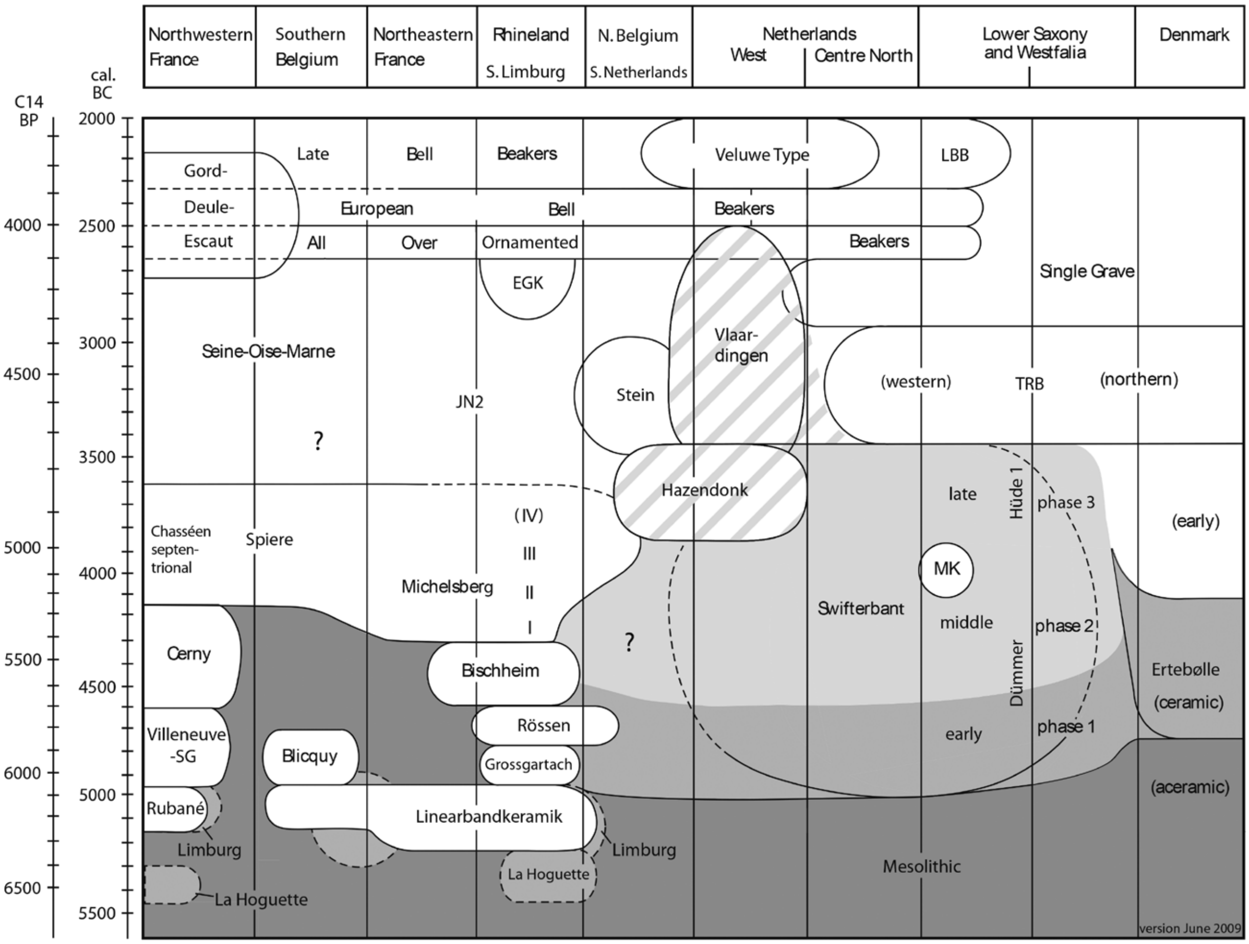

Figure 1. Spatio-temporal culture chart of the Mesolithic and subsequent Neolithic cultures in the Lower Rhine Area (based on and adapted from Amkreutz 2013; Louwe Kooijmans 2007).

counterpart of the wetland-oriented Vlaardingen culture, in fact forming a continuity of cultural variations, or has been seen as more separate, evolving out of preceding Michelsberg communities and culturally associated with the larger Seine-Oise-Marne complex (SOM), where it forms a cultural grouping with the aforementioned Vlaardingen culture in the Wartberg-Stein-Vlaardingen group (Amkreutz 2013; Louwe Kooijmans 1976; 1983; Verhart and Amkreutz 2017). Both Vlaardingen and Stein and the Seine-Oise-Marne complex are succeeded by Corded Ware and Bell Beaker communities, which in most places are classified as agricultural with a distinct pastoral component.

What the above-mentioned complex development towards fully agricultural societies in the Netherlands demonstrates is that, following the rather clear-cut case of the Linearbandkeramik, there appear to be a multitude of smaller and larger socio-economic and cultural developments into Neolithic communities, even in a small area like the Low Countries. The Lower Rhine Area in particular underlines the long-term impact of communities rooted in the Mesolithic within this process, especially in the wetlands. It demonstrates that elements of a Neolithic package were autonomously and diversely incorporated into existing practice, in fact creating a range of hybrid communities (Amkreutz 2022). To some extent these aspects will have had repercussions into the Late Neolithic. The Neolithic and Mesolithic 'signatures' of the related Vlaardingen-Stein group form a case in point. I will now present a megalithic monument from the previously little-known Stein group that questions the notions with which we often study this period and demonstrates the fluidity of cultural boundaries even in the very late Neolithic.

The Stein burial chamber

On the 3rd of April 1964, Leiden University professor Pieter J. Modderman discovered a unique constellation of rocks in his Bandkeramik settlement excavations in the current

Figure 2. Photograph of Pieter Modderman and his team excavating the Stein burial chamber in the spring of 1964 (Faculty of Archaeology, Leiden University).

village of Stein, Limburg (the Netherlands). His excavation of this feature several weeks later (Figure 2) resulted in the only 'megalithic' burial in the southern part of the Netherlands, although much of its construction was made of wood. The discovery of the Stein burial chamber and the pottery documented in the process was eponymous for the definition of the Stein group or culture. The description below is based on the initial excavation report by Modderman (1964) and a new study into the grave conducted in 2017 (Amkreutz and Verhart 2018; Verhart and Amkreutz 2017).

The burial chamber was constructed in a seemingly inconspicuous location on the Graetheide plateau. It consists of a shallow pit of no more than 50 cm below the Neolithic (and current) surface within which a stone floor or paving was constructed, oriented north-east–south-west and measuring roughly 5.5 × 1.75 m. The stones used were gathered from among gravels in the nearby Meuse valley. Recent research indicates that there were no exotic stones among them, but a pair of white quartz blocks behind a larger lintel stone seem to have marked the entrance to the burial chamber, something that may have been deliberate. As the stones were hauled from 500–600 m away this can be interpreted as a considerable investment of time and energy. The construction of the paving exhibited a recessed central zone of 35–55 cm and a rough tripartite division. An entrance part in the east is supposed to have been created by wider and flatter stones resulting in a relatively flat surface. Part of this entrance section may have been on the outside of the structure. Next to this is a smaller central room formed mainly by cobbles, and in the back, separated again by larger slabs, a back chamber or antechamber that again is somewhat larger (Figure 3). The sides of the paved area were characterised by gaps where postholes were documented, indicating that the roof was constructed with fairly large wooden posts, up to 40 cm in diameter, which possibly also supported a plank-built wall on their inside or outside. The entrance was possibly located in the eastern side. One metre north-east of the stone burial feature an isolated pit was discovered that also held some larger cobbles.

The contents of the grave are remarkable. Apart from several sherds these comprise a large S-shaped, flat-bottomed pot, typical of the Stein group and otherwise found in settlement contexts. The pot was found in the entrance section of the chamber and may have served for offerings or perhaps for transporting the cremated remains. Furthermore, a small collared flask was discovered. Recent research at the Dutch cultural heritage agency (RCE) indicated that the flask contained an organic substance, possibly a fluid, and may have been sealed with textile (Amkreutz and Verhart 2018; Verhart and Amkreutz 2017). On the spoil heap a polished flint axe was discovered. More conspicuous was the discovery of 45 fragments of bone arrowheads, including 11 more or less complete ones, the largest measuring 15 cm. The items were made with the groove-and-splinter technique (Verhart and Amkreutz 2017, 71) using bones of medium to large mammals. In addition, 105 transversal flint arrowheads (and fragments of at least four more) were recovered. This is a remarkably large number, especially if these were complete arrows. In that case they would point to the considerable importance of hunting in a largely agrarian Late Neolithic society, or perhaps they can be interpreted as warrior attributes.

Apart from this highly selective artefact assemblage, the chamber also yielded over 40 kg of cremated remains. An earlier report mistakenly based itself on only a small

Figure 3. Photograph (left) and 3D scan (right) of the east–west oriented paved area of the burial chamber (length 5.5 m) as preserved *in situ* in the Museum voor Grafculturen in Stein (Rijksmuseum van Oudheden).

selection of the finds, reporting five individuals and a child. Barbara Veselka (Verhart and Amkreutz 2017), however, was able to review the entire assemblage. This resulted in 42 individuals, men and women, including 36 adults and children as well as a foetus. Some of the cremated remains displayed evidence of stress such as illness and malnourishment, infections such as tooth decay, and osteoarthritis. The composition of the cremated remains indicates a collective burial, deposited in three loose concentrations with somewhat different degrees of burning suggestive of different pyres or moments in time. During the field campaign a distinct concentration of cremated skull parts was discovered as well. Next to the human remains a small number of cremated animal bones was discovered. These comprise a large fish vertebra, possibly of a pike, bones of a wild or domesticated pig and sheep or goat, as well as small bones of possibly a hare and a hedgehog or pine marten. The aforementioned arrowheads are burnt as well and must have been part of the funeral pyre. The collared flask also shows burn marks.

In sum, we are dealing with a burial chamber that consists of a stone floor and a wooden superstructure that may have been topped by an earthen mound. The cremated remains indicate a mixed composition representing what may have been a settlement community. Nevertheless, the spectrum of grave goods is fairly homogeneous and mainly consists of arrowheads. Most peculiar, however, is that the burial feature stands alone. In the wider regional and supraregional surroundings no comparable discoveries have been made at distances ranging for 100–300 km in various directions. This is thus a fairly unique feature regionally. On the other hand, if we look even further afield we appear to be finding parallels in various directions.

Cultural connections of a burial vault

In order to determine the cultural affiliations of the Stein burial monument it is possible to trace connections to other socio-cultural groups for different variables. These are presented below.

Structural joints

From a structural point of view, the Stein monument has no direct parallel (Figure 4 top and middle). The megalithic *hunebedden* of the TRB culture, which come into existence during this same timeframe in the northern part of the Netherlands, do come to mind, but are built with large moraine boulders and are much larger. At the same time we should not neglect the fact that these were also communal burial monuments with a roofed and chambered space that may have remained accessible for a

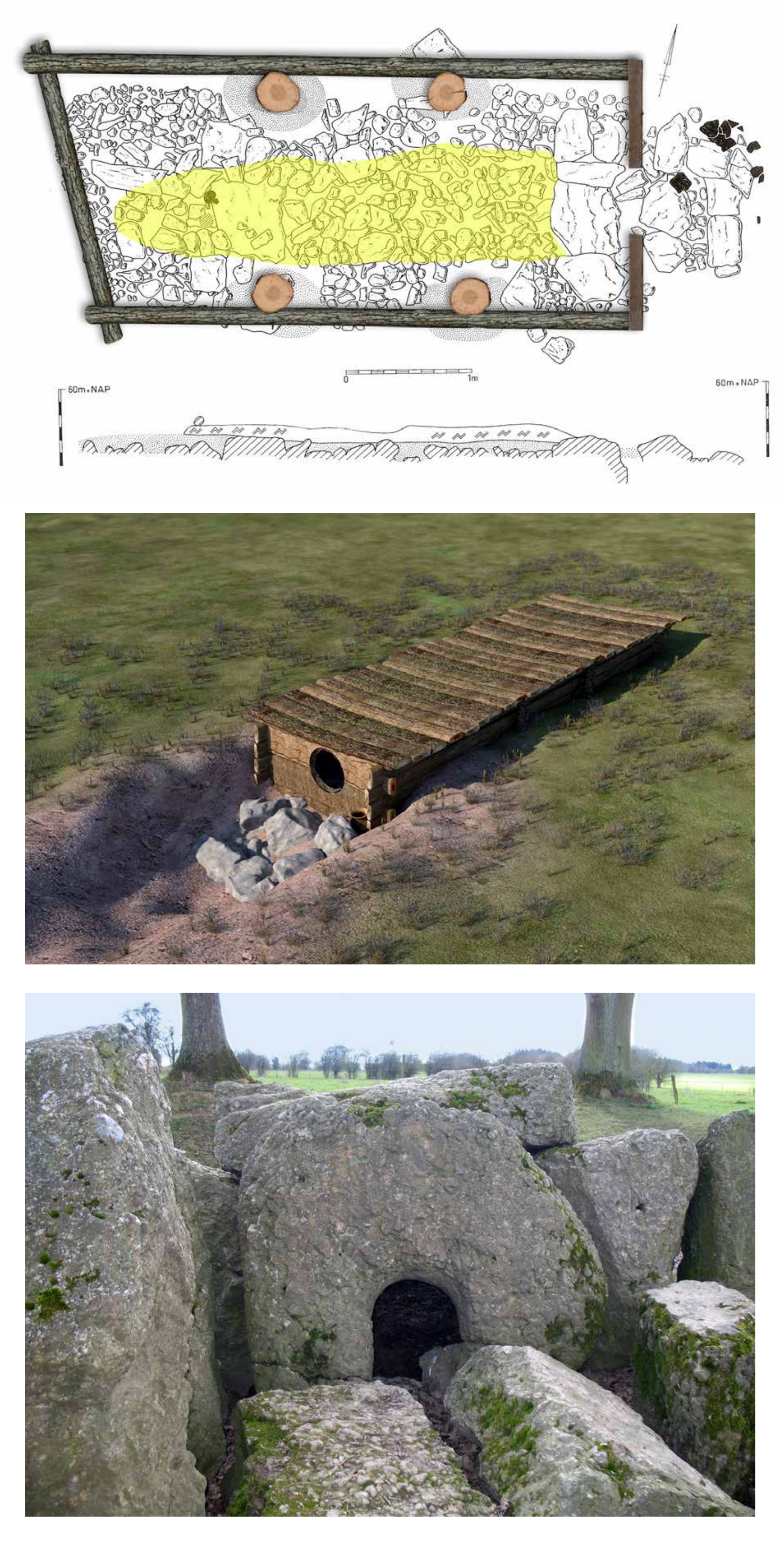

Figure 4. Reconstruction drawing (top) of the Stein burial chamber with walls and posts; the area with cremated remains is depicted in yellow (Rijksmuseum van Oudheden based on Modderman 1964); Artist's impression (middle) of the Stein burial chamber with possible mound (Rijksmuseum van Oudheden/Olav Odé); Photograph of the entrance section at the Wéris II monument (bottom) in the Ardennes (Rijksmuseum van Oudheden / Leo Verhart).

long time (e.g. Midgley 2008). If we look a bit further afield, there are distinct parallels in the Seine-Oise-Marne culture (SOM) in France, in particular in the Paris Basin, especially the so-called *allées sépulchrales* or *allées couvertes* (e.g. Blin 2018; Laporte *et al.* 2011). These are also characterised by rectangular chambered plans of upright stones, covered by stone slabs or wooden roofing and potentially an earthen mound. The floors are often paved and there is a clear entrance section that often includes pottery and other finds (e.g. Bailloud 1974). The north-eastern distribution of these monuments reaches as far as the Belgian Ardennes mountain range and Luxemburg. This is also where we find the nearest megalithic structures to our Stein burial, just under 100 km further south at Wéris. Two *allées sépulchrales* remain at Wéris, and both were built of large conglomerates situated in a landscape that also comprised menhirs. They appear to be built with separate chambers, including the entrance in the form of a small hole or *Seelenloch* (e.g. Toussaint *et al.* 2009; Verhart and Amkreutz 2017, 125–8) (Figure 4 bottom).

It would appear that the SOM groups may provide a good parallel or inspiration for our burial chamber at a somewhat closer distance than the megalithic TRB *hunebedden* in the north. However, we should also look east. There we see another megalithic phenomenon in the so-called *Galeriegräber* or *hessisch-westfälische Steinkisten* in central and northern Germany. These are associated with the TRB culture in the north, but further south also appear in the Walternienburg and Wartberg groups (e.g. Günther 1997; Raetzel-Fabian 2002). These elongated gallery graves are positioned in the ground, in a manner comparable to the *allées couvertes,* and are created by upright rows of stones with a stone or wooden cover and potentially an earthen mound. The entrance is mostly in the short side and can also be in the shape of a small circular *Seelenloch* (Verhart and Amkreutz 2017, 128–30). Obviously there is a considerable overlap between these kinds of monuments and the Stein chamber, and it appears our monument draws on the ideas underlying the *allées sépulchrales* and *Galeriegräber* or *Steinkisten*. Its geographic position right in the centre between both of these burial phenomena, yet isolated, is telling. Nevertheless, the neighbouring monuments are mainly built with large stones similar to the northern *hunebedden*. The absence of these in the southern part of the Netherlands, too far north of the Ardennes-Eifel mountain ranges and too far south for the erratic moraine boulders, seems to be the main reason for this. Furthermore, there are also monuments in these groups that appear to be largely constructed of wood. An example is the wooden burial chamber or cult house (skeletal remains were absent) of Warburg II (Günther 1997). This does not mean that wood and stone were interchangeable, but neither were the two rigidly kept apart, as the occurrence of wooden roofs also demonstrates.

Material mobility

Moving on to the artefacts, certain connections also appear. As argued above, the Stein site lent its name to the Stein group, which in the Netherlands is closely associated with the Vlaardingen culture. There have in fact been arguments to interpret this as one cultural group, with a 'wet' and 'dry' variant, all the more so since the pottery of both is largely indistinguishable, except for rim perforation in the Vlaardingen assemblages (Verhart 2010, 220). Whether that is the case remains up for debate. In any case the coarse pottery from Stein (Figure 5) is similar to that of a number of other sites of this group located in the Dutch and Belgian Meuse valley area, such as Toterfout, Koningsbosch, Kessel-Keuperheide, Geistingen and Linden-Kraaijenberg (Verhart and Amkreutz 2017, 58), but it clearly ties the site to other locations further afield and into the riverine delta and coastal area, where most sites are culturally classified as Vlaardingen. At the same time, the S-shaped profile and coarse make of the pottery is also reminiscent of the ceramic spectrum of the Seine-Oise-Marne culture group of the Paris Basin (D'Anna *et al.* 2008) and also seems affiliated with aspects of the Wartberg ceramic spectrum (e.g. Schwellnus 1979), although here there is more variability of shapes (Verhart and Amkreutz 2017, 140).

This is different if we look at the other ceramic element, the collared flask (Figure 5). Some fragments are known from Limburg, but they do not appear to have been a regular part of the Stein group material repertoire. Collared flasks, however, do appear in a number of cultural settings over north-west Europe (e.g. Knöll 1981), such as the Funnel Beaker (TRB) culture, which around 3400 cal BC became established in the northern Netherlands, over 200 km north of Stein. There are also some isolated finds of collared flasks in Brittany. The area between Stein and the Paris Basin, where other cultural connections of our site lie, appears to be largely devoid of this type. They again do occur in some instances in central Germany in the *hessisch-westfälische Steinkisten* and the *Wartberg Gruppe* (Verhart and Amkreutz 2017, 63). The occurrence of star-shaped collars seems typical for the central German burial monuments, such as Güntersberg near Gudensberg and Hasenberg near Lohne (Schwellnus 1979), indicating this may be a northern and eastern connection (although convincing parallels are known from Mellemballe in Denmark, Mooriem-Gellenerdeich in Germany and Ploubazlanec in Brittany: Knöll 1981; Modderman 1964).

Moving to the lithic finds, the axe from Stein (Figure 5) appears to be of a southern type of flint (possibly of Hesbaye type) and fits into the known spectrum of both the Stein group sites as well as those of the Vlaardingen culture. Axes also occur in burial chambers of contemporaneous groups. The 105 transversal arrowheads at Stein, of which most were burnt, are peculiar (Figure 5). These types of arrowheads do occur in the TRB culture, as well as in

Figure 5. Finds from the Stein burial chamber: large S-shaped pot (22.8 cm), collared flask (11.1 cm), selected bone and flint arrowheads (the longest is 15 cm), polished flint axe (length: 14 cm) and the cremated remains of one individual (scale 1:4) (Rijksmuseum van Oudheden).

the French SOM burials and in the German *Steinkisten* (e.g. Bailloud 1974; Schwellnus 1979). However, while arrowheads are a dominant feature of the SOM tradition, both here and in the German graves there is a wider variety of arrowheads. For the *Steinkisten* these include leaf-shaped and triangular arrowheads with partial surface retouch reminiscent of Michelsberg predecessors (e.g. Raetzel-Fabian 2002; Schwellnus 1979). Yet what is more striking is that in most graves there is a much wider range of lithic tools and weapons than in Stein, including axes, pointed blades, flint daggers and blade- and flake-based scrapers (Bailloud 1974; Schwellnus 1979). This patterns is even clearer if we include the bone tool assemblages, as at Stein this also only includes arrowheads (at least 45), although they may perhaps equally be small spearpoints (Verhart and Amkreutz 2017, 79) (Figure 5). Bone arrowheads or spearheads also occur in the SOM area and in central Germany, but in both are accompanied by other bone and antler tools such as awls, adzes, sleeves, maceheads, spoons (not in Germany), perforated beads and pendants (e.g. Chambon and Salanova 1996; Günther 1997; Mariën 1981; Schwellnus 1979; Toussaint 2007; Warmenbol 2013). Moreover, the numbers and occurrences of bone arrowheads in both the French and German burials are often very limited. In his overview of 266 sites, Gérard Bailloud (1974) mentions only four with bone arrowheads (see also Sidéra and Giacobini 2002). This makes it clear that the typological range of artefacts in the Stein burial chamber is highly specific. It may represent burials where the inclusion of (bows and?) arrows was of importance to the exclusion of other objects. As far as we currently know, this is without direct parallel. Finally, there were finds of calcined animal remains. While some of the smaller species could represent background fauna, their calcined state argues against this, unless they inadvertently walked into a cremation pyre. Faunal remains have also been found in a number of German graves, including both wild and domesticated species, the latter comprising dog, pig, cattle and sheep or goat (Schierhold 2015).

Burning or burying?

Another striking aspect of the Stein burial is the considerable amount of cremated remains representing a mixed community of at least 42 individuals. These may have been cremated on a number of occasions due to differences in the intensity of burning. What is most peculiar, however, is that they are cremations. Both in the German *Steinkisten* and in the French *allées sépulcrales* inhumation is the common burial mode (e.g. Bailloud 1974; Raetzel-Fabian 2000; Schwellnus 1979; see also Verhart and Amkreutz 2017, 131). The occurrence of rock *hypogées* and *ossuaria* in the SOM area (Bailloud 1974) further underlines the importance of inhumation and manipulation of unburnt bone. Where cremations occur they are a minority, as at Warburg I and III (Günther 1997). There are rare exceptions, such as at Lohra, where the burials do solely consist of cremations (Uenze 1954). Inhumation also seems to be the rule for most megalithic *hunebedden* in the north (Midgley 2008). For the Vlaardingen culture, however, there is a mix of traditions that includes (allegedly seated) cremations, excarnation (as at Hekelingen, see Amkreutz 2013, 399 with references) and probably also inhumations. These have not been unambiguously attested, but can be deduced on the basis of the traditions of the previous Hazendonk group (Louwe Kooijmans 2007) and the partially contemporaneous Corded Ware. In any case, the complete focus on cremations appears striking and slightly unusual in the wider landscape of mortuary traditions.

From cultures to corridors?

The various aspects of the Stein burial chamber point to wide-ranging connections. The question is how to interpret these. Are we dealing with shared cultural and funerary concepts of geographically wide-ranging communities? Do we perhaps see the local variants or interpretations of these wider trends? Or is it perhaps more useful to think of migrating objects or people? As argued by Daan Raemaekers (2022, 298) it may be useful to think of these shared but not identical material expressions through linguistic and cultural concepts, such as the development of pidgin languages or the process of bricolage for understanding the mixing of cultural aspects, or for understanding variants with a more asymmetrical development. It is interesting and understandable that these frameworks are often applied to the original Mesolithic communities becoming farmers and that those areas where 'farming came from', as it were, are often perceived as relatively static and unchanging. They are the backdrop from which change elsewhere is understood (e.g. Louwe Kooijmans 2022). To some extent this is a result of discussions focusing on the transition to agriculture. These are aimed at distinguishing stages in this trajectory or even a moment at which an end date for this process may be defined (Raemaekers 2022, 300). Those communities that may have 'provided' change are then perceived as having reached the finishing line. However, this obfuscates that change went both ways and that cultural concepts such as the Michelsberg, TRB or Seine-Oise-Marne cultures are far from static entities. This cultural 'permeability' has to some extent been incorporated in the thinking on, for instance, the start of the TRB culture in the Netherlands (Ten Anscher 2015), or the diversity in economic and social practices in the Hazendonk group and Vlaardingen culture (e.g. Amkreutz 2013; 2022), but is less common for what is regarded as established Neolithic communities.

However, recent research, especially including aDNA and isotope analysis, has demonstrated the wide range of social, biological and material connections between and within communities, indicating that the Neolithic in north-west continental Europe very often was an open-ended and dynamic phenomenon. The burial evidence from the Blätterhöhle cave near Dortmund, for instance, points to the co-existence of groups with different genetic backgrounds and diverging diets in the same area roughly between 3800 and 3000 cal BC. It also points to the presence of people associated with a genetic and dietary hunter-gatherer background well into the fourth millennium (Bollongino *et al.* 2013). This ties in with more recent genetic studies demonstrating the complex interactions between Mesolithic hunter-gatherers and Neolithic famers in France, where there is an important contribution of hunter-gatherers already during the fifth millennium, especially west of the Rhine (Rivollat *et al.* 2020).

Similar discoveries consistent with multiple processes of interaction and change also apply to later periods, including the later fourth and early third millennium, making this a particularly 'blurry' period (cf. Nyland *et al.* 2023). They also particularly involve those communities that form an important cultural background for interpreting the Stein burial chamber. This was for instance demonstrated by a genome-wide study of a Neolithic Wartberg collective burial from Niedertiefenbach (Hesse, Germany), which is contemporaneous (3300–3200 cal BC) with our Stein burial (3400–3150 cal BC; Verhart and Amkreutz 2017, 138). The composition of the burial community in the gallery grave included a farming population with a large contribution (34–58 %) of hunter-gatherer ancestry (Immel *et al.* 2021). Importantly, the population represents a genetically diverse group with a broad range of hunter-gatherer proportions. This is taken to be indicative of a situation where admixture was still ongoing or had taken place only a few generations before and probably included individuals that had exclusive or near exclusive genetic hunter-gatherer ancestry (Immel *et al.* 2021, 5). Moreover the evidence indicates that the grave was used over about 100 years, mainly by people who were not closely related and may have lived in neighbouring locations (Immel *et al.* 2021, 2, 5).

The fact that at Stein we are dealing with cremated remains prevents a comparative aDNA analysis, although future research on these remains for carbon, nitrogen and strontium isotope analysis may provide information on diverging diets and mobility patterns. The Niedertiefenbach grave demonstrates the existence of fairly recently (i.e. somewhere in or during the fourth millennium) admixed communities. This genetic perspective opens up a diverse background of communities with different traditions, connections, economic foci and material culture that in combination form the cultural background for the third and fourth millennium BC. Until fairly recently this diversity was artificially compressed into more or less coherent cultural groupings, mainly based on static concepts of ceramic traditions and burial ritual. Yet now we know that reality was much more diverse and indeed 'blurry'. One way forward, I think, is to further deconstruct the cultural concepts we work with and instead focus on the avenues through which change

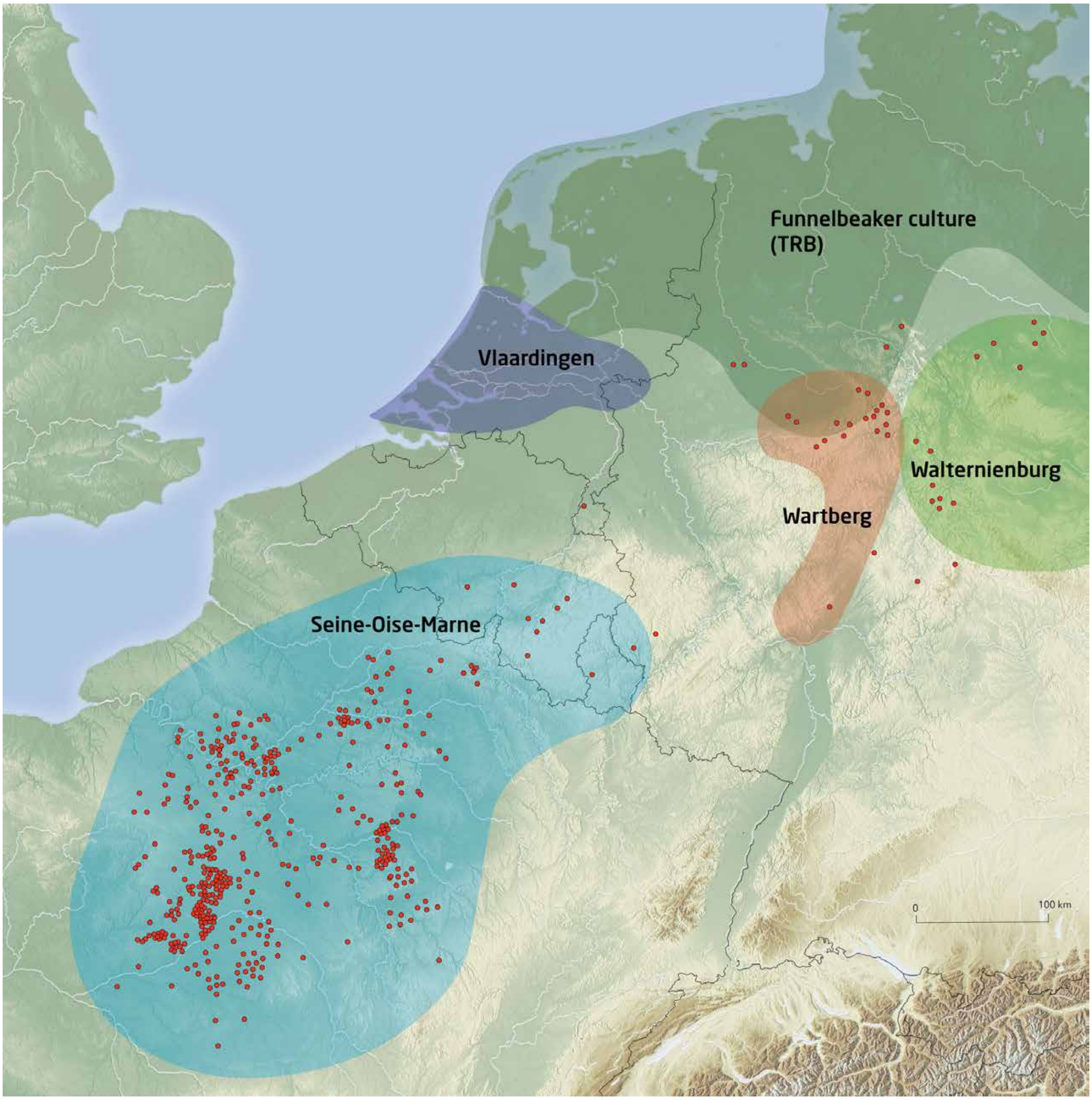

Figure 6. Distribution map of contemporaneous cultural zones in the later fourth millennium. The Stein burial chamber is the isolated red dot depicted in between the Seine-Oise-Marne, Wartberg, TRB and Vlaardingen cultural zones (Rijksmuseum van Oudheden/Olav Odé).

and inter- and intra-cultural diversity manifest themselves. This means tracking the mobility of material culture and human migration and the way these relate to the social and geographic landscapes in which they are embedded. In essence, this means investigating the manifold aspects of the social and physical routes or corridors of interaction (see also Piezonka *et al.* 2023, 8–9). So, in fact, we need a focus on networks. Additionally, the discussion would benefit from a more nuanced and ethnographically embedded discourse on what aspects of material culture, social, ritual and economic practices are more or less likely to be adopted, ignored or perhaps actively employed in interaction between groups and individuals with different backgrounds. An appreciation of the chronologically and regionally diverse multi-linear trajectories of interaction and change must be drawn up (Figure 6).

It remains difficult to determine the exact connections of the Stein burial chamber, and this is further obfuscated by the fact that this was the type site for defining the Stein group, leading to the inclusion of elements that set it apart from contemporaneous groups (e.g. Modderman 1964). However, in trying to understand its position in the Neolithic it is on the other hand rather the shared elements that stand out (Verhart and Amkreutz 2017). If we reason from this, we see that the Stein site and related sites of the Stein group actually incorporate many cultural elements of surrounding groups. The Stein group is characterised by a diverse ceramic spectrum that incorporates elements from Wartberg to the Seine-Oise-Marne culture, with distinct coarse S-shaped pottery, but different additions and shapes in different areas. The S-shape and plump appearance seem most related to south-easterly influences. This contrasts with the collared flask, which mainly seems to point to TRB and Wartberg affinities and a north-easterly sphere of influences. The dominance of trapezes among the arrowheads again might point in northerly directions or to the SOM-tradition. The axe is a match with comparable axes in the more western Vlaardingen culture. The bone arrowheads, on the other hand, could relate to both Wartberg and the SOM tradition and thus point to both east and west. This is also the case for the burial structure and its architecture. Finally, cremations are rare in the other cultural areas, but may have been more common in the Vlaardingen culture. Alongside the occurrence of the bones of small wild animals, they could also relate to the hunter-gatherer backgrounds of the communities involved.

While it is difficult to establish to what extent cultural connections and migrations contributed to the specific combination of influences at Stein, it is tantalising to draw in the characteristics of this group. In the Netherlands, the Stein group is envisaged as something of a counterpart of the wetland-oriented Vlaardingen culture (Verhart 2010; Verhart and Amkreutz 2017). The latter in particular is rooted in the earlier Hazendonk group and Swifterbant communities and ultimately in the indigenous Mesolithic. Given that for areas where there is sufficient preservation there is increasing evidence of a genetic Mesolithic contribution into later Neolithic societies (Rivollat *et al.* 2020), it may be assumed that interaction was often prominent at various levels. In that sense, the Vlaardingen-Stein cultural complex can be seen as a cultural amalgamation of originally Mesolithic and Neolithic elements. It has been argued that the characteristics of a broad-spectrum economy for the Swifterbant and subsequent wetland communities were related to a cultural practice of flexibility (in relation to landscape dynamics) regarding which Neolithic elements were integrated (Amkreutz 2013; 2022). These practices of adopting a fluid, flexible attitude towards novel elements, be they economic, social, material or even ritual, may have become an intrinsic aspect of these groups and of the wider sphere of interaction in the developed Neolithic period. Developing such a 'reading grid' based on the interpretation of these communities in the process of Neolithisation may also help understand the Stein burial monument. If the Vlaardingen-Stein cultural complex is the Late Neolithic outcome of a process of combination, inclusion and flexibility engrained within these types of communities, then it could be assumed that this was also the manner in which they acquired, adjusted, and integrated various aspects of their wider cultural connections. The cultural hybrid that the Stein monument is may therefore be rooted in the types of communities that built it and how they approached familiar and less familiar elements beyond their society. In general, it exemplifies how trying to fit certain discoveries into clearly defined and differentiated cultural borders may be pointless for some periods and areas.

Reasoning from this perspective it still remains hard to determine the affiliations and influences that converge in the Stein burial chamber, but they do point to the fact that the Neolithic world in this part of Europe at the end of the fourth millennium was strongly connected. The geographical position of our site in the centre between these more clearly defined cultural zones forms a further argument for the diverse connections we observe. Furthermore, if we reason from the viewpoint of routes and connections, then Stein itself is situated directly on the Meuse river, connected to northern France and tapping into the Seine-Oise-Marne world, and forming an important connection to the Vlaardingen communities in the delta. At the same time, the site is situated only 80 km from the Rhine river at Duisburg, indicating access and influences from the Wartberg culture as well. It is argued here that these riverine patterns are crucial in understanding the connections we see. This geographical argument forms one axis for investigation, another is formed by the long-term influences of communities with a distinct and recent hunter-gatherer background.

Conclusion

With the advent of the Third Science Revolution (Kristiansen 2014) it has become apparent that there is much more evidence for genetic and material diversity in the Neolithic than previously thought. This has opened up new perspectives and argues against dichotomous labels and unilinear trends and in favour of an appreciation of chronologically dynamic and regionally diverse interactions (Hofmann *et al.* 2022, 285). The Stein burial presented here forms a case in point of the diverse combinations and influences that exist between and within materially defined cultural phenomena. Based on this growing awareness, the processes taking place in the Neolithic must be characterised as multi-stranded and diverse in space and time; we should therefore refocus on the physical and social networks that existed between communities and employ these as a starting point for understanding and defining the cultural groupings we use to sketch the large-scale process defining this period. It is to be expected that these will become both more diffuse and more interesting.

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LOOKING FOR GAPS

Fourth-millennium cal BC Neolithic monuments from western France and beyond

Luc Laporte

Abstract

When megaliths and causewayed camps appear in northern Europe and in Great Britain and Ireland, the building of megaliths seems to come to a stop in western France, while an increasing number of new causewayed enclosures are built. Previously, many megaliths, some few causewayed camps and a very few (currently known) large timber buildings were part of Neolithic monumentality during the last third of the fifth and the early fourth millennium BC. Later on, passage and gallery graves spread in north-western France, as well as new developments occurring at many causewayed camps in west central France, during the last third of the fourth and the early third millennium BC. A new tradition of very long timber houses then arose in western France. But, dealing with megaliths, what really happens during the interval of 3700–3300 BC? Would such a gap be really consistent? And, if so, how should it be explained? Exploring these questions, I review available radiocarbon dates both for the construction and use of French megalithic monuments, providing revised or new Bayesian analyses for each relevant sequence.

Keywords: megalith; Neolithic; France; radiocarbon dating; Bayesian analysis

Introduction

In France, the fourth millennium BC was a pivotal period between the last Middle Neolithic societies, who left their mark on the landscape of the Atlantic seaboard by building megaliths, and the early stages of Late Neolithic societies, whose territories were dotted with fortified villages, ditched enclosures and collective burials. This is at least the picture that emerges from the state of knowledge at the end of the twentieth century, sometimes based on investigations initiated a century earlier. In the west of France, each of these periods was associated with its own type of monument, from those assumed to be the more rudimentary (megaliths made of ‘rude’ stones) to the most elaborate (long houses of the Final Neolithic with sophisticated framing techniques), while the development of regional studies tended to focus on the internal dynamics of each human group to explain such changes. However, new discoveries have considerably redefined these issues over the last ten years (e.g. Ard *et al.* 2023; Laporte 2024).

Throughout the second half of the twentieth century, the first radiocarbon dates, and then their calibration, considerably extended the timespan of the Neolithic period, the duration of which was previously at times estimated at less than a thousand years in western Europe. At the same time, the development of dendrochronology gave access

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to a hitherto unequalled level of chronological precision, highlighting social changes that were likely to have a lasting impact on the evolution of material culture in the space of just a few generations. For example, the hypothesis of a population migration from the Ferrières group, from the south of France, along the Rhone axis and as far as the shores of the Jura lakes, could then be put forward (A.-M. Pétrequin and P. Pétrequin 1988; P. Pétrequin 1997). The question of chronology has thus become key in assessing possible population movements or the emergence of certain forms of monumentality.

Through this article, I propose to question the chronology attributed to different megaliths in France through a critical analysis of the radiocarbon dates available, the contexts associated with dated samples, and the types of events that we seek to date (construction, uses, etc.). Particular attention will be paid to the fourth millennium cal BC, a period during which these architectures tend to appear or multiply in northern Europe: the highlight of a pivotal period between 3800 and 3600 cal BC, when no megaliths are built in western France, coincides with this expansion, also in southern France. I will first question how such chronologies were gradually built and conceived. Then, I will discuss previous Bayesian analyses produced for each sequence, and produce some new ones (see Appendix). Such structuring of the data will then be compared to that which emerges from the study of other forms of contemporary monuments, the enclosures, no longer dedicated to the genesis of a collective memory but even more to its transmission. Finally, I will question whether such observations can also account for migration.

Chronologies

The chronology attributed to different forms of megalithic architecture has constantly been adjusted to reflect distinct and autonomous regional dynamics. In this context, Glyn Daniel (1941) proposed a continuous, bushy model for the evolution of megalithic architecture for western France, inspired at the time by recent developments in human palaeontology, which was subsequently extended and remained in use right up to the end of the twentieth century (Boujot and Leclerc 1995, 72). Such an evolutionary approach explains the place given in those publications to a few 'missing links' (the V-shaped gallery graves of the Armorican Massif), or to architectures considered to be more elaborate and therefore rather recent (transept dolmens on the southern coasts of Brittany, Angevin dolmens in the Loire valley), within this continuum.

In a previous article, published over ten years ago, I noted the existence of at least two distinct major cycles in the construction of megalithic funerary monuments in western France during the Neolithic period, separated by a major interruption around the middle of the fourth millennium BC (Laporte 2010). The first cycle comprises cists and dolmens of the Scandinavian terminology, including dolmens with a passage (Middle Neolithic), and the second cycle elongated passage graves and gallery graves of the Scandinavian terminology (both attributed to the Recent and Late Neolithic in western France). Previously, megaliths were assumed to be a continuous phenomenon with authors searching for transitional features linking one type of architecture to the other (Giot *et al.* 1998; Joussaume and Pautreau 1990), although the same interruption had already been identified on a cumulative diagram of just eleven radiocarbon dates, selected by Johannes Müller, and deemed likely to reflect the construction or use of megalithic collective burials in Brittany and Normandy (Müller 1998). In fact, among the data available at the time, a charcoal sample taken from the cairn surrounding the V-shaped gallery grave of Ty ar Boudiged in Finistère (Le Goffic 1994) suggests that the monument was built no earlier than the second half of the fourth millennium BC (Gif 8730, 4570±70 BP, 3518–3032 cal BC, 2σ). The same goes for another charcoal sample (Gif 5012, 3960±70 BP, i.e. 2835–2206 cal BC) collected in Mayenne at the base of the cairn surrounding the Brécé elongated megalithic chamber with a short axial and transverse passage (Bouillon 1989), and which suggests construction during the third millennium BC.

Conversely, a radiocarbon date on a deer antler pick from the socket of one of the orthostats from the Angevin dolmen at Sainte-Suzanne (Letterlé 1986) placed the construction of the latter before the end of the fifth millennium BC (Ly 3100, 5580±140, 4054–4772 cal BC, 2σ). As for the monuments with lateral cells at Colpo, Ty Floch and Château Bû, and the transept dolmens or those with compartmentalised chambers at Quelarn, no dating element was compatible with construction after 3800 cal BC (Joussaume and Laporte 2006). Gwenole Kerdivel (2012) demonstrated the complementary spatial distribution of Angevin dolmens and *tombes à couloir* (passage tombs), and the extent to which they contrasted with the geographical distribution of gallery graves with axial or side[1] entrances. However, such reasoning is rather tenuous given that it is based, even today, on a fairly limited number of radiocarbon dates (Figure 1).

Following on from work by Alasdair Whittle, among others, on the dating of ditched enclosures and Cotswold-Severn monuments in Britain (Whittle *et al.* 2007; 2011), the current prevailing idea highlights a succession of intense but short-lived events for the construction and use of these sites. Technological innovation is no longer viewed as the result of a long process of maturation, with gradual improvements over time, but also as a consequence of interactions (sometimes over very long distances) and social

1 These latter (elongated chambers with a lateral entrance, and passage) would be named passage graves in northern Europe.

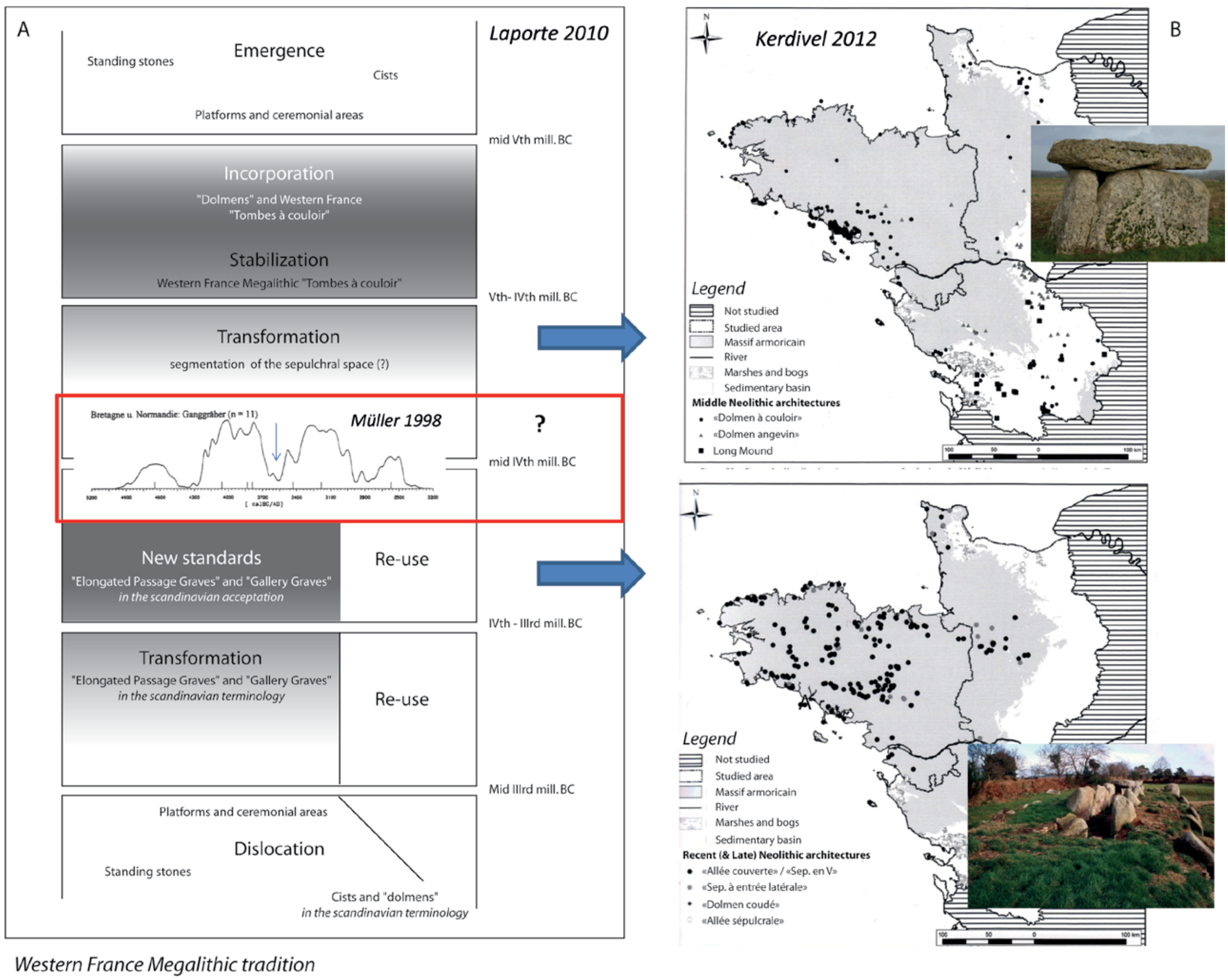


Figure 1. Funerary monument traditions of the middle of the fourth millennium BC in western France. A) Scheme proposed in 2010 for the main dynamics governing the construction and use of different forms of megalithic funerary monuments during the Neolithic in western France. B) Totally different patterns in the spatial distribution of so-called dolmens and passage and gallery graves, as higlighted by Kerdivel (2012), are rather consistent with the gap proposed by Müller (1998); in the legend, French denominations illustrate a diversity that doesn't always fit with the acceptance of terms such as dolmens, passage tombs or gallery graves in northern Europe. Top right, photograph of the Ardillères dolmen (Charente-Maritime); bottom right, photograph of a passage grave at Crec'h Quillé (Côtes d'Armor). Photos L. Laporte.

dynamics (locally) that can take place in the space of just a few generations. Even so, the margin of uncertainty in each of the radiocarbon measurements produced by different laboratories, once calibrated to 95 % confidence, is still usually of the order of a third or a quarter of a millennium. A number of corrections have therefore been proposed, such as progressively reducing the margin of uncertainty in the BP measurement by incorporating the impact of the ocean reservoir effect through the animal food chain ($\delta^{13}C$) a little more effectively, or giving preference to short-lived plant samples (Schulting *et al.* 2017, amongst others). Multiplying the number of dates produced for a single event eliminates a few inevitable outliers. And finally, applying Bayesian statistical processing to such series obtains levels of accuracy closer to dendrochronology, which is only available in a few specific contexts.

However, such dating strategies require fairly heavy investment, which can only be made on a limited number of particularly well-documented examples (Bayliss *et al.* 2016; Whittle 2018). Above all, this requires what is sometimes presented as a clean sweep of previous investments in this area (García Sanjuán *et al.* 2022; Sjøgren and Fischer 2023), some of which date back more than fifty years, as in France. Under the label of 'chronometric hygiene', it is for example often advocated that dates with large confidence intervals should be excluded, but in some regions these make up the majority of the corpus. The use of samples from old excavations often raises the question of the sampling strategies of the initial excavators, who at the time attempted to answer rather different questions from those that prevail today (Whittle *et al.* 2007). Other analyses of more recently acquired date series sometimes aimed to confirm initial hypotheses (Cassen 2009), which is not in fact the purpose of a Bayesian analysis. While we do not always have all the documentation needed to date each cycle or series of events precisely, in the following section I will at least try to assess whether it is possible to identify interruptions in a sequence, as for example in the model I sketched out in 2010. Dealing with successive short events should mean that there are also (at least some) large gaps. Would these gaps be large enough to be identified?

Construction and use of megalithic monuments

Precisely dating the construction of a megalithic monument mainly made up of inorganic materials, using radiocarbon dating, is a difficult exercise (Laporte *et al.* 2022). This is particularly true for stones merely raised towards the sky, where some sporadic charcoal present in the sockets is, at best, contemporaneous with or even predates the erection of the megalith. In a few rare cases, stratigraphic observations are favourable, such as at the Casa de don Pedro site in Andalusia, where the installation of a first standing stone is associated with *in situ* hearths. This is covered by a sterile layer into which the pits for the dolmen walls were dug, the slabs of which rested against the menhir previously built on this site (Gavilán Ceballos and Vera Rodríguez 2001).

Dating the period of construction of a megalithic funerary monument is not so simple either. The case of the Danish monument at Maglehøj, where birch bark is preserved between each course of drystone walls, is an exception (Dehn and Hansen 2006). Elsewhere, very detailed observations of the building construction sequence, as for the uses of the site, are required, combined with a sufficient number of coherently ordered radiocarbon dates, including a terminus ante quem (TAQ) and post quem (TPQ). In this way, narrow and largely overlapping confidence intervals can precisely date a given stage of construction. In France, as is often the case in Europe, rigorous examples of this kind are extremely rare. In fact, there are scarcely more than fifteen (see Appendix).

For a long time, it was assumed that the burial space would only have been used for funerary purposes for a short time after it was built. On the whole, this approximation proved pertinent for establishing the broad outlines of a history at a time when precision within half a millennium or more seemed sufficient. But such broad chronological approximation is no longer appropriate. To date the funerary use of the site, radiocarbon dates on human bones are preferred, but with a lesser degree of reliability in dating the construction (as opposed to the use) of these megaliths. And the nature of the substrate must be conducive to the preservation of such remains, which is very rarely the case in Brittany, for example. By default, and as a means of verification, we sometimes compare the summed probabilities of radiocarbon dates on human bones with those obtained on other kinds of sample.

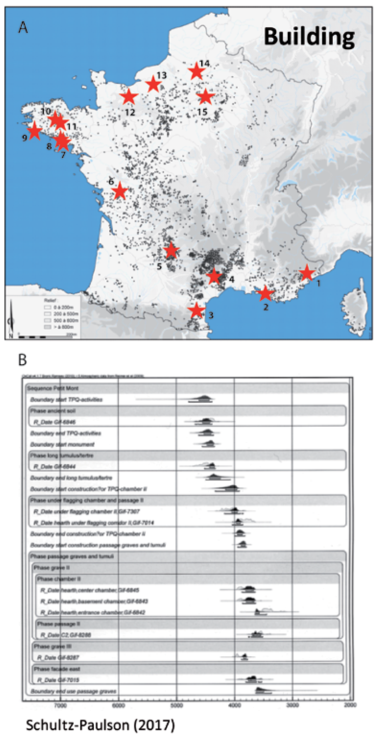
Furthermore, among the dates on human bones, only bones associated with individuals for whom an anthropological field study clearly attests that the body decomposed inside the sepulchral space should be retained, to exclude the possibility of the introduction of relics or any curated bones that could predate the construction of the tomb. And each of the individuals deposited in this tomb would need to be dated with certainty, or samples would at least have to be systematically taken from the same lateralised bone to ensure conformity with the anthropologists' (or now geneticists') MNI. This is what we set out to do in order to contribute to the dating of the burial contexts in the sequence of mound C at Péré, in the Deux-Sèvres region of western France (Laporte *et al.* 2021). Here again, however, there are still too few examples of this kind.

Different degrees of reliability have thus been established as to the possibility of dating precise events (construction, uses, etc.) distinct from those actually dated by radiocarbon (death of a plant, an animal, a human being), and independently of current trends towards greater precision, the degree of statistical reliability, or the different types of correction that should be applied to laboratory measurements.

Dating the construction of a megalith

In a recent work covering the whole of megalith-building Europe, Bettina Schulz Paulsson (2019) proposed rigorous reasoning incorporating these different factors, as well as the architecture of the megaliths concerned and the nature of the associated artefacts. In addition to Passy-type structures and Chamblandes cists, specific Bayesian analyses were proposed for sixteen different monuments in north-western France and two others in southern France. However, a detailed analysis of the arguments put forward by the author sometimes leads to question the value of certain samples as terminus post quem or ante quem. In addition, the Bayesian analyses do not take into account the mathematical signs greater than or equal to, and less than or equal to, which also sometimes leads to the dates being ordered in a somewhat arbitrary way within each phase proposed. Details of these discussions, as well as new Bayesian analyses, are presented in the Appendix.

Bearing this in mind, I excluded the sequences from Bougon F2, La Hoguette, La Hougue Bie, Er Grah and La Table des Marchand from the analysis (for references, see Appendix). Other sequences concerned the whole cemetery and yielded little evidence for the precise dating of any particular construction episode, as at Champs-Châlon,



95,4%, Cal. BC	Inf	Sup	Delta
Building Lannec-er-Gadouer (Bayesian An.)	4615	4171	*444*
Building Péré Ch. II (Bayesian An.)	4326	4265	*61*
Building Péré Ch. I (Bayesian An.)	4321	4228	*93*
Building Le Souc'h Ch. I (Bayesian An.)	4461	3832	*629*
Building Bruyères du Hamel A (Bayesian An.)	4445	4106	*339*
Building Croaz Dom Herry (Bayesian An.)	4296	3997	*299*
Building Petit Mont Ch. II (Bayesian An.)	4172	3690	*482*
Building Pech Laglaire 1 (Bayesian An.)	3601	3386	*215*
Building Saint-Eugène (Bayesian An.)	3337	3060	*277*
Building La planquette (Bayesian An.)	3321	3116	*205*
Building Ventabren "Dolmen" IVb (Bayesian An.)	3316	2949	*367*
Very first use Bury (Bayesian An.)	3245	3095	*150*
Building Le Prieuré (dendrochronology)	3010	2952	*58*
Building Butte Saint-Cyr (Bayesian An.)	3403	2783	*620*
Building Liscuis II (Bayesian An.)	3318	2598	*720*
Building Le Villard (Bayesian An.)	3360	2224	*1136*

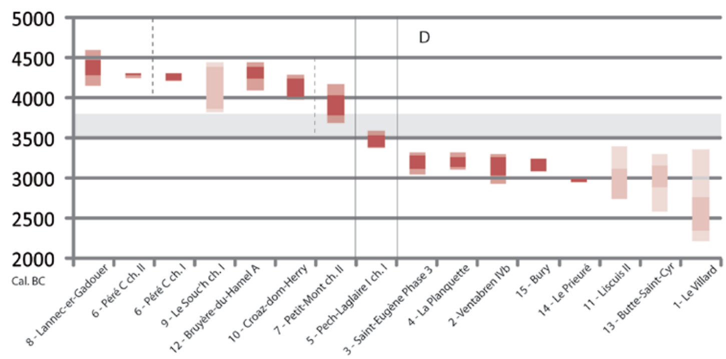


Figure 2. Dating the construction of megalithic monuments in France. A) Distribution map of the 15 monuments selected for this study (map after Laporte *et al.* 2011). B) Example of a complete sequence presented by Schulz Paulsson (2017) for western France. C) Results of Bayesian analyses presented in the Appendix, concerning the period of construction of at least part of the monuments. D) These same results presented in the form of histograms, with 95 % confidence. The shaded bars are those covering a period of more than 500 years. The darker part denotes the 68.3 % confidence interval.

Barnenez, Le Déhus, Vierville and Cairon in western France. Both a TAQ and a TPQ do exist for the construction of the Ubac dolmen in Provence, south-east France, but their margins of uncertainty do not overlap. New Bayesian analyses were recently proposed for the Souc'h, Petit Mont and Prissé-la-Charrière monuments, as well as for monument IV at Ventabren, focusing exclusively on the dating of one event (the construction of the monument or one of its parts). In the end, only the results obtained by Schulz Paulsson (2019) for the Lannec-er-Gadouer monument can be used without any difficulty. I added new Bayesian analyses for recently published sequences, or sequences supplemented by the publication of new dates (La Bruyère-du-Hamel, Croaz-Dom-Herry, Liscuis II, La Butte Saint-Cyr, Pech Laglaire, Saint-Eugène, La Planquette, Le Villard), or even as yet unpublished for one of them (La Planquette).

The results of a previous analysis published for the gallery grave at Bury (Salanova *et al.* 2017), and the dendrochronological dates obtained on the building materials from the Prieuré gallery grave at La Croix-Saint-Ouen in the Paris Basin (Bernard *et al.* 1998), were also taken into account. Of the fifteen megalithic monuments selected for this analysis in France, only five have the data required to date at least one of the construction stages to within a 95 % confidence interval of 250 years (Péré chambers 1, 2 and C; Pech Laglaire 1; La Planquette; Bury; Le Prieuré), and six others with an accuracy of less than 500 years (Lannec-er-Gadouer; Bruyère du Hamel A; Croaz-Dom-Herry; Petit Mont II; Ventabren 'Dolmen' IVb; Saint-Eugène). For four other monuments (Le Souc'h I; Butte Saint-Cyr; Liscuis II; Le Villard), ultimately the overlap of radiocarbon dates results in a range of uncertainty covering a period of more than 500 years, which is hardly satisfactory (Figure 2).

In the west of France, the construction of each of these megalithic monuments can certainly be placed within a time interval between 4615 and 3690 cal BC, with 95 % confidence, whereas in the south and north of France, this same time interval is between 3337 and 2224 cal BC. We will exclude Souc'h 1, which has a too high margin of uncertainty. Two large cists included in a mainly earthen mound (Lannec-er-Gadouer, Péré C ch. II) are only slightly older than three passage tombs with walls and elevations mainly made of dry stone (Bruyères du Hamel A, Péré C ch. I, Croaz Dom Herry), with a confidence rate of 68.3 %

(4474–4236 for the first two and 4396–4025 for the other three), and the latter are certainly older than two passage graves with largely megalithic walls (Petit Mont chamber and passage II — between 3943 and 3784 cal BC, 68.3 %; Table des Marchand — after 3949 cal BC, 68.3 %). The megalithic chamber at La Hougue Bie, however, seems to have been built before 3991 cal BC (2σ).

Only dolmen 1 at Pech Laglaire I, in Quercy, southern France, was built between 3604 and 3387 cal BC, with 95 % confidence. There is thus a time interval of the order of at least a hundred years (250 years at 68.3 % confidence) during which no megalithic construction has yet been documented in France, probably between *c*. 3700/3600–3400/3300 cal BC. These initial results therefore suggest an interruption in the construction of megalithic funerary monuments in France and the existence of at least two major cycles corresponding to distinct architectural forms, although these can be peculiar to each region or sector (Laporte *et al.* 2011). The secure dates are still clearly too scarce, and will require confirmation as knowledge progresses. The necessity of perfectly controlled excavation with regard to the architectural sequence of the megaliths, and appropriate sampling for radiocarbon dating, is clearly crucial.

Dating the use of a megalith for burial purposes

I have recorded just under 200 radiocarbon dates in France on human bones from Neolithic megalithic chambers, regardless of their architectural types. In the west and south of France, there are often only a few dates per burial chamber, and exceptionally more than ten. This is inadequate, given that many of these burial chambers were used for several hundred years at least, and sometimes for more than a thousand years. Conversely, older bones may have been placed in these burial spaces, which may or may not have allowed for permanent access throughout the sequence, not just at the earliest dates, as is generally suggested. However, this issue is beyond the scope of this article.

The acquisition of these radiocarbon dates began in the 1960s and continues to the present day, so that the margin of uncertainty attached to them fluctuates greatly. I have only discarded dates for which the margin of uncertainty is greater than 200 years. But at least all these dates cover a fairly complete and, on the whole, representative sample of different megalithic architecture, for each sector. The situation is exactly the opposite for the gallery graves in the Paris Basin, where only the Bury site with its recently published 50 highly accurate radiocarbon dates fulfils these criteria (Figure 3).

The distribution of megalithic funerary monuments in France tends to be concentrated in an area running diagonally across the country from north-west to south-east, as was established as early as the end of the nineteenth century (de Mortillet 1883, 592). It has also long been known that the *dolmens à couloir* (passage tombs) built in western France are older overall than those in southern France (Laporte *et al.* 2011; Soulier 1998). A cumulative diagram of the dates available in the west of France compared with those in the south of France fully confirms this observation, with a tipping point around 3500 cal BC, both for construction (Figure 2) and use (Figure 3). The same structuration of the data applies for dolmens in southern France and gallery graves in the Paris Basin, despite the reservations concerning the low number of well-dated sites (Chambon *et al.* 2018), already expressed in the previous paragraph (Figure 3).

Finally, in some regions, such as Brittany and the Massif Central, soil acidity is not conducive to the preservation of human bone, except in exceptional cases. Keeping the dates on charcoal associated with the construction of monuments in these areas (but discarding all those from ancient soils or uncertain contexts) improves sampling in geographic terms or according to the architecture of the monuments. However, in each major region, the cumulative curves obtained do not differ greatly from those corresponding to radiocarbon dates on human bone alone.

The diagram of cumulative dates corresponding to samples taken from passage tombs in western France is of particular interest (Figure 4). It contrasts with all the dates obtained in the south of France, and with those for buried gallery graves in the Paris Basin (including some made of wood), as well as those of the above-ground gallery graves (and a few passage tombs, as they would be named in northern Europe) of the Armorican Massif. The use of passage tombs (*dolmens à couloir*) in western France seems to have been particularly intense between 4300 and 4000 cal BC, and then gradually declined until the middle of the fourth millennium. This does not rule out more recent reuse, but in other forms; collective burials of numerous individuals during the Recent and Late Neolithic while there are scarcely more than a dozen during the Middle Neolithic; different patterns of deposits and commemorative practices; etc. (Laporte 2012).

Initial overview

The chronological range of passage tomb (*dolmens à couloir*) construction in western France undeniably extends at most between 4500 and 3750 cal BC. The use of these tombs for funerary purposes seems particularly intense between 4300 and 4000 cal BC, perhaps with two successive peaks.[2] Use for burial gradually became more occasional during the first half of the fourth millennium BC. As far as we know, only a few monuments in the Quercy region

2 A KDE (kernel density estimation) model could probably have been applied, refining dates for the different types of architectures as well, but the results would mainly concern the fifth millennium cal BC, which is not the aim of this paper.

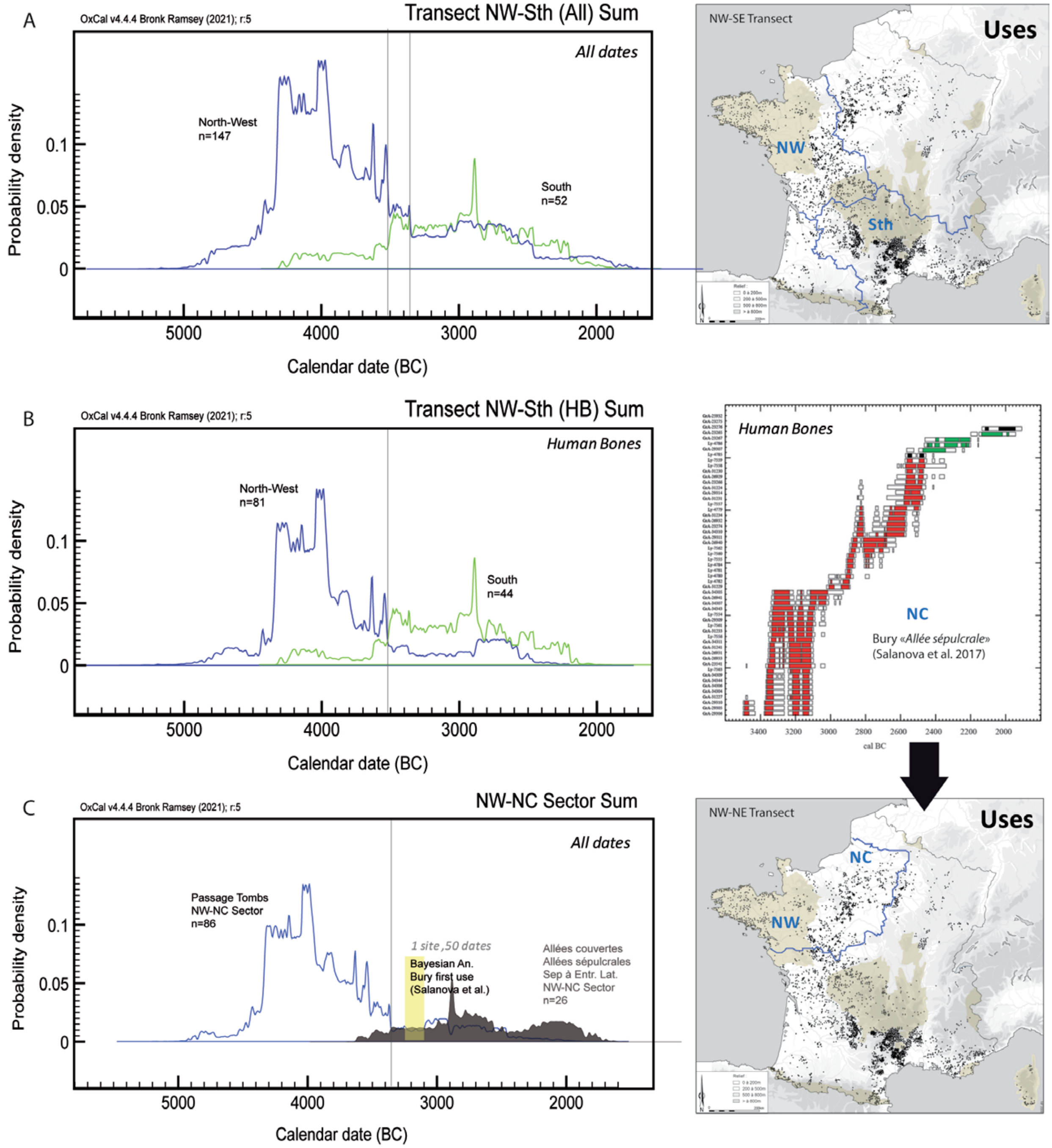


Figure 3. Dating the use of megalithic tombs in France. A) Cumulative curves of radiocarbon dates associated with megalithic monuments in north-west France (blue) and southern France (green). The boundaries of each region are shown on the map to the right, with areas favourable for bone preservation highlighted in yellow. B) Cumulative curves of radiocarbon dates on human bone from megalithic monuments in north-western France (blue) and south-eastern France (green). C) Cumulative curves of radiocarbon dates associated with *dolmens à couloir* (in blue) and gallery graves with axial or side entrances (in grey), in north-western and north-central France. The Bury site stands out for its more than 50 published dates on human bone and low margins of error (Salanova *et al.* 2017).

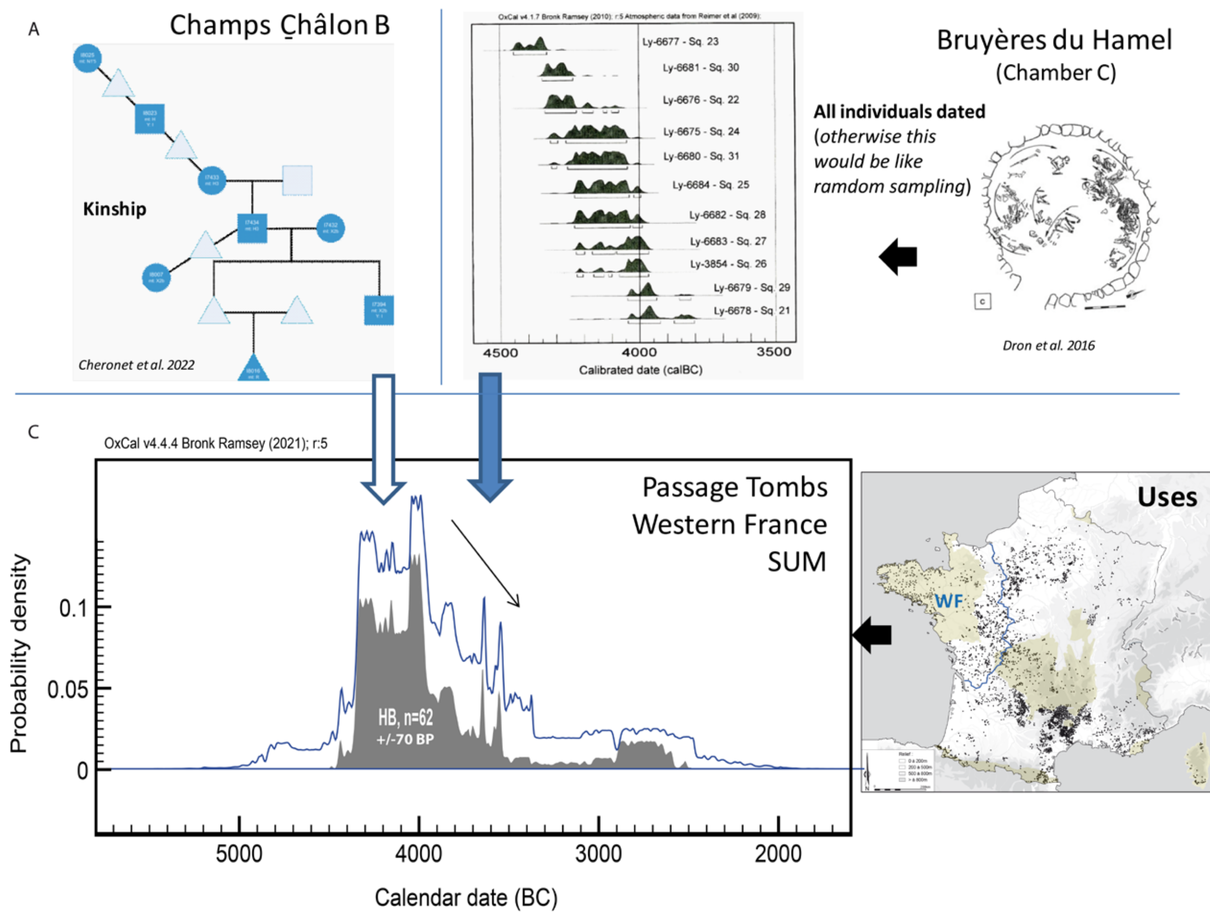


Figure 4. Funerary use of passage tombs (*dolmens à couloir*) in western France. A) Recent genomic analyses at Champs Châlon (western France) demonstrate the frequency of family ties between the deceased laid to rest in burial chambers, especially during the Middle Neolithic. B) Many passage tombs are used for burial over several hundred years, as in tomb C of Bruyères du Hamel. C) Summed radiocarbon dates associated with western French passage tombs show very intense activity in the last third of the fifth millennium cal BC, which progressively lessens throughout the first half of the following millennium. Dates on human bones with a BP standard deviation of less than ±70 BP are shown in grey on the cumulative date curve.

were built between 3600 and 3400 BC. The vast majority of megalithic funerary monuments in southern France and the Paris Basin, as well as the passage graves and the gallery graves of the Armorican Massif, were built after this date. Overall, then, there was a gap of around 250 years in the construction of megalithic monuments in France, during the second quarter of the fourth millennium BC. Yet it was precisely during this period that such examples of megalithic architecture proliferated throughout northern Europe (e.g. Schulz Paulsson 2019). How should we interpret these results?

Discussion

Dolmens and ditched enclosures appear only a few hundred years apart in Britain, Ireland and northern Europe, where the latter formed a new generation of causewayed enclosures, different to the typical LBK examples. Previously, such enclosures had already been present for a long time in western and northern France, as well as more occasionally in southern France (Figure 5), and with other forebears mostly in central Europe (e.g. Andersen 1997; Klassen 2014; Řídký *et al.* 2020) but also from some Mediterranean regions (e.g. Gandelin *et al.* 2018). Here again, we will concentrate our analysis on the fourth millennium BC. However, recent work indicates a fifth millennium BC (Middle Neolithic) date between the Atlantic coast to the west, the Gironde valley to the south and the Seine valley to the north (Laporte *et al.* 2023). North of the Seine, causewayed enclosures only reached the Rhine valley and then the Ems valley during the last quarter of the fifth millennium. They then tended to multiply in southern England, Germany and the limestone plains of central-western France during the first half of the fourth millennium BC. There,

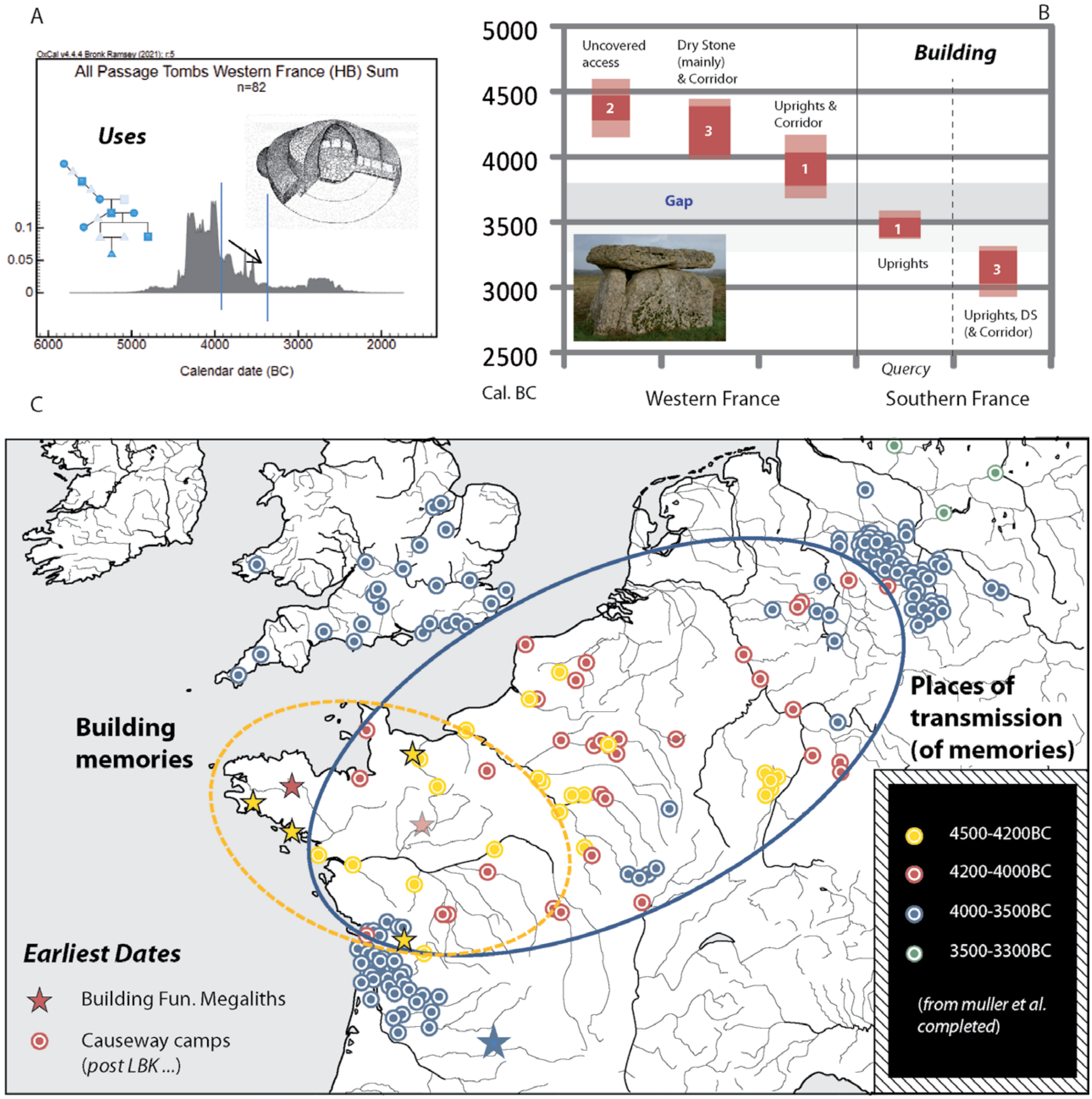


Figure 5. A 'gap' in the construction of funerary megaliths (western France) and a 'spread' of monumental settings beyond the 'core' (western Europe). A) Summed dates on the use of passage tombs in western France, mainly for burial. B) Summed dates on the construction of Neolithic megalithic funerary monuments in western and southern France (*Uncovered access*: sites 6 and 8 in Figure 2; *Dry stone and corridor*: sites 9, 10 and 12; *Uprights and corridor*: site 7; *Uprights*: site 5; *Uprights, DS (& corridor)*: sites 2, 3 and 4). C) The earliest available radiocarbon dates for each study region in northern France, showing ditched enclosures and the construction of megalithic monuments (4500–3500 cal BC; same colour for the same date range). Map of enclosures after Laporte *et al.* 2023.

enclosures are mainly the work of the Matignons group of central-western France, between 3700 and 3400 cal BC (*Néolithique récent*; Ard 2014).

The Quatre Chevaliers single-ditch enclosure at Périgny (Charente-Maritime) dates to the Middle Neolithic (Soler 2012). It yielded the remains of an individual in anatomic connection, radiocarbon dated to between 3934 and 3711 cal BC (95.4 % confidence), after taking into account the marine reservoir effect due to a marine component to the diet. The double burial in the Font-Rase enclosure in Charente also yielded a date between 4070 and 3818 cal BC (Semelier 2007). The presence of human bones and even burials in enclosure ditches is more frequent during the Recent and Late Neolithic, but still not comparable to the number of individuals found in passage tombs during the previous period (Soler 2014). These depositional contexts are therefore not an alternative to the burial practices associated with megalithic funerary monuments, but rather one of the many complementary practices specific to each group. Ditched enclosures and megalithic monuments, on the other hand, are two facets of a monumentality that evolved differently in each region over time (Laporte 2022).

In an area south of the Seine and north of the Gironde, from Poitou to Finistère in Brittany, numerous megalithic funerary monuments were built during the second half of the fifth millennium BC, along with a relatively small number of ditched enclosures. Recent palaeogenomic data suggest that each burial chamber was assigned to a family or clan, in lineage-based, probably patrilocal societies (Cheronet *et al.* 2022). Built in stone, these monuments left a lasting mark on the landscape. They were often used for several hundred years for funerary purposes, until the beginning of the fourth millennium. They then gradually declined, perhaps as a clan's dominant position waned or as the clan disappeared. Another clan or family sometimes took its place, even in the burial space. But, overall, the deposition of human bodies or bones in the burial chamber became increasingly episodic over the ensuing centuries and throughout the first half of the fourth millennium cal BC.

The question of enclosure function has been widely discussed (Laporte *et al.* 2014). Whatever the option chosen, we propose to see them as a place for the transmission of memory, which is in no way incompatible with diverse and sometimes even successive functions in the same place, as a lowest common denominator uniting this diversity. The large wooden buildings sometimes found in the enclosures could thus be considered communal houses, or attributed to certain age classes. A detailed study of children's skeletal remains indicates the existence of age thresholds at death for those buried with adults, while the absence of younger children could indicate that they did not yet fully belong to the group (Le Roy 2015). Integration into the group in such societies is achieved through rites of passage, which are held in the same place at regular intervals. The Fontbelle enclosure in Charente underwent no fewer than four major phases of development by the Matignons group, and six by the Peu-Richard group, with few real changes to the layout of the enclosure (Burnez 2006).[3] This kind of construction history is compatible with an interpretation of episodic use for recurring ceremonies that are several years apart (sometimes dozens of years, up to eighty for some Dogon ceremonies for example), as can be the case for initiation rites.

At the beginning of the fourth millennium, in the west of France, social practices were quite established and landscapes were well structured. Innovation was not emphasised and new kinds of monumentality only arose later on. We observe a gap of at least 100 and up to 300 years at around 3800/3600 cal BC in the building of places of memories (megaliths), while the number of places of transmission (enclosures) exploded. The latter spread abroad from the initial core to regions where the landscape still had to be structured and new memories had yet to be built (Figure 5). Such observations are not incompatible with the idea of a period of migration, which some would explain by the restrictive nature of rigid and sometimes despotic social structures (Ray and Thomas 2018; Thomas 2020). In the west of France, genetic data suggest that small and possibly rigid residential groups continued to exist until well into the fourth millennium BC, as illustrated by the Auzay burials (Birocheau *et al.* 1999). Other authors prefer to focus on economic factors, with the possible introduction of the plough and wider cultivation of the primary soils of ancient massifs. The first signs of animal traction appeared in the Late Neolithic period, in the form of characteristic marks on bovid limb bones (Braguier 2000).

A strong demographic expansion could have occurred from 3400 BC onwards in the limestone plains of central-western France (Laporte 2007, 74), and perhaps also in Quercy, on the southern edge of the Massif Central, although this is still difficult to quantify. Numerous dolmens were then built in the south of France, some of which may have been inspired by the monuments with elongated chambers and axial entrances in central-western France (Joussaume *et al.* 2008). Gallery graves in the Paris Basin do not seem to have been built before this date (Blin 2018; Salanova *et al.* 2011), nor were the gallery graves or elongated chambers with side entrances in the Armorican Massif. These latter have been compared with the architecture of some of the Dutch *hunebedden* and Danish passage graves (Briard *et al.* 1995). The presence of collared flasks, although made locally, also points to the TRB/Funnel Beaker area.

Conclusions

The available data indicate that very few megalithic funerary monuments were built in western France during the second quarter of the fourth millennium BC, and that their use for burial came to a halt in the middle of the same millennium. However, it was during that period that a great many dolmens were built in the British Isles and northern Europe, and perhaps also in part of the

3 Building megaliths is here likened to building memories, while their use, as well as the recurrent erection of ditched enclosures, could be partly linked to the transmission of these memories. Each takes on different social functions, which could be expressed with different degrees of intensity and balance over time. Thus, the cycles and gaps observed in megalith building are not necessarily related to the building and use of enclosures.

Iberian Peninsula (Schulz Paulsson 2019). Far from the over-simplistic diffusionism of the 1950s, on either side of the Channel (for example) this coincides with multiple combinations (Laporte and Tinevez 2004), or more indirect inspirations (Scarre and Laporte 2021), of architectural forms that are sometimes similar but always a little different. This in no way rules out population movements, notably via long-known maritime routes (Fergusson 1872; Scarre 2018). The results presented here do indeed point in this direction. One scenario is that now well-established social structures within a landscape marked by a long-term process of building ancestral memories in north-western France, perhaps becoming somewhat too rigid, would have encouraged some to create new and adapted memories overseas, while we simultaneously observe a multiplication of places dedicated to the transmission of such memories at the margins of previous core regions.

We must remain cautious, however, because what now appears to be an exception within the scheme proposed here, the dolmen of Pech Laglaire I in the Lot, may be the only truly well-dated example among the thousands of simple or Causse-style dolmens built on the southern edge of the Massif Central (see Appendix). Approximately 5650 megalithic funerary monuments and 3500 standing stones have been identified in France, although there are considerable regional disparities (Lejeune and Vigneau 2021). Very few megalithic monuments have not been subject to some form of human intervention or archaeological investigation in the past two hundred years. However, to date, only around 15 of them can be dated with the precision required to fully address today's issues. This necessary observation is a very honest one, and somewhat disappointing; nevertheless considering France as an exception on this point in western Europe would be illusory.[4]

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4 Translation from French. L. Byrne, refined by D. Hofmann and two anonymous reviewers. Many thanks to C. Scarre and A. Whittle for their advice in improving this article. All mistakes it could contain are mine.

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Appendix: Bayesian analyses concerning the construction of megalithic monuments in France. A critical review of the evidence

Absence of desirable criteria in the radiocarbon date sequence

The sites listed below are among the examples cited by Bettina Schulz Paulsson (2017) in France.

Champ-Châlon megalithic cemetery (Benon, Charente Maritime)

Six radiocarbon dates have been published, none of which relates to an event prior to the construction of one of the three monuments and the four burial chambers concerned (Joussaume 2006).

Barnenez monument (Plouézoc'h, Finistère)

Seven radiocarbon dates have been published, all on charcoal, for six of the eleven burial chambers in a monument with a far more complex architectural history than initially imagined (Cousseau 2016; Giot 1987; Laporte *et al.* 2017). None of these dates allows us to set a TAQ and TPQ for the construction of one of these megalithic chambers or any other part of the monument.

Déhus monument (Guernsey, UK)

Six radiocarbon dates on human bone have been published, none of which relate to an event prior to the construction of this monument, such as the corridor dolmen or the side chambers it contains (Patterson *et al.* 2022; Schulz Paulsson 2017, 69).

Vierville monument (Calvados)

Six radiocarbon dates have been published, none of which relate to an event prior to the construction of this monument or to one of the two burial chambers (Chancerel *et al.* 1986; Schulting *et al.* 2010).

Monument at Cairon (Calvados)

Seven radiocarbon dates have been published, none of which relate to an event immediately prior to the construction of this monument or to one of the two burial chambers (Ghesquière and Marcigny 2011).

La Chaussée-Tirancourt monument (Somme)

Nine radiocarbon dates have been published, none of which relate to an event immediately prior to the construction of this gallery grave (Blin 2018). Many other dates have been produced, but are pending publication.

Questions concerning the value of a sample as a TAQ or TPQ

Bougon megalithic cemetery (Deux-Sèvres)

Twenty dates have been published, only one of which relates to an event prior to the construction of one of the five monuments and the eight burial chambers identified in them to date (Mohen and Scarre 2002). This radiocarbon date was measured on a red deer antler pick (OxA-9183: 5415±65 BP) collected in the quarry ditches alongside monument F. At least two or three distinct stages of construction have been identified for this latter monument. The Angoumois dolmen in chamber F2 is thought to correspond to the most recent construction, but the middle part of tumulus F1 has not yet been explored in depth and the link with cairn F2 needs to be refined. As things stand, it appears difficult to correlate above-ground the constructions with the events dated in the quarry ditches. In any case, the high margin of uncertainty in the two radiocarbon dates on samples taken in chamber F2 (Ly-967: 4790±220 BP; Ly-968: 4470±230 BP) cannot date the construction of this chamber with adequate precision.

La Hoguette (Fontenay-le-Marmion, Calvados)

Nine dates have been published, only one of which is considered by Schulz Paulsson (2017, 89) to be related to activities prior to or contemporaneous with the construction of this monument, which contains eight burial chambers. But the date of soil organic matter from above the floor of chamber IV (accepted by Schulz Paulsson) is not a valuable TPQ for the whole monument, and there are very few dates from chambers V and VIII (especially compared to the MNI), in a context where we do not know the sequence of construction.

La Hougue Bie (Jersey, UK)

The charcoal from the primary terrace of the La Hougue Bie monument is only a TPQ for the last phases of construction, while the monument core has never been explored, except for a vertical shaft opened in 1924 and re-excavated in 1995 (but with few details published). However, the Bayesian analysis proposed by Schulz Paulsson (2017, 70) enables us to date the **enlargement of this extensive circular cairn fairly precisely to between 4275 and 3991 cal BC**. The cairn contains a large cruciform megalithic chamber, certainly built before the end of the fifth millennium.

Table des Marchand (Locmariaquer, Morbihan)

The sequence from the Table des Marchand has yielded 25 radiocarbon dates, but no samples date an event immediately after the construction of the megalithic chamber or any other part of this monument, which was built in at least two successive stages (Cassen 2009). Bones have not been preserved. The radiocarbon date from soil organic matter sample 'earth 3' at the Table des Marchand, the most recent layer under the cairn, only indicates that the building is **later than 3968 cal BC** with 95 % confidence. This partial result is nevertheless consistent with results for chamber II of Petit Mont in Arzon.

Er Grah (Locmariaquer, Morbihan)

Pit e13, as well as the fill within it, are attributed to a pre-building phase by the excavators (Le Roux 2006), and not to phase 1 as stated by Schulz Paulsson (2017, 45). Among the nine published radiocarbon dates, a charcoal sample taken from the backfill of lateral quarry ditches/pits, subsequently partially covered by the construction of a **quadrangular cairn** which the excavators consider to be phase 1, suggests that it may have been **built after 4319 cal BC**, with 95.4 % confidence.

New Bayesian analyses focused exclusively on dating the construction of the monument or one of its parts

Bayesian analyses do not allow for the use of the mathematical signs greater than or equal to, and less than or equal to, even though this is the very essence of the meaning of a TAQ and TPQ. This can sometimes lead to a somewhat arbitrary ordering of such series of dates. This is particularly true for individual burials within cists or in the ground, which are ordered according to the median probabilities of the assigned age, as there are no stratigraphic relationships between them. But this may also concern, on a more ad hoc basis, different events relating to the construction or use of a megalithic monument or one of its parts. So, within each sequence, I preferred to use only radiocarbon dates that are definitely successive and close in time, strictly associated with the events to be dated. Complete sequences can be consulted in Schulz Paulsson (2017).

Le Souc'h (Plouhinec, Finistère)

Thirteen radiocarbon measurements can be used to date the various stages in the construction, and later use of this monument, which has a complex history (Laporte 2010a; Le Goffic 2006). 'In a first phase, a round tumulus or mound was built with a pit burial. [...] A charcoal sample from the burial pit indicates an age of around 4450 cal. BC [...]. On one part of this structure, five passage graves were erected, two of them P-shaped and covered by stone tumuli [...]. The radiocarbon dates connected to the passage graves do not begin before around 4070 (4107–3846 cal. BC, 68.2%, 4318–3817 cal. BC, 95.4%) or possibly even later, since the charcoal samples from grave 1 originate from debris, which includes the possibility of termini post quos value' (Schulz Paulsson 2017, 60).

In fact, three dates directly frame the construction of chamber 1, which is a passage tomb with walls made exclusively of drystone walling, as is the case for the corresponding cairn, which was clearly identified during the excavation. On the other hand, the two pieces of charcoal collected in the rockfall of the façade or passage cannot be considered as TPQs for the construction. A new Bayesian analysis, taking these elements into

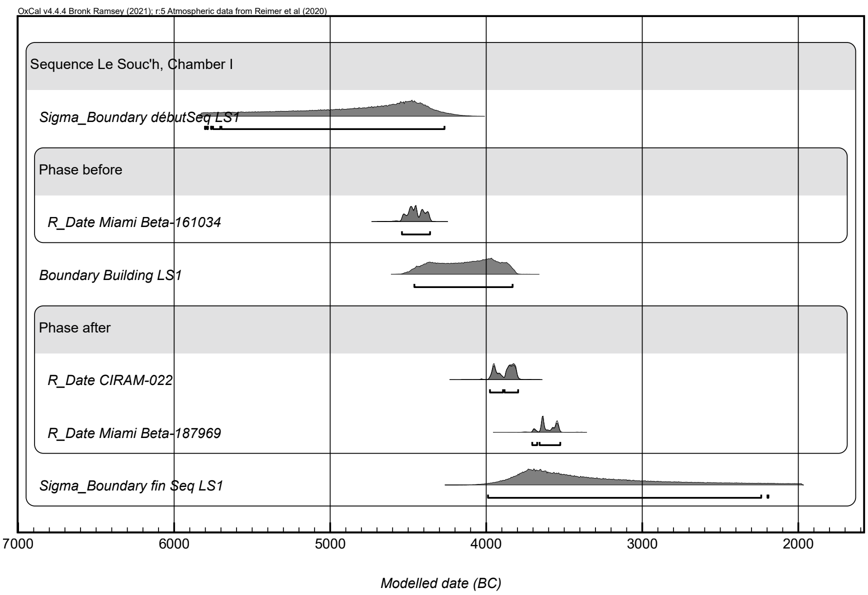

Figure A1. Dates for the building of chamber 1 at Le Souc'h (Plouhinec, Finistère). Model agreement: A_{model} & $A_{overall}$ = 98.6.

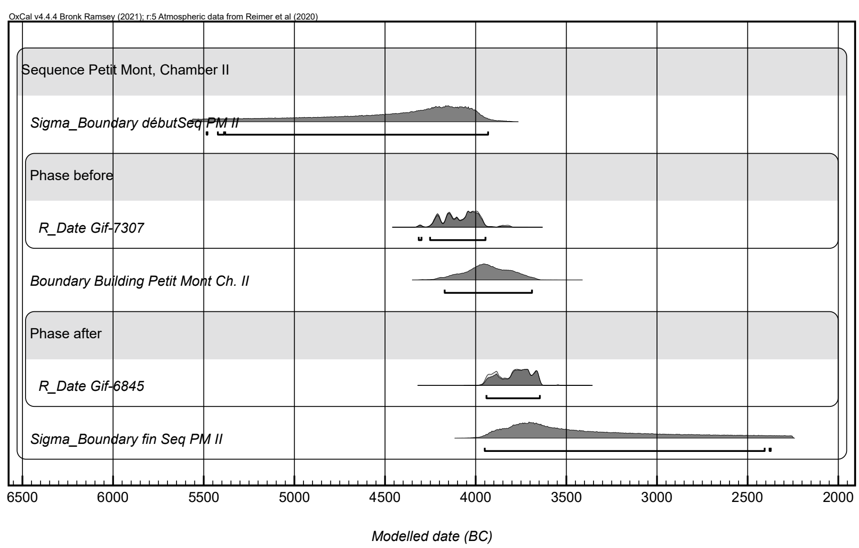

Figure A2. Dates for the construction of chamber 2 at Petit Mont (Arzon, Morbihan). Model agreement: A_{model} & $A_{overall}$ = 101.

account, places the construction of chamber 1 somewhere between **4461 and 3832 cal BC** with 95.4 % confidence (4383–3864, 68.3 %) (Figure A1).

In this sequence, two radiocarbon dates also frame the events associated with the construction of chamber 2, which is a passage grave with a segmented megalithic chamber. The chamber was subsequently altered, however, and it is not clear what impact this had on the body of the cairn, which had already been largely levelled at the time of excavation. One of the charcoal samples was taken from the body of the cairn, just behind one of the orthostats in chamber 2, and the other from the corridor. This segmented chamber dolmen could therefore have been built between 3491 and 3039 cal BC, with 95.4 % confidence. However, this result would appear to correspond better to the later construction of an elongated megalithic chamber with side entrance in this same space, which opened outwards via the same access corridor. Given the uncertainty, this result was not taken into account for this analysis.

Petit Mont (Arzon, Morbihan)

Eleven radiocarbon measurements can be taken into account to date the various stages in the construction and later use of Petit Mont in Arzon (Lecornec 1994). 'The construction of grave II, which is the earliest passage grave of the complex, is calculated to 3944–3798 cal. BC (95.4 %, 3887–3817). One result is available from passage grave III, indicating construction or use of grave III some decades later at around 3830 cal. BC' (Schulz Paulsson 2017, 64).

The dates initially published by the excavator were later corrected by the laboratory. In fact, only chamber II provided all the necessary information to date its construction. Originally, this was a passage tomb (*dolmen à couloir*) with walls exclusively composed of megalithic blocks, from floor to ceiling. Five radiocarbon dates frame the construction event. In relation to this event, the three separate hearths on the floor slab cannot be considered as strictly contemporaneous and belonging to a single phase. Similarly, its corridors can be lengthened and the walls of this chamber were undoubtedly partly rebuilt, perhaps as a result of an accident during construction (Laporte 2010b).

Therefore, I will not take into account the date obtained from charcoal taken from a hearth located under the floor slab of the corridor (Gif-7014), preferring the date obtained from charcoal taken from under the floor slab of the chamber (Gif-7307), as well as the earliest date obtained from charcoal taken from hearths located on this same floor slab (Gif 6845). An old wood effect cannot be ruled out. A new Bayesian analysis, taking into account the updating of the calibration curve in 2020 (Reimer *et al*. 2020), places the **construction of chamber II between 4172 and 3690 cal BC** with 95.4% confidence (4044–3784, 68.3 %) (Figure A2). However, the date obtained from the charcoal sample from a hearth under the **corridor** paving suggests that it was **built after 3956 cal BC**.

Péré Tumulus C at Prissé-la-Charrière (Plaine d'Argenson, Deux-Sèvres)

Twenty-three radiocarbon dates have been obtained for the Péré tumulus C sequence at Prissé-la-Charrière, all but one from human bone. Two yielded results from the historic period, while all the others fall between 4300 and 4000 cal BC (Laporte *et al.* 2021). New dates are currently being processed to refine this sequence. Those already published have been the subject of Bayesian analyses produced successively by Christophe Sevin-Allouet (2011) and by Bettina Schulz Paulsson (2017, 79).

Tumulus C covers three burial spaces, corresponding to three distinct and partly successive monuments. Chamber III is a passage tomb in a circular cairn, with drystone walls, a paved area and a capstone. Chamber II is a large cist without permanent access, later sealed under a 23 m long quadrangular mound. Chamber I is an Angoumois-type passage tomb, built in a 100 m long elongated mound that covers the two previously separate monuments. All the individuals whose bones were collected in each chamber have been dated. In the two passage tombs, the bodies decomposed *in situ*. However, no radiocarbon date indicates an event prior to the construction of chamber III and its circular cairn. Deposits of bones in the socket of an orthostat from the Angoumois dolmen (chamber I), or against the external side of one slab of the cist (chamber II), combined with a detailed study of the various stages of construction, make it possible to date the construction of chambers I and II fairly precisely.

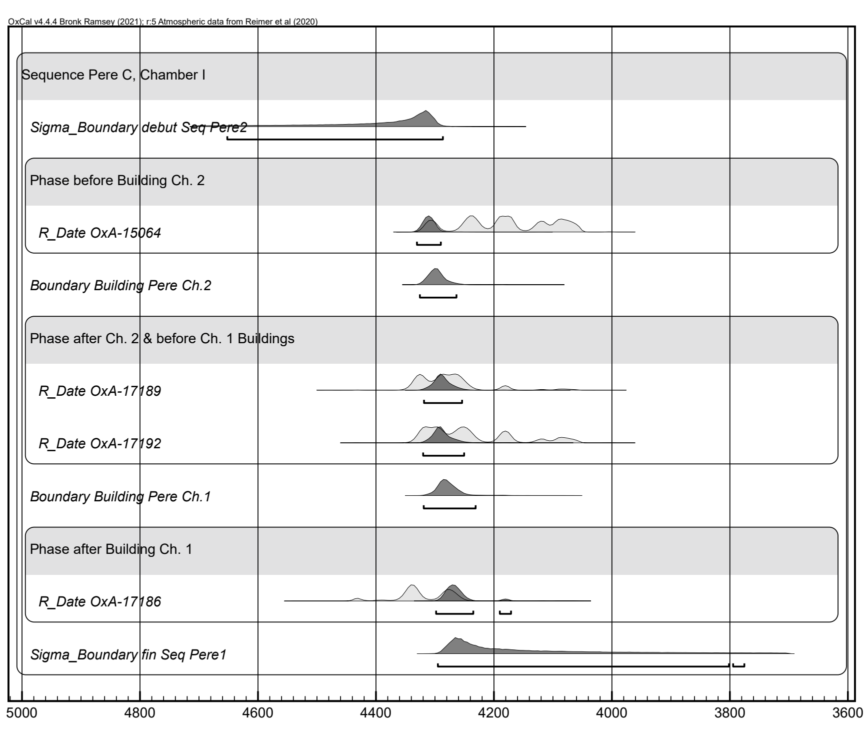

Figure A3. Dates for the construction of chambers I and II at Péré C (Plaine d'Argenson, Deux-Sèvres). Model agreement: A_{model} = 93.1 $A_{overall}$ = 92.8.

The bone deposits lying against the external side of one slab of the cist (chamber II) certainly predate the surrounding drystone construction, and the deposits of human bone within the cist indicate the time of its use as a burial chamber, although we cannot totally rule out the introduction of bones of people who died earlier. On the other hand, the existence of anatomical connections attests to the fact that the bodies decomposed in the central *dolmen à couloir* (chamber I), and therefore that the corresponding dates are contemporaneous with the individuals' death (Soler *et al.* 2004). However, we do not know where the few phalanges found in the socket of one of the orthostats in chamber I might have come from.

A Bayesian analysis of these two sequences independently places the construction of chamber I between 4342 and 4238 cal BC, and that of chamber II between 4322 and 4085 cal BC, with 95.4 % confidence. Assuming that chamber I was built after chamber II (Figure A3), the two events thus appear to have occurred close in time, over less than a hundred years between 4326 and 4228 cal BC, with 95.4 % confidence (between **4326 and 4265 cal BC for chamber II**/cist, then between **4321 and 4228 cal BC for chamber I**/passage tomb). This new model will be refined with a few more dates for the entire sequence, but corresponds to previously published results (Laporte *et al.* 2021).

Monument IV of Château Blanc (Ventabren, Bouches-du-Rhône)

Eight radiocarbon measurements are available for this cemetery composed of five different tumuli, with five dates relating to tumulus IV (Schulz Paulsson 2017, 157). A Provençal dolmen (phase IVb) was secondarily inserted into this mound (phase IVa), a human bone from which also yielded a radiocarbon date (Hasler *et al.* 2002). Three other dates on human bone relate to various stages of the collective burial inside the dolmen. The construction of this Provençal dolmen therefore took place between the death of the individual buried in the phase IVa burial mound (ETH-15732) and the earliest stages of the collective burial (ETH-15730, then ETH-15731, ETH 15733). This event can therefore be dated to between **3316 and 2949 cal BC** with 95.4 % confidence (3260–3034 cal BC, 68.3 %) (Figure A4).

Bayesian analyses of sequences not previously taken into account, or published recently

La Bruyère-du-Hamel (Ernes, Calvados)

Twenty-five radiocarbon measurements date the Middle Neolithic occupation of the site of la Bruyère-du-Hamel (Dron *et al.* 2016) (Figure A5).

The three earliest dates correspond to domestic occupation by the Cerny group. All the other dates concern activities associated with a group of six drystone-built passage tombs. Grave A contains two simultaneously built circular chambers. The bones found on the floor of chamber A1 correspond to a MNI of five individuals. Only one date is available (Lyon-6673: 5385±40 BP) on human bone. The bodies of at least eight individuals were deposited on the floor of chamber A2, for which no date is available. The outer face of the cairn covers a hearth, from which charcoal was taken for dating (Gif-11743: 5510±70 BP). These two dates can be considered to date the construction of **tomb**

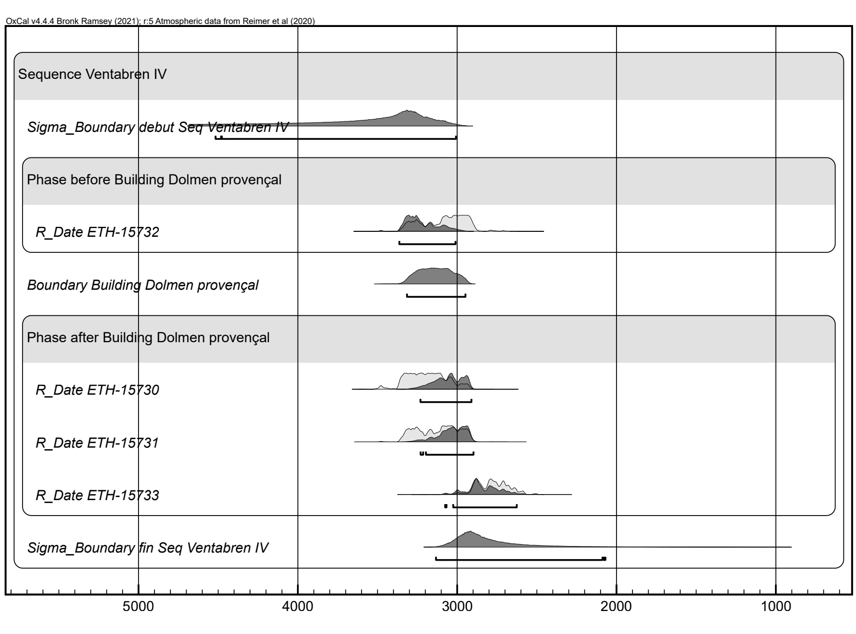

Figure A4. Dates for the building of the Provençal dolmen in tumulus IV of Château Blanc (Ventabren, Bouches-du-Rhône). Model agreement: A_{model} = 74.6, $A_{overall}$ = 76.4.

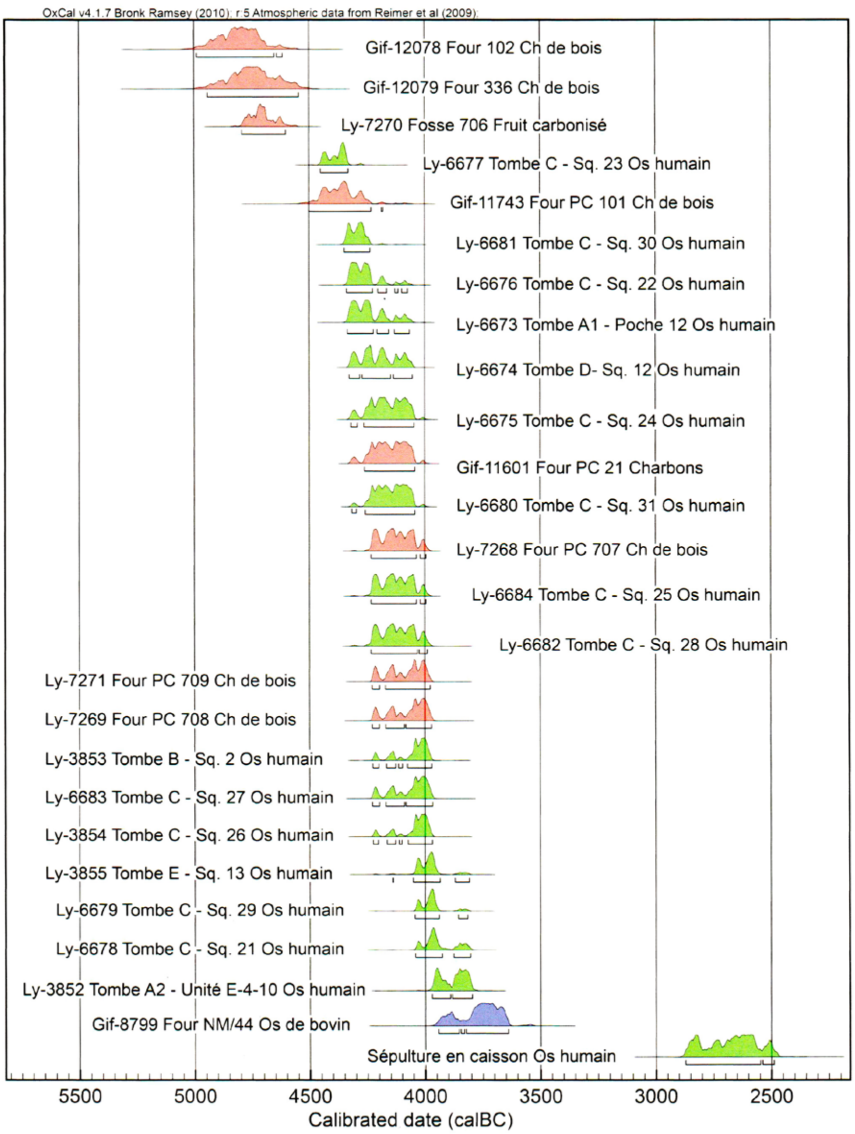

Figure A5. Sequence of radiocarbon dates from the Bruyère-du-Hamel site in Ernes (Calavados). After Dron *et al.* 2016, fig. 10. Green, human bones; orange, charcoal; purple, animal bone.

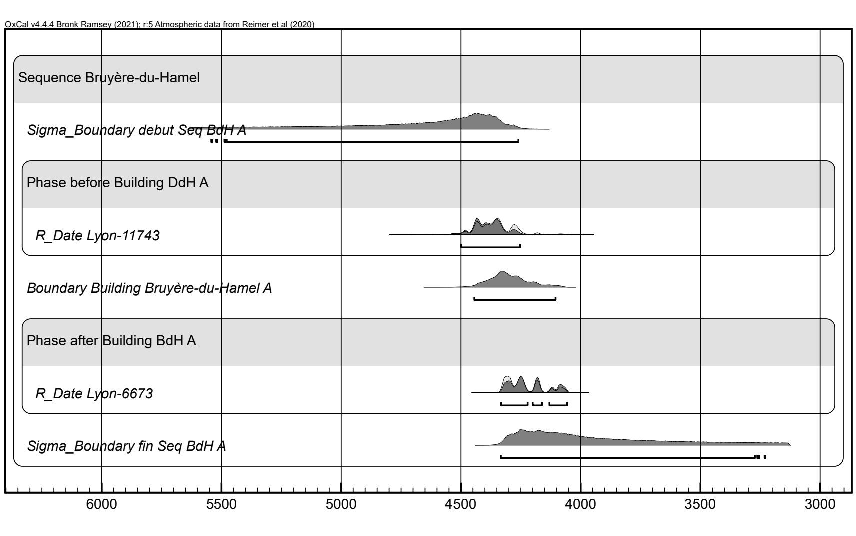

Figure A6. Dates for the building of tomb A at Bruyère-du-Hamel (Ernes, Calvados). Model agreement: A_{model} = 96.6; $A_{overall}$ = 96.3.

A to between 4445 and 4106 cal BC, with 95 % confidence (4396–4236, 68.3 %) (Figure A6).

Grave C is located immediately east of Grave A. The bone remains of 12 individuals lay on the floor of the circular chamber, eleven of which have been radiocarbon dated. The bodies decomposed *in situ*. The earliest of the obtained dates (Lyon 6677: 5525±35 BP) could be considered an outlier, if we only take dates on human bones into account. However, it is broadly contemporaneous with the date obtained for the charcoal taken from hearth 101. It is therefore not impossible that the construction of tomb C preceded that of tomb A, before 4330 cal BC.

Croaz Dom Herry (Saint-Nicolas-du-Pelem, Côtes d'Armor)

Nine radiocarbon measurements are available for the sequence of this monument, which consists of four circular chambers, all lined with small orthostats but mainly built of drystone (Tinevez *et al.* 2012, 233). The chambers and their corridor all seem to have been built at the same time. One date is from the historic period. Two others come from the backfill of adjacent quarries. Another, taken from the buried soil under the monument, undoubtedly corresponds to an earlier occupation, and yet another relates to a sample taken from a hearth outside the monument. Two charcoal samples have been dated to the second half of the fourth millennium BC or the third millennium. They come from the base of a cairn that has been levelled and severely disturbed in places. Only the two remaining samples can be taken into account for dating the construction, with falls between **4296 and 3997 cal BC**, with 95.4 % confidence (4238–4025 cal BC, 68.4 %; Amodel = 106.3; Aoverall = 107.3). These are pieces of charcoal collected at the base of an orthostat socket on the north wall of chamber B (Lyon-5556: 5375±35 BP), and organic matter taken from the inner wall of a Middle Neolithic pot, found crushed at the base of the outer facing of the eastern façade of the monument (Lyon-4660: 5230±35 BP).

Liscuis II (Laniscat, Côtes-d'Armor)

Two radiocarbon measurements were carried out on charcoal samples taken during the excavation of the gallery grave at Liscuis II (Le Roux 1984), one in the tumulus surrounding the megalithic chamber (Gif-3944: 4450±110 BP), and the other on the floor of the terminal cell (Gif-3585: 4170±100 BP). We will consider these two dates as framing the construction of the monument. Two dates can hardly be considered sufficient, and the margins of error are significant. However, these are the only dates available to date the construction of a gallery grave in Brittany, between **3318 and 2598 cal BC** with 95.4 % confidence (3125–2784, 68.3 % A_{model} & $A_{overall}$ = 101).

Butte Saint-Cyr (Val-de-Reuil, Eure)

Four radiocarbon measurements, all on human bone, contribute to the sequence of the buried gallery grave of the Butte Saint-Cyr. This monument yielded the remains of more than 90 individuals. Sample OxA-5366 (4590±100 BP) 'concerns an isolated bone located in the "pre-phase 3 C" pit, which is completely sealed under orthostats 6 and 3' (Billard *et al.* 2010, 152). Samples Lyon-4822 (4270±35 BP) and OxA-5365 (4130±35 BP) 'date at least part of the cell's burial deposits' (Billard *et al.* 2010, 152). The orthostats would thus have been erected between **3403 and 2783 cal BC** with 95.4 % confidence (3164–2884 cal BC, 68.3 %) (Figure A7). The fourth date (OxA-5364: 4690±90 BP) was obtained from a human bone collected at the base of the burial layer, just after the erection of the orthostats.

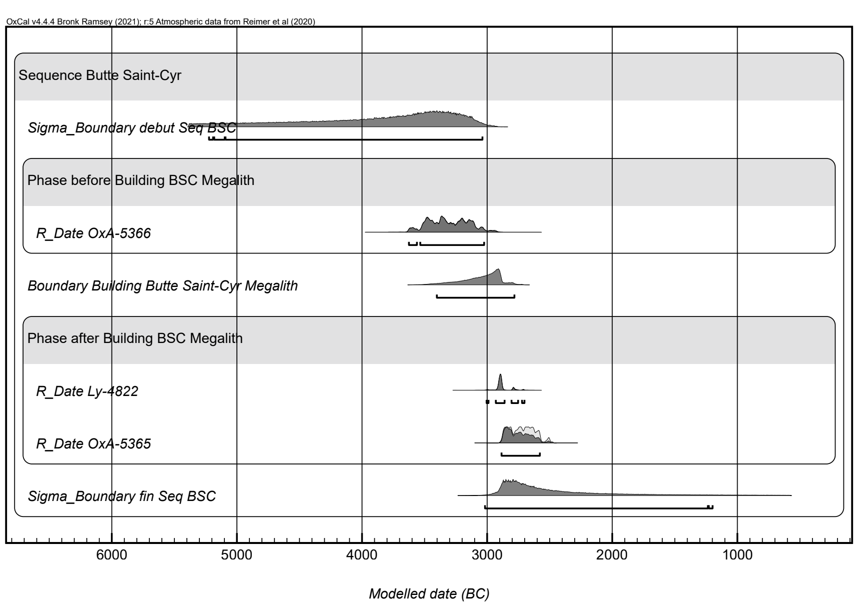

Figure A7. Dates for the construction of the Butte Saint-Cyr gallery grave (Val-de-Reuil, Eure). Model agreement: A_{model} = 98.8, $A_{overall}$ = 98.9.

However, associated with this stratigraphic position, it shows very low compatibility (50 %) with the Bayesian analysis presented above. We cannot rule out the possibility that this bone came from earlier deposits.

Pech Laglaire I (Gréalou, Lot)

Three radiocarbon measurements were taken for the sequence of this monument, which consists of a cairn encompassing two successively built Causse-type dolmens. Several architectural phases were identified (Ard *et al.* 2022). One of these three dates relates to an immature individual's metatarsus found in the socket of one of the orthostats from dolmen 1 (Beta-599985: 4720±30 BP), while another was carried out on a fragment of an adult's left femur from the bundle of bones discovered in the centre of the chamber (Beta-599986: 4710±30 BP). Dolmen 2 appears to be older. A final radiocarbon date was obtained on a human bone from a pit originally located at the front of the monument, and it cannot therefore be used for our purposes. **Dolmen 1 was built between 3601 and 3386 cal BC**, with 95 % confidence (3535–3397, 68.3 %; Amodel = 99.4, Aoverall = 99.2).

Saint Eugène (Laure Minervois, Aude)

Ten radiocarbon measurements, all but one on human bone, date the sequence of this *dolmen à couloir*, which contained the remains of at least 200 to 300 individuals, according to still rather uncertain estimates (Guilaine 2019). Several distinct architectural phases have been identified, as many as six or seven successive phases, corresponding perhaps first to an elongation of the corridor, and subsequently to enlargements of the diameter of the cairn. 'During a survey carried out in 1972, in the fill of the mound, between walls 1 and 2, outside the cell but close to the angle formed by the low wall extension of the capstone slab and its meeting point with the pillar of the eastern wall […], at the base of the fill, a charcoal sample was taken' (Guilaine 2019, 309). The resulting date (Lyon-1449: 4485±40 BP) is very close to that obtained from a fragment of an adult's right humerus taken *in situ* from the lower fill of the corridor (Lyon-2205: 4485±30 BP). The **construction period of architectural phases 2 and 3**, which may not have been the earliest, is framed by these two dates. It took place between **3337 and 3060 cal BC**, with 95.4 % confidence (3293–3124 cal BC, 68.3 %; Amodel & Aoverall = 97.3). The other dates were obtained from bones found when the chamber was emptied during earlier excavations, and in one case from sediments dumped on the eastern side of the tumulus. Two of these dates correspond to the Bronze Age and the others to the end of the Neolithic. Only one is broadly contemporaneous with the date on the humerus taken from the corridor, but it cannot be located stratigraphically (Lyon-2204: 4520±30 BP, 3356–3101 cal BC, 95.4 %).

La Planquette (Joncels, Hérault)

Seven previously unpublished radiocarbon measurements were obtained for the La Planquette dolmen sequence. I would like to thank Jean-Paul Cros for allowing me to use them for this work. One of them is from a charcoal sample taken from between the stones of the outer facing, overlain by rockfall (Poznan PL 08 ch. 4: 4470±40 BP). The others were measured on human bone from the chamber and corridor, with the exception of an animal bone collected from the upper levels of the chamber, which dates to the historic period. These five dates on human bone are from the end of the fourth or the beginning of the third millennium, for a MNI of over 50 individuals. The oldest date is from the last third of the fourth millennium (Lyon-11460: 4535±30BP) and was taken on a bone found at the base of the chamber's burial levels. This monument was therefore **built between 3321 and 3116 cal BC**, with 95.4 % confidence (3274–3150 cal BC, 68.3 %; Amodel & Aoverall = 106.9).

Le Villard (Lauzet-Ubaye, Var)

Seven radiocarbon measurements date the sequence of this Alpine dolmen, all but one on human bone (Sauzade and Schmidt 2020). The MNI in the chamber is 16 adults and nine immatures. At least two of these individuals, from the top of layer 2, died during the Bronze Age. Four other samples correspond to bones taken from the base of layer 2 (Ly-9995: 3895±35 BP, for the oldest). The charcoal sample was collected under the mound (Ly-9993: 4640±35 BP). There is no overlap between the date from the ancient floor and the earliest layer attesting to use of the site for burial, so we only know that the **mound** was **built after 3360 cal BC** (and probably before 2244 cal BC), with 95.4 % confidence (2773–2338 cal BC, 68.3 %; A_{model} = 98.1; $A_{overall}$ = 97.4).

Updated result of previously published Bayesian analyses

Lannec-Er-Gadouer (Erdeven, Morbihan)

Seven radiocarbon measures were taken to establish the sequence of the monument (Cassen 2000). 'Lannec er Gadouer is […] a long tumulus or mound with a maximal length pf nearly 45 m and a width of 16 m […]. From the western central part, a small half-buried cist is documented, clearly implanted in a pit […]. The tumulus was built in several phases and one layer under the monument records pre-monument activities and contains Ancient Castellic material […]. The construction of the chamber is calculated at around 4300 cal. BC (4503–4104 cal. BC, 95.4%, 4431–4232 cal. BC, 68.2%)' (Schulz Paulsson 2017, 42).

Here we will simply update this sequence in relation to the new calibration curve published in 2020 (Reimer *et al.* 2020). A wheat seed collected in hearth 2, sealed under the mound in the first phase of construction, yielded the most recent date (ERD-Sol-Foy2: 5640±80 BP) among the five dates associated with the buried soil under the monument. There is no stratigraphic evidence to enable us to order these dates. Softwood charcoal was also collected from the floor slab of the dolmen (ERD-TOM-PLancher: 5445±60 BP). Construction of the dolmen therefore took place at some point between **4615 and 4171 cal BC** with 95.4 % confidence. (4474–4284 cal BC, 68.3 %, A_{model} = 98; $A_{overall}$ = 97.9).

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THE STONE AGE BOATS OF ATLANTIC EUROPE AND THE ADJACENT NORDIC REGIONS

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Abstract

While there is abundant evidence of sea crossings in the Stone Age through material culture, our comprehension of the boats and nautical technologies of early seafaring and boat-building societies remains limited. Our knowledge primarily stems from depictions in rock and megalithic art discovered in Fennoscandia and Brittany. A new documentation of several sites in these two areas, utilising a handheld laser red light scanner, not only revealed additional boats but also provided insights into technical aspects. The following chapter presents an overview of the confirmed Stone Age representations of boats in north-western Europe. Additionally, it analyses the development of watercraft and proposes a systematic classification of potential boat types in north-western Europe during the fifth and fourth millennia cal BC.

Keywords: Stone Age boats; rock art; megalithic art; prehistoric boat technologies; ancient mariners; coastal Stone Age communities

Introduction: surveying Stone Age watercraft

The archaeology of human use of the seas is extremely challenging. Outside of a few harbours and shipwrecks, anything sunk in the seas is largely lost and evidence for sea travels has to be sought at journey's end (Kehoe 2016, 33). Inferences must be developed from land data, ranging from basic observations such as that humans reached other continents at least 50,000 years ago, to the spread of exotic materials and historical documents. However, there must have been seagoing watercraft of great antiquity, with the settling of Australia as the strongest evidence for sea passages in the Pleistocene (e.g. Bednarik 1999; O'Connell and Allen 2015).

Recent research into the mobility of Stone Age societies in Europe suggests that seafaring at that time was far more developed than previously supposed. Radiocarbon and archaeological evidence strongly suggest seafaring, coastal migrations and inter-societal contacts along the entire Atlantic coast (Cassen *et al.* 2019; Schulz Paulsson 2017; 2019; Schulz Paulsson *et al.* 2019). Evidence for ancient mariners and long-distance maritime journeys, however, is often limited to the pattern and transfer of material culture. Little is known regarding the maritime capabilities and technologies of Stone Age societies.

Worldwide there is no direct archaeological evidence for boats and rafts before the Mesolithic (McGrail 2014, 45) and physical evidence of boats and nautical equipment is limited, with dugout canoes or log boats being the most prevalent type of surviving

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watercraft found in the archaeological record. The earliest known log boats worldwide are from Pesse in the Netherlands (8230–7610 cal BC, 95.4 %) and Noyen-sur-Seine in northern central France (7140–6600 cal BC, 95.4 %); both boats were built with pine (Lanting 1997/1998; Momber and Peetersen 2017; Mordant and Mordant 1989). In terms of other wooden boats, there is no evidence for plank vessels during the Stone Age. The earliest evidence dates back to the third millennium cal BC in Egypt, and there are sewn plank boats recorded from the British coast from around 2000 cal BC onwards. Only a limited number of log rafts have been documented, appearing no earlier than the second century cal BC (e.g. McGrail 1998; 2001; 2014).

No or very few remains have survived from Stone Age watercraft built out of skin, bark, reeds and bundles. An exception are the remains of an inflated sea lion skin boat from the Atacama Desert in Chile (Ballester and Gallardo 2016). Indirect evidence for boats in the archaeological record mostly takes the form of solidified bitumen with for instance reed impressions and waterproofing outer layers of bundle boats (Brown 2016; Fauvelle 2014; Kehoe 2016; McGrail 2014).

In the European context, our archaeological understanding of the broad spectra of Stone Age boats primarily stems from rock art representations in Fennoscandia and Brittany (Figure 1). These engravings and paintings indicate a variety of boat types and materials used for watercraft in the Holocene, even if the physical evidence is lacking. However, dating rock art is generally challenging and can only be achieved through the typological classification of motifs, context analysis and, where available, shoreline chronologies, as seen in Scandinavia. Hence, the secure attribution of boat depictions to the Stone Age is only possible in these two regions, even though other areas in Atlantic Europe, such as Galicia, also exhibit rock art featuring boats.

The Fennoscandian rock art reveals numerous representations of boats, primarily the so-called elk-head boats, indicative of mobile maritime hunting societies operating between the eighth and third millennia cal BC. These groups fished and hunted marine mammals, elk

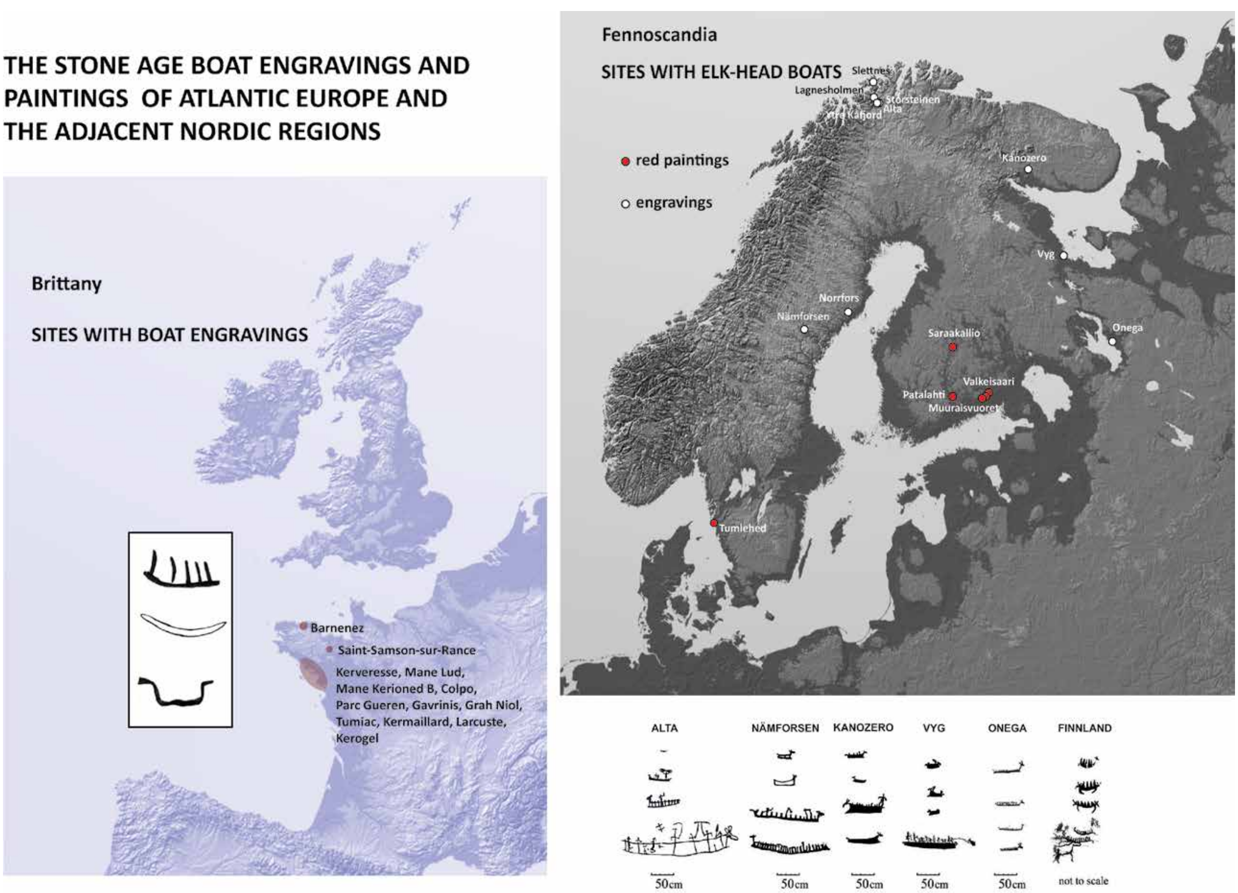

Figure 1. The Stone Age boat engravings of Atlantic Europe and the adjacent Nordic region. Left: megalithic sites with boat engravings in Brittany. Right: map of the distribution of elk-head boats in the rock art of Fennoscandia (red: paintings, white: engravings) (after Gjerde 2010; Schulz Paulsson *et al.* 2019).

and reindeer along the coastal expanses and partly inland along the rivers of Norway, Sweden, Finland and Russia. The second region in north-western Europe with early boat representations, particularly from the fifth and fourth millennia cal BC, is Brittany. Here the boats are evident in megalithic contexts such as engravings in megalithic tombs and on standing stones (Cassen et al. 2007; 2019; 2021; Schulz Paulsson in press a; in press b) (Figure 1). Just a few examples are known from Irish megalithic contexts (Bradley 2022; Robin 2009).

This chapter offers an overview of authenticated Stone Age depictions of boats in north-western Europe and proposes a systematic classification of potential boat types, drawing on parallels from cultural anthropology.

Stone Age boat technologies and the elk boat people of Fennoscandia

Fennoscandia refers to the geographical region comprising the North European Peninsula, which is formed by Finland, the Scandinavian Peninsula along with Karelia and the Kola Peninsula. Globally, it holds the highest concentration of Stone Age boat depictions in coastal rock art. Carved or red-painted boats are situated along the coasts of Northern Atlantic Fennoscandia, the Baltic region, and the White Sea (Gjerde 2010, 399, fig. 283).

The Valle boat from Norway (Gjerde 2021) stands as the earliest identified boat. Shoreline dating estimates its age to be around 10,000 to 11,000 years old. This boat engraving, exceeding four metres in length, is preserved in fragments. One end features a horizontal stem interpreted as horns, possibly designed to facilitate the transportation of a skin boat. The open-air rock art of the Early Mesolithic otherwise primarily depicts various wild animals, including reindeer, elk and marine mammals.

In the Late Mesolithic (6500–4000 cal BC) there is a large range of depictions and more complex arrangements involving boats and anthropomorphic figures of humans or supernatural beings forming pictorial narratives (Gjerde 2021; Skoglund *et al.* 2023), such as the hunting of game from boats (Figure 2).

These boats are drawn as the hull shape in profile, most of them with a stem extension in form of an elk. Other animals might occur, there are a few examples of reindeer and bird heads in the stem, but these are an exception (Gjerde 2010). It is a reasonable assumption that the elk heads depicted at the upper end of the frontal stem have a factual basis, suggesting that the boats either featured sculpted wooden elk heads or were crafted from dried elk skin with the head mounted atop the frontal stem (Schulz Paulsson *et al.* 2019). The discovery of a wooden elk head in the Lehtosjärvi bog outside Rovaniemi in Finland is interpreted as the stem of a hide boat. It has a ^{14}C date attributed to the eighth millennium cal BC, suggesting that these boats were manufactured as early as the Early Mesolithic (Hel-168, 7740±170 BP; 7045–6374 cal BC, 95.4 %; 6766–6436 cal BC, 68.2 %) (Lindqvist 1983, 5; Westerdahl 2005, 12).

Elk-head boats as engravings are found in north-east Norway, northern Sweden and adjacent areas of north-west Russia, with Alta, Nämforsen, Vyg, Lake Onega and Kanonzero being the most prominent sites. Red-painted boats occur in Finland and on the west coast of Sweden (Lahelma 2008; Schulz Paulsson *et al.* 2019). Whether carved or painted, these elk-head boats demonstrate considerable

Figure 2. The elk boats and the elk boat people of Fennoscandia. Left: red rock painting of Tumlehed, north of Gothenburg; detail with three elk-head boats, a seal, a porpoise and fish. This site is interpreted as the seasonal hunting camp of sea mammal hunting groups from distant Arctic or eastern regions (Schulz Paulsson *et al.* 2019). Digital photography, enhanced with D-stretch, LRE algorithmus. Right: elk boats at Alta Bergmanbukten I. Above: drive hunt proceeding from a boat, phase 1 (5200–4200 cal BC) enhanced with D-stretch, YRE algorithm. Below: boat, phase II (4200–3000 cal BC).

stylistic similarities and it is possible to reconstruct a similar chronological and boatbuilding technological development using the shoreline data from Alta on the Norwegian coast, Vyg on the White Sea and Päijanne in Finland (cf. Gjerde 2010; 2019, figs 152, 153, 283).

The adjustment of the Alta chronology from recent shoreline radiocarbon data calculated phase 1 to lie within a time interval of 5220–4240 cal BC (95.4 %; 5220–4225 cal BC, 68.2 %). In this phase, the elk boats are already relatively long and slim, depicted with two to eight crew strokes, that means strokes representing crew members. The keel and gunwale have the same length, or the keel is slightly shorter. These boats are featured in hunting scenes, such as in Bergbukten I, showing a drive hunt on elk and reindeer carried out from an elk-head boat, or a seal hunt conducted by a single hunter on an elk-head boat (Figure 2).

The earliest boats on the Kola Peninsula in Vyg phase I (5300–4200 cal BC) are similarly depicted with an elk-head stem and a pronounced helm. However, these boats are smaller and deeper, featuring a forward protruding keel and one to three crew strokes. Some of these boats are portrayed as being involved in hunting sea mammals, identified as beluga whales (Gjerde 2013; Janik 2022; Savvateev 1970). Finally, the Päijänne shoreline chronology indicates a date around 5000 cal BC for two red-painted single line representations of elk-headed boats on the Patalahti panel. These small boats with four to five crew strokes are among the earliest known rock paintings in Finland (Lahelma 2008, 26; Poutiainen and Lahelma 2004, 77–8).

Larger elk-head boats are evident in Alta from phase II onwards within the 4230–2920 cal BC (95.4 %; 4230–2940 cal BC, 68.2 %) range and in Vyg confirmed within a time interval of 3700 to 2500 cal BC. In Alta, these boats are deeper and larger than in the previous phase, with a pronounced helm but often only a few crew strokes. In Vyg, the more elongated elk-head boats, again with a forward protruding keel, exhibit up to 12 crew members involved in partly complex whale hunting scenes (Gjerde 2010; Savvateev 1970). Of the altogether 68 known Finnish boats, which are paintings in red ochre, most are substantial boats with between six and 25 crew strokes (Lahelma 2008, chapter 2.3.3); the chronological classification of these boats is, however, difficult.

From this time horizon, there are first indications of longer maritime ventures. The red rock paintings at Tumlehead exhibit elk boats with up to 12 crew strokes. Being the most southern and rather isolated elk boat site, it is interpreted as the seasonal camp of maritime societies on the move, hunting sea mammals in Bohuslän's nutrient-rich waters (Schulz Paulsson *et al.* 2019).

Namförsen in Sweden stands out as an exceptional rock art site, since it served as a focal point where diverse rock art producing societies converged. Beside the hunter-gatherer rock art including 387 boats (Larsson *et al.* 2018) the site features Bronze Age engravings and depictions of Late Neolithic artefacts (Bertilsson 2017; 2018). Carved on rock panels on islands and along the river Ångermanälven, the rock art presents challenges in establishing a chronology compared to sites near the sea with shoreline data.

The most notable boat, likely of a more recent origin, is from Notön and exhibits 62 crew strokes (Larsson *et al.* 2018, fig. C: 6–7). However, the most detailed elk-head boats have been documented at Lillforshällan on Laxön, and a recently produced laser scan survey using a HandyScan 700 red-light laser scanner with a resolution of 0.05 mm has provided additional detailed insights (Figure 3).

Boat I on this panel is identified as a flat raft or skin boat featuring a forward protruding keel with a pronounced helm and at the stem a one-dimensional elk head with a beard. The depiction includes 13 crew members, three of whom are illustrated with oversized elk staffs. This feature is commonly found in Nordic rock art and is illustrated either in connection with boats or in ritual battles (Mantere and Kashina 2020). In the back of the boat the skipper, as the second person close to the helm, is depicted with either an oar or a navigation instrument in their hands.

Boat II, located on the panel adjacent to the previously described one, shares a similar design as a flat raft or skin

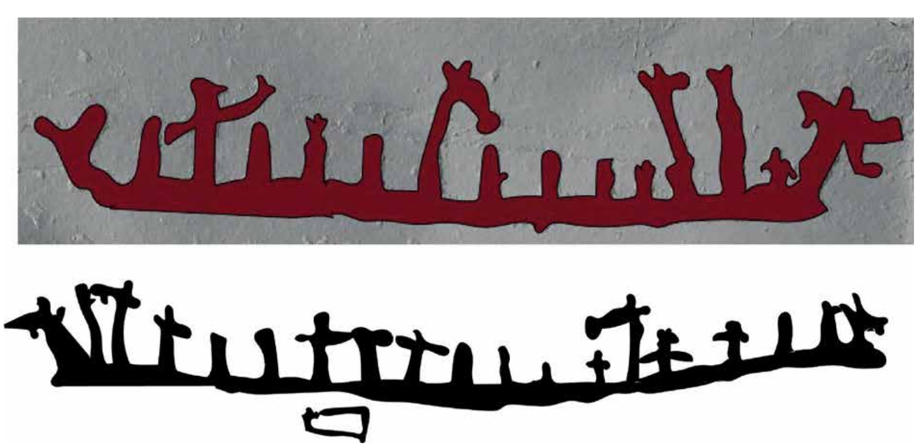

Figure 3. Elk boats with crew and elk-head staffs, Nämforsen, Lillforshällen, Laxön. Above: boat I. Below: boat II. Both boats were scanned using a HandyScan 700 red-light laser scanner with a resolution of 0.05 mm and processed in the program Meshlab 2021.37.

boat. Both the helm and the stern are carved as elk heads, complete with beards. On board, there are 15–16 crew members, with eight of them suggested to be holding oars (or perhaps this is a depiction of their arms). Two individuals are adorned with elk staffs, and the person positioned at the back, near the helm, appears to hold a significant role. This particular figure with the elk-head staff is depicted in detail, wearing what seems to be either a mask or an animal head with small ears. Compared to the other regions with elk-head boats, the dimensions of the described Nämforsen boats suggest a later date, likely not before the second half of the fourth or even the third millennium cal BC.

In Nämforsen, one observation is the abundance of engraved elk; however, unlike the earlier phases in Alta or Vyg, there are no clear hunting scenes featuring elk-head boats. It seems evident that the large elk-head boats may have served expeditions or trade along the river. These vessels would have been well-suited for transporting cargo, indicating that Nämforsen functioned as a meeting point for northern hunter-gatherers and other Stone Age and Bronze Age groups.

Maritime symbols of the megalithic societies in Brittany

The second region in Europe with clear Stone Age boat engravings is Brittany. Here, maritime symbols in megalithic contexts on standing stones and megalithic tombs are dated back to the fifth and the fourth millennium cal BC. In recent years, European megalithic research has shifted its paradigm, moving away from the concept of megalith builders as Neolithic sedentary farmers, back to maritime mobile societies, with evidence suggesting that some of these groups or a specialised section had advanced maritime technologies. New research is consistent with the conclusion that the megalith builders undertook long-distance voyages along the Atlantic coast, enabled by skills in shipbuilding and navigation, *c.* 2000 years earlier than the previously proposed Bronze Age date (e.g. Cassen *et al.* 2019; Schulz Paulsson 2019). The coastal setting and the radiocarbon dates suggest three main phases of megalithic expansion over the seaways (Schulz Paulsson 2019). Megalithic tombs emerged in Brittany and spread outward to west Iberia and the Mediterranean coast. Widespread trade in green stone artefacts, such as callaïs and jadeite, and a partly shared symbolic imagery indicate societies strongly associated with maritime environments (Cassen *et al.* 2019; 2021; Querré *et al.* 2019; Schulz Paulsson in press a; Schulz Paulsson *et al.* 2019).

North-west France, and in particular Brittany, is the region of megalithic origin in Europe; it is also the megalithic region with the earliest and best-known boat depictions. Only a few boats are recognised in Irish contexts, such as at Knowth (Bradley 2022, 20; Robin 2009).

The most tangible examples of boats are those featuring crews resembling those in Nordic rock art. In early megalithic research, these were initially identified as boats (de Mortillet 1894). These depictions have been a subject of debate (Cassen 2011; 2007) and the boat interpretation was partly rejected and/or interpreted differently (e.g. Laporte and Le Roux 2004; L'Helgouac'h 1998; Thomas and Tilley 1993), primarily due to the prevailing terrestrial association of megalithic societies at that time. The re-interpretation of several Breton megalithic symbols to e.g. sperm whales (Cassen and Vaquero Lastres 2000; Whittle 2000) re-opened the scope for a nautical interpretation mainly for the manned boats or barques of Mané Lud, Gavrinis, Mané Kerioned B, Sarzeau and Saint-Samson-sur-Rance (Cassen 2011; 2007; Cassen and Grimaud 2020; Cassen *et al.* 2019; 2021). Interestingly enough, these kinds of boat depictions are limited to only a few sites. The abstracted boat engravings, on the other hand, referred to as yokes or U and V signs, are significantly more abundant. Initially interpreted as bovid horns (e.g. Shee Twohig 1981) or waterbirds (Cassen 2007), a reinterpretation through the lens of Nordic rock art, along with a comparison to ethnohistorical records, clarifies their interpretation as boats (Schulz Paulsson in press b). The renewed documentation of engravings in Breton megalithic contexts with the HandyScan 700 red-light laser scanner for the Marie Curie megalithic art project *Symbol and Stone*, conducted as part of the extensive research program *Corpus des signes gravés néolithiques, Programme Collectif de Recherche (PCR)*, revealed several additional sites with megalithic boats.

But what kind of boats are depicted, what do these images reveal in terms of nautical details and is it possible to reconstruct a megalithic boat chronology? Compared to the Nordic examples, the Breton boats seem to exhibit a broader range of distinct types and materials, reflecting diverse technologies and functions. However, it is challenging to describe a technological development of megalithic watercraft, since it is not possible to associate many of these engravings with the tombs and tomb chronology. The reason for this is that the megalithic tombs in the region were partly erected with re-used standing stones. This is even more obvious when observing megalithic funerary art in the field. Some of the engraved orthostats exhibit overlaps, a part is inverted or rotated by 90 degrees. Additionally, some orthostats display breaks within the images and it is even possible to refit orthostats from different tombs to the same standing stone (e.g. Cassen 2011; Cassen and Lastres 2000).

However, some contexts provide an idea on the age of the engravings. One of the earliest megaliths with boats is the standing stone from Saint-Samson-sur-Rance (Côtes-d'Armor) (Cassen *et al.* 2017). It is nearly completely covered with engravings, some are maritime symbols such as boats and oars in combination with the depiction of jadeite axes, which are associated with the Ancient Castellic horizon

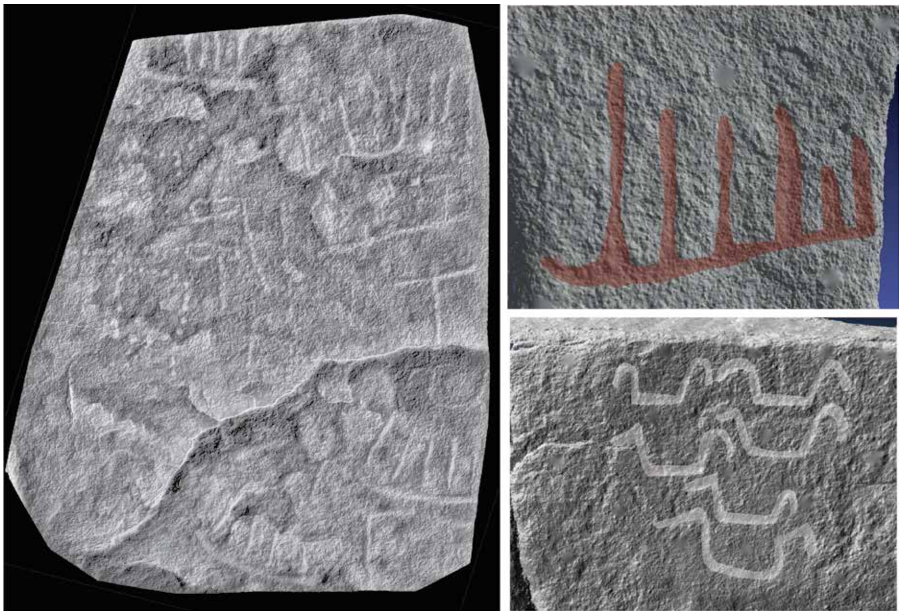

Figure 4. The megalithic boats of western Europe I. Left: orthostat showing boats with crew strokes in the passage grave Mané Lud, Locmariaquer, enhanced by ratopoviz (rock art topographic visualisation) (after Horn *et al.* 2022). Right, above: boat with crew, passage grave Kerveresse, Locmariaquer. Below: stylised boats in the gallery grave Grah Niol, Arzon.

(4700–4200 cal BC). Here we have simple, small boats or in one case also a double boat or piroque.

A second site featuring an evident early boat engraving of the fifth millennium cal BC is Tumiac. The old drawings of the now-closed site (Shee Twohig 1981, fig. 165) strongly resemble the animal-headed skin boats of circumpolar and adjacent regions. The tomb itself is one of the early megalithic tombs designed not to be re-opened after burial and the boat type is considered a terminus post quem or contemporaneous with the construction date, estimated to be around 4300 cal BC (Schulz Paulsson *et al.* 2019).

The previously described boats with crew are similar to common Nordic rock art motifs and they are potentially also depicting skin boats. In the case of the manned boats in the megalithic tombs of Mané Lud, Kerveresse and Grah Niol, we have to take the re-use of standing stones into consideration (Figure 4). The passage grave at Gavrinis, on the other hand, is entirely covered with engravings in a consistent and homogeneous style, suggesting that the art was created specifically for the tomb, which was built in the first half of the fourth millennium cal BC (Schulz Paulsson 2017). Here we find the largest known boats with up to 12 crew strokes, depicted partly with oars and fishing or hunting tools (Cassen *et al.* 2019).

The most elaborated boat types were revealed in the passage grave Mané Kerioned B (Cassen *et al.* 2019, fig. 10; 2021), which was also constructed in the first half of the fourth millennium cal BC. The depicted vessels exhibit an upwardly bent bow and some kind of tent or cabin. The bent bow and the lines along the boat's hull suggest possible wooden or reed boats, which were common building materials along the coasts of Brittany. The orthostat carrying the boats in Mané Kerioned B is turned by 90 degrees and seems to be re-used, thus even an earlier chronological setting of these boat types is possible.

Other engravings are either interpreted as barques (Cassen 2007; Cassen *et al.* 2019) or as rafts. The symbols resembling U or V shapes can be interpreted as the depictions of smaller boats made of skin or other materials used for inshore fishing, trips and transport, as well as river or lake watercraft (Schulz Paulsson in press b) (Figure 4).

Discussion

There must have been a great variety of boats and materials used in the European Atlantic Stone Age, boats which were seagoing and suitable for long-distance maritime or riverine journeys, but also smaller watercraft suitable for inshore sea trips or hunting ventures and on lakes and rivers. Taking a theoretical approach, Sean McGrail (2014) considered various watercraft for the Stone Ages, including hide boats and float rafts, basket boats, bundle boats and rafts, log boats (stabilised, extended, paired) and pot-float rafts. In the subsequent discussion, I will explore potential watercraft depicted in the described Stone Age contexts.

Umiaks, curraghs, skin kayaks and bark canoes

Most of the northern elk boats, especially the larger ones, can be interpreted as hide boats similar to the *umiaks* of Arctic maritime hunters or the Irish *currach*, made by sewing hides onto a light wooden or bone framework (see also Gjerde 2010; Hornell 1938; Kolpakov and Shumkin 2012; Luukkanen *et al.* 2020; McGrail 2014). Animal skin served as the main material, most plausible here is elk or the skin of sea mammals. *Umiaks* are both inland water and sea-going vessels with tall frontal

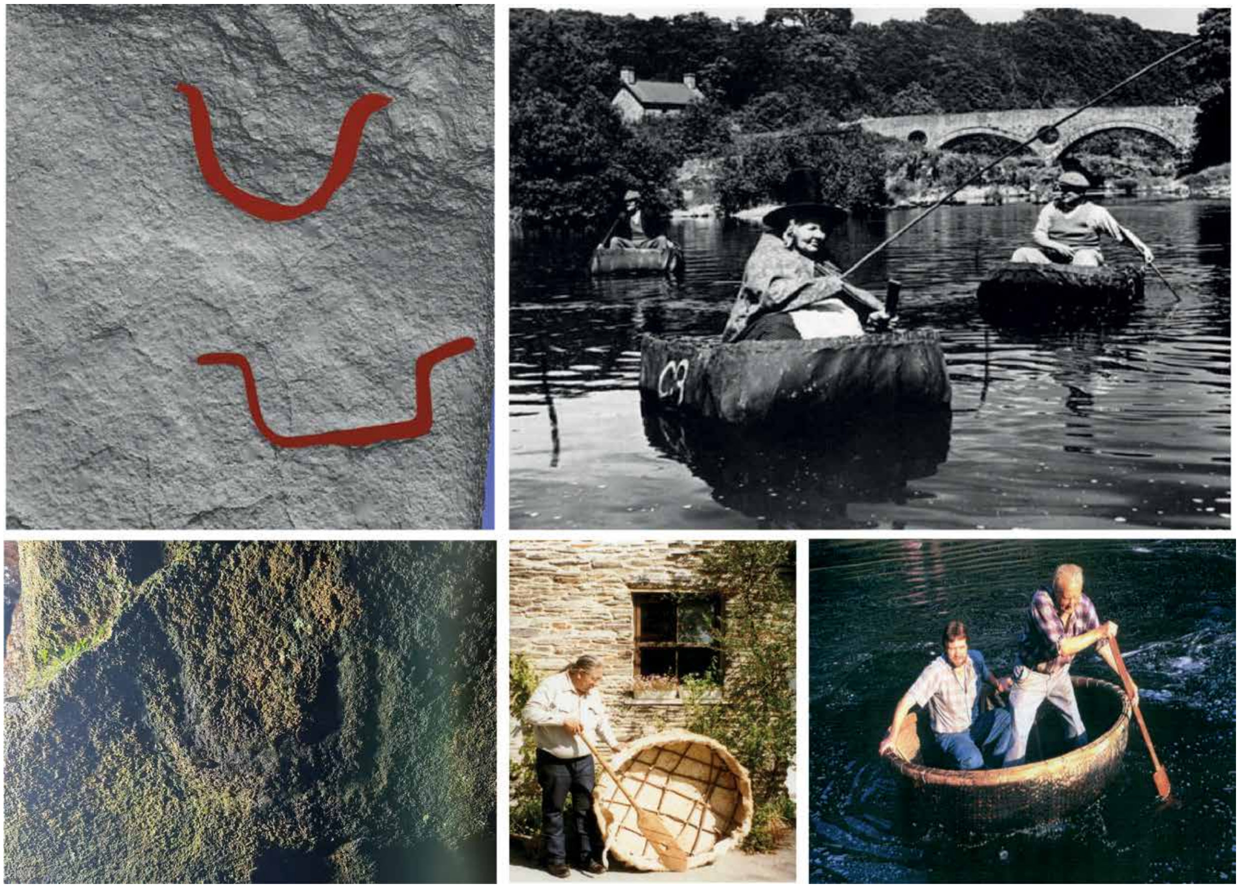

Figure 5. The megalithic boats of western Europe II. Re-interpretation of yoke, U- and V-signs as boats. Top left: orthostat in the passage grave Mané Lud, Locmariaquer; laser scan using a HandyScan 700 red-light laser scanner with a resolution of 0.05 mm and processed in the program Meshlab 2021.37. Bottom left: orthostat in the passage grave Mané Kerioned B, Plouharnel, Carnac. Right: coracles and coracle-like boats. Besides being interpreted as *umiaks*, the yoke, U- and V-signs could also represent coracles. Top: Ironbridge coracle from the river Severn on the Welsh–English border. Bottom centre: bull boats once used by Native Americans in North Dakota. Bottom right: Vietnamese coracle in Cenarth; to the left Martin Fowler, director of the National Coracle Center. Printed with the kind permission of the National Coracle Center, Cenarth.

stems that make it possible to cut across waves. Their light frames made these boats easily manoeuvrable and suitable for hunting inshore as well as for longer journeys. Hide boats offer advantages for longer journeys compared to plank boats: construction and maintenance is relatively fast, the materials are readily available and the boats are easily transported between rivers and the sea. Moreover, they could be used in more difficult, informal landing places. Less frequent engravings of smaller boats can be seen as skin kayaks, suitable only for one to three persons. The elk-head boats are often associated with sea mammal hunting and fishing scenes; *umiak* boat types are also suitable for this purpose when used in combination with smaller skin kayaks. Similar boat types, the so-called *curraghs,* were known in the Irish Sea (McGrail 2014, 99–101). Earlier types, or the 'wild historical Irish *curraghs*', are described as boats with prominent keel or stem and an osier or wickerwork frame. For Brittany we can imagine similar boat types, skin boats with a light frame that were used on inland waterways, inshore, but also for longer maritime ventures.

Hardly recognised in the archaeological record, but well documented ethnohistorically, is the technique of building canoes with bark and in particular with the bark of birch, elm, aspen and spruce. We find bark canoes for example in the circumpolar regions and the Near East (Luukkanen *et al.* 2020). The bark is taken from a living tree, attached to gunwales with a third timber as keelson, sewn together and caulked with larch or birk resin. Birch bark canoes are the best-known type; however, huge birch trees are needed to produce the required bark for boats and these rather grow in colder climates, so this is a possibility for a part of the Fennoscandian boats but not conceivable for the Breton watercraft.

Coracles, basket boats and *kuffas*

Skin boats with a smaller round or oval form, the so-called coracles, are still in use in Wales, the West Country and Ireland (Hornell 1938; Jenkins 2007). They are fishing boats suitable for inland streams and lakes. Similar boats are known from Tibet and south-west Asia (McGrail 2003), partly also built with basketwork. In the Near East, Euphrates River boats or *kuffas* were already described by Herodotus as round skin boats filled with straw and able to carry a large cargo of several tons (Herodotus 1.194). Within megalithic contexts, the interpretation of smaller boats or V and U signs could align with this specific type of vessel (Figure 5).

Rafts and *kelleks*

An additional aspect to consider in the examination of depicted watercraft involves the potential portrayal of rafts. In Atlantic Europe, recent usage has witnessed two types of rafts — log rafts and bundle rafts. While rafts are typically utilised in inland waterways, their application on open seas is constrained. Rafts were used to transport cargo and are argued to have ferried the building material for Stonehenge (Hazell 2001; McGrail 2014, 98). In the context of Brittany, it is essential to consider the transport of construction materials for megaliths using watercraft. To enhance cargo capacity, a practice involved attaching inflated animal skins underneath rafts. This type of watercraft is commonly referred to as *kelleks*. Ethnohistorical records suggest that rafts equipped with inflated animal skins were used for cargo transportation, with historical examples documented in regions such as the Euphrates and Tigris Rivers (Moltke 1876).

Conclusions

The Atlantic coasts of Stone Age Europe may have hosted a broad range of boat types. However, the clearest boat depictions dated to the Stone Age are concentrated in Fennoscandia and Brittany. In the former region, this association is supported by shoreline chronology, while in the latter it is established through the megalithic contexts. From these two regions, we gain insights into watercraft technologies and the maritime achievements of Stone Age boat building communities. What unites the two regions is the use of smaller, likely skin boats in the early phases for fishing and hunting marine mammals. These boats can be described as similar to *umiaks* and *curraghs*. In later phases, the boats are expanded for more crew and continue to be used for hunting, as well as for longer expeditions and cargo. Compared to the attested Nordic examples, the Breton boats appear to exhibit a broader range of distinct types and materials, indicating alternative technologies and diverse functions linked to these vessels in megalithic societies. Besides skins, wood, bark and reed boats, rafts and smaller coracle-like boats or *kelleks* are also conceivable.

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CROSSING THE STRAITS

Islands, monuments and maritime mobility in Neolithic north-west Europe

Chris Scarre

Abstract

Archaeological evidence from offshore islands provides an effective window into the maritime voyaging undertaken by Neolithic communities in north-west Europe, and the networks that may have connected communities in different regions. These are documented by the movements of raw materials and finished artefacts, by settlement evidence — whether for persistent or more impermanent occupation — and by traditions of funerary monumentality. A review of material from the Isle of Man, the Channel Islands and the Isles of Scilly demonstrates similarities and contrasts and shows that while all of these island groups were accessible to Neolithic navigators from mainland France or mainland Britain, the patterns of contact were very variable. Recent studies of Atlantic storminess identify periods of greater or lesser intensity, but it is unclear that these provide a sufficient explanation for the differences. The relative size of the islands and their distance from the mainland may have played a part, along with changes in society and maritime technology between the fifth and third millennium BC. While there is no doubting the capacity of Neolithic mariners to cross areas of open sea, or the evidence that they did so, the regularity and intensity of contact between mainlands and islands must also be carefully considered.

Keywords: Neolithic; megalithic monuments; islands; Atlantic storminess; maritime technology

Introduction

The megalithic monuments of western Europe have long been associated with narratives of maritime mobility. As early as the mid-eighteenth century, the Comte de Caylus in his *Recueil d'Antiquités Egyptiennes, Etrusques, Grecques, Romaines et Gauloises* drew comparison between megalithic monuments of north-west France and those of Britain, concluding that those of north-west France had been built by a people coming by sea from the north (Caylus 1764). A century later, the Baron de Bonstetten in his *Essai sur les Dolmens*, and Alexandre Bertrand, the first director of the Musée des Antiquités Nationales at Saint-Germain-en-Laye, echoed this conclusion, but within a wider geographical framework in which people from central Asia or Crimea had settled first around the Baltic, then spread southwards down the Atlantic coast to north Africa, bringing megalithic monumentality with them (Bertrand 1863; Bonstetten 1865).

Oscar Montelius reversed the direction of travel, with dolmens 'a tomb form which has spread from the Orient along the north coast of Africa, and from there to the south-west, and further to northwest and northern Europe' (Montelius 1899, 34; translation by

In D. Hofmann, V. Cummings, M. Bjørnevad-Ahlqvist and R. Iversen (eds) 2025, *The early Neolithic of Northern Europe. New approaches to migration, movement and social connection*, 69–80. Leiden: Sidestone Press.

the author). That interpretation was developed further by Daryll Forde who, drawing on earlier writers, placed the earliest megalithic tombs of western Europe in southern Iberia and traced their distribution northwards through France and Britain to northern Europe. Forde commented also on the possible relevance of greenstone and callaïs (variscite) ornaments in connections between Brittany and Iberia (Forde 1930a; 1930b). That the megalithic monument tradition had spread from south to north was echoed by Glyn Daniel (1941) and Gordon Childe (1950). Carl-Axel Nordman specifically traced the origins of the northern megalithic culture to Brittany (Nordman 1935, 111). But it was not universally accepted, and others, such as German writers Matthaeus Much and Gustaf Kossinna, still supported the idea of an independent northern origin (Much 1902; Kossinna 1914), or even a two- or even three-centre origin, in Spain, Scandinavia and north-eastern France (Kendrick 1925, 105–6).

The two-centre model was revived in the 1960s. Excavations by Paul Ashbee at Fussell's Lodge led Daniel to conclude that the long barrows of southern Britain along with the *allées couvertes* of Brittany and the Paris Basin, the non-megalithic long mounds of Denmark and the Kujavian graves of Poland might be part of a northern tradition, separate from the southern tradition responsible for the passage graves (Daniel 1967). Childe, of course, in a famous paper, had already drawn attention to the 'curious circumstance' that trapezoidal northern long mounds had ground plans comparable to those of the long houses revealed at settlements such as Brześć Kujawski (Childe 1949). He also suggested that the building of megalithic cists or *dysser* might be an independent northern tradition. Excavations in the 1960s at Danish long mounds revealed timber tent-like structures similar to the mortuary structures beneath southern British long mounds such as Wayland's Smithy, and raised the possibility of direct connections between monument forms across the North Sea (Madsen 1979). This idea has been explored again in a more recent study, but direct support for such a connection remains elusive (Ahlers 2018; Rassmann 2011).

In all of this, seafaring was an important component. Portuguese archaeologist Augusto Filipe Simões compared the megalith builders to the Portuguese and Spanish explorers of the sixteenth century, who converted to Christianity the peoples whom they encountered (Simões 1878, 99). For Much, they conjured the image of a 'Stone Age Norman sea-king' ('ein normannischer Seekönig des Steinalters') with his followers (Much 1902, 160). Thomas Kendrick made reference to 'merchant adventurers' whereas Childe wrote of 'missionaries or prospectors' and envisaged 'not a folk migration or conquest but voyages, quite possibly unintentional, of isolated families who spread not a new population nor even a new economy but a new cult and a new technique of navigation' (Childe 1950, 88, 90–1; Kendrick 1925, 76). For northern and western Britain, Stuart Piggott envisaged a direct connection between the arrival of farmers by sea, and the 'stone-built collective family tombs which were constructed not far from the beaches on which the first boat-loads had landed' (Piggott 1954, 16). More recently, Alison Sheridan has interpreted megalithic tombs such as Broadsands in Devon and Achnacreebeag in Argyll as the work of incomers from northern France or their direct descendants (Sheridan 2000; 2010; Sheridan *et al.* 2008). More generally, at the European scale, the spread of megalithic tombs has been modelled from the available radiocarbon dates as a multi-stage process, beginning in north-west France and spreading thence along the sea routes of the Mediterranean and Atlantic coasts in three successive phases (Schulz Paulsson 2019).

Movements of specific artefacts or materials have become integral to the discussion of long-distance maritime movements along the Atlantic façade. Among these are the greenstone axeheads of Alpine origin that were the subject of *Projet Jade* (Pétrequin *et al.* 2012a; 2017). Such axeheads are relatively common finds in France, western Germany, Britain and Ireland, but much less so in Iberia. Furthermore, Alpine greenstones could have reached Iberia overland through southern France. Special significance therefore attaches to the fact that Alpine greenstone axeheads were refashioned in Brittany to create distinctive new forms. These include the Tumiac type with perforated butt, one example of which has been found in north-west Iberia (and indeed one fragment from south-west England) (Pétrequin *et al.* 2012b). It has been argued that the appearance of Tumiac axeheads, presumably brought from Brittany, inspired the creation of local forms such as the Cangas axeheads of Iberia and the Zug axeheads of Switzerland and southern Germany that also have the characteristic perforated butt. Likewise in southern Scandinavia, where no Tumiac axeheads have been found, long axeheads with perforated butts found in Early Neolithic contexts (*c.* 3800–3500 BC) may have been copied from a Tumiac original. It has been suggested that the idea of building megalithic tombs may have come to south Scandinavia together with imports of such *haches carnacéennes* (Klassen 2014).

The distribution pattern of Alpine axeheads does not in itself indicate the routes of travel taken by those objects. Brittany plays a key role in this debate. It was the source of the Tumiac axes referred to above, and there is Castellic style pottery from the megalithic passage tomb of Dombate in north-west Iberia (Cassen *et al.* 2019a). Connections between western Iberia and southern Brittany are demonstrated by the return traffic in variscite beads and pendants from Encinasola in south-west Iberia and Palazuelo de las Cuevas in west-central Iberia that were deposited in Carnac mounds such as the Tumulus de Saint-

Michel, Tumiac, Mané Lud and Mané er Hroëck (Cassen *et al.* 2019b; Querré *et al.* 2019). The traffic of greenstone and variscite may have been sustained by direct contact across the Bay of Biscay, involving several days sea voyaging out of sight of land, or by cabotage in multiple short stages along the coasts of western France and northern Spain (Callaghan and Scarre 2017; Fábregas Valcarce *et al.* 2012). Much depends on the kind of watercraft we envisage in the fifth millennium BC when these exchanges took place, but a direct open-sea crossing would have been a difficult undertaking and very much subject to tides, currents and storms.

Whether or not larger sea-going vessels were in use in north-west France in the mid-fifth millennium BC, as has been proposed (Cassen *et al.* 2019a), Neolithic seacraft will have emerged from a much longer tradition of maritime technology. Here we should recall the extensive maritime capabilities of pre-Neolithic societies around the coasts of Britain, with evidence of Mesolithic activity on outlying islands including Harris in the Outer Hebrides and West Voe on Shetland (Gregory *et al.* 2005; Melton 2008). It may be, as has been suggested, that the coastal waters of north-west Europe were 'if not bright, then certainly strongly illuminated by "argonauts" throughout the fifth and early fourth millennia' (Garrow and Sturt 2011, 68). Contacts may indeed have carried people and materials from place to place — between islands and mainlands — but questions remain about the regularity and reliability of those contacts, and the cultural and social changes that they may have initiated or encouraged. Some of the smaller and more remote islands may not have been able to sustain permanent human settlements based on fishing, hunting and gathering. Even after the introduction of domestic plants and animals, the distance and difficulty of moving between certain of these islands and their closest mainlands may have made them less attractive places for persistent colonisation. Hence in assessing the significance of maritime connections it is not only the ability of early seafarers to navigate coasts or cross open waters that must be considered, but also the ease and regularity with which they did so.

Islands, megaliths and maritime mobility

Islands have the potential to provide special insights into prehistoric maritime networks. By definition, they could only be accessed by sea crossings, and in some cases (such as the Alderney Race between Alderney and Cap de la Hague, or the Pentland Firth between Orkney and Caithness) tidal forces make these crossings particularly difficult to navigate. In western Europe, several Atlantic and West Mediterranean islands are nonetheless notable for the numbers of megalithic monuments that survive, more than might have been expected from their surface area and arable potential. They offer the opportunity to draw comparison between islands and their adjacent mainlands, and between different groups of islands. These comparisons can help to illustrate patterns of maritime contact that have a direct bearing on Neolithic seafaring. They suggest how strong those connections may have been and how they varied through time. The point here is not to assess what Neolithic mariners were capable of doing, but what they actually did. At the same time, they also show how island communities often adopted mainland traditions but then transformed them.

Figure 1. Map showing location of the islands and island groups referred to in this paper.

The Channel Islands serve as an excellent example of the tension between continental traditions and insularity in monument traditions. On Jersey, which today is only 25 km from the Normandy coast, the circular drystone passage grave of La Sergenté with corbelled vault is closely comparable to late fifth millennium BC mainland chambered tombs such as Vierville A near Carentan or the cluster of tombs at Condé-sur-Ifs south-east of Caen in Lower Normandy (Dron *et al.* 2016; Hawkes 1939, 247–9). The precise chronology of the separation of Jersey from the mainland is difficult to determine, but it is possible that it was still connected to France by a tidal causeway at this period (Garrow and Sturt 2017). Guernsey had been separated from Jersey and France several millennia earlier, but still has early tomb forms broadly comparable to those of the mainland. These include Les Fouaillages on Guernsey and Gaudinerie Field on Sark, the latter compared to the later fifth millennium mounds or *tertres* of southern Brittany (Cunliffe and Durham 2019). Among the passage tombs of Guernsey is Le Déhus, a passage tomb that incorporated a carved stele as one of its chamber capstones (Cassen *et al.* 2015; Kendrick 1928, 131–54). Recent aDNA analysis of human remains from Le Déhus dated *c.* 4300–3900 cal BC showed them to be comparable genetically to samples from northern France (Brace and Booth 2023, 133–5). That would be consistent with the Neolithic settlement of Guernsey by farming colonists from the adjacent mainland *c.* 5000 BC, or with the introduction of megalithic tombs to the Channel Islands by subsequent Middle Neolithic population movements after *c.* 4500 BC.

Later Neolithic tomb types in the Channel Islands show a greater degree of insularity. The most striking insular form is the cist-in-circle, a box-like slab-built chamber of modest proportions within a circular kerb or surround (Kendrick 1928, 69–70). The kerb may have been the edging to a low cairn or mound. On the small island of Herm, to the east of Guernsey, no fewer than seven of the dozen or so tombs described and classified by Kendrick belong to this category, outnumbering the three or four possible passage tombs (Kendrick 1928, 198–221). Cists-in-circles are found at several other sites on Guernsey and Jersey, and to these may be added recently recorded examples on the Îles Chausey, closer to the French mainland (Chancerel *et al.* 2022). The cists-in-circle are difficult to date, although associated Late Neolithic and Beaker pottery indicates activity during the late third and early second millennium BC (*c.* 2500–1800 BC). But the Late Neolithic in the Channel Islands is not marked solely by insular monument forms, and at Ville ès Nouaux on Jersey, a cist-in-circle is located only a few metres from an *allée sépulcrale*, a type of long-chambered monument found widely in mainland north-west France (Scarre 2011) (Figure 2).

The megalithic monuments of the Isle of Man in the middle of the Irish Sea likewise indicate connections with adjacent mainlands, in this case during the fourth millennium BC. Man is substantially larger than the Channel Islands (572 km^2 as compared to 198 km^2) and has significantly fewer Neolithic chambered tombs (only ten, in contrast to the total of 92 for the Channel Islands, although as already observed some of the latter are relatively small in size: Lynch and Davey 2017). A number of the Manx tombs have trapezoidal cairns with chambers opening within a deep concave forecourt at the broader end. Two of the Manx tombs (Cashtal yn Ard and King Orry's Grave) have been compared to the court cairn tradition of northern and eastern Ireland and to the Clyde tombs of western Scotland (Figure 3). A third site, Ballafyle, has a trapezoidal cairn covering the burned remains of a timber chamber with an early fourth millennium date (Fowler *et al.* 2021). The Cloven Stones has tentatively been identified as either a Clyde cairn or court cairn (Darvill 2000; Davey 2004). Other sites are more difficult to classify, although Ballakelly has been compared to Mid-Gleniron in south-west Scotland, and Scottish parallels have also been suggested for the circular multi-chambered monument of Meayll Hill (Cummings and Fowler 2004; Lynch and Davey 2017, 109). The Isle of Man tombs hence generally conform to monument forms found on the adjacent mainlands of Scotland and Ireland, consistent with its position as a stepping-stone for navigation within the Irish Sea and less than 30 km from the Scottish coast.

The various types of chambered tombs illustrate how communities on the Isle of Man and the Channel Islands adopted or adapted the mainland traditions of funerary monument with which they were familiar. Direct maritime connections are also demonstrated by the presence of polished stone axeheads from mainland sources. Axeheads from Antrim (Group IX), Cumbria (Group VI), Wales and south-west Britain (Groups VII and XXIII) and northern England (Group XVIII) have all been found on the Isle of Man (Kewley 2016). A single example of Alpine greenstone (jadeitite) demonstrates still more distant connections (Sheridan and Pailler 2012). There are some 20 axeheads of Alpine greenstone from the Channel Islands, along with dolerite from Plussulien and Cinglais flint from Normandy, and a number of the distinctive polished stone rings associated with fifth-millennium mainland traditions of the Early Neolithic and early Middle Neolithic (Charraud 2015; Fromont 2013, 207–8; Garrow and Sturt 2017, 61–2). Ceramic forms, too, illustrate close connections with the mainland, including the distinctive *coupes à socle* from La Hougue Bie on Jersey (Lucquin *et al.* 2007). These islands may have been insular in some respects, but they certainly were not isolated, and were actively choosing which elements of mainland material culture and practices to adopt for their own purposes.

The third example, Scilly, presents a rather different picture. This cluster of small islands has undergone significant change since the Neolithic period as a result of sea-level rise and coastal erosion. In modelling these changes, the Lyonesse Project showed that in the middle of the fourth millennium, several of the islands were connected as part of a single larger island, but by the middle of the second millennium BC they had become separated by an extensive intertidal zone (Charman *et al.* 2016).

Despite their small size and the relative distance (45 km) separating the Isles of Scilly from the tip of Cornwall, there is evidence of significant Mesolithic activity, notably in the form of the microlith assemblage excavated at Old Quay, St Martin's, attributed to the Late or Final Mesolithic (Garrow and Sturt 2017, 112). There is also evidence for the intentional burning and clearance of the woodland from the seventh millennium BC (Charman *et al.* 2016, 196–200). Mesolithic Scilly — with a combined land area

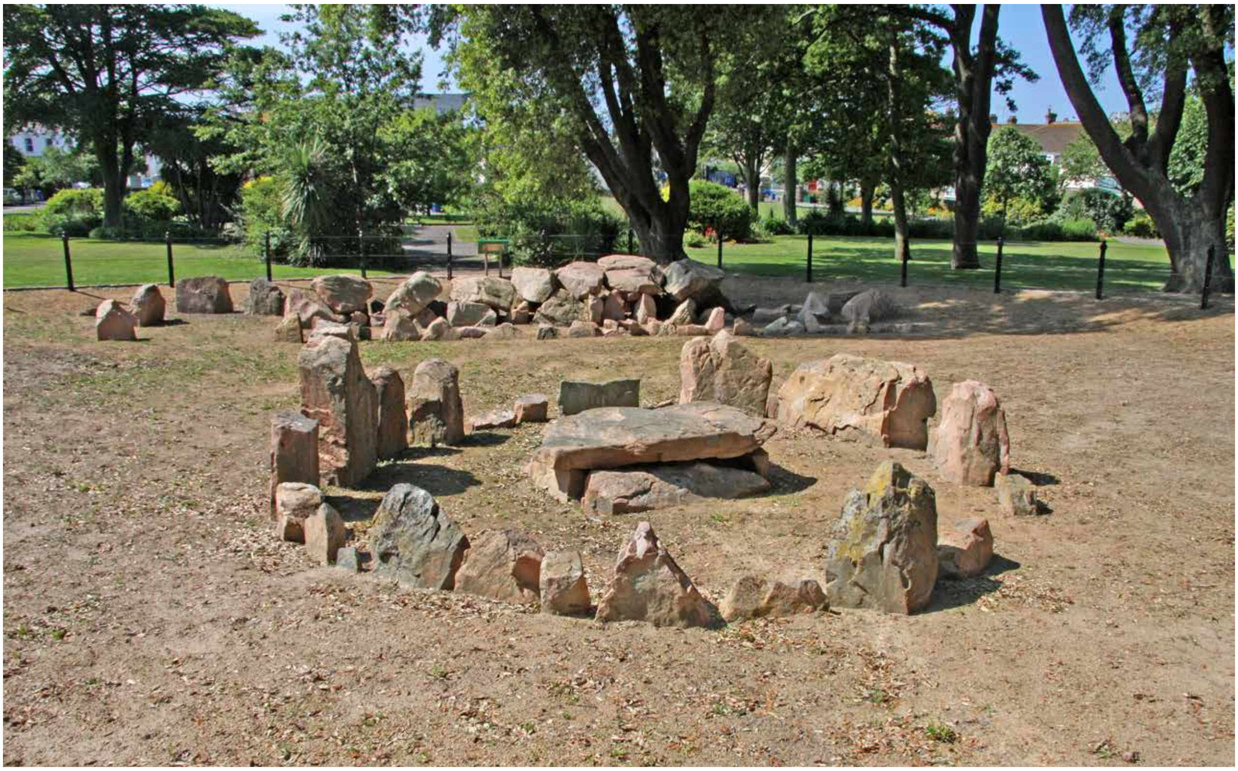

Figure 2. Cist-in-circle at Ville ès Nouaux, Jersey, with *allée sépulcrale* in the background (photo: Chris Scarre).

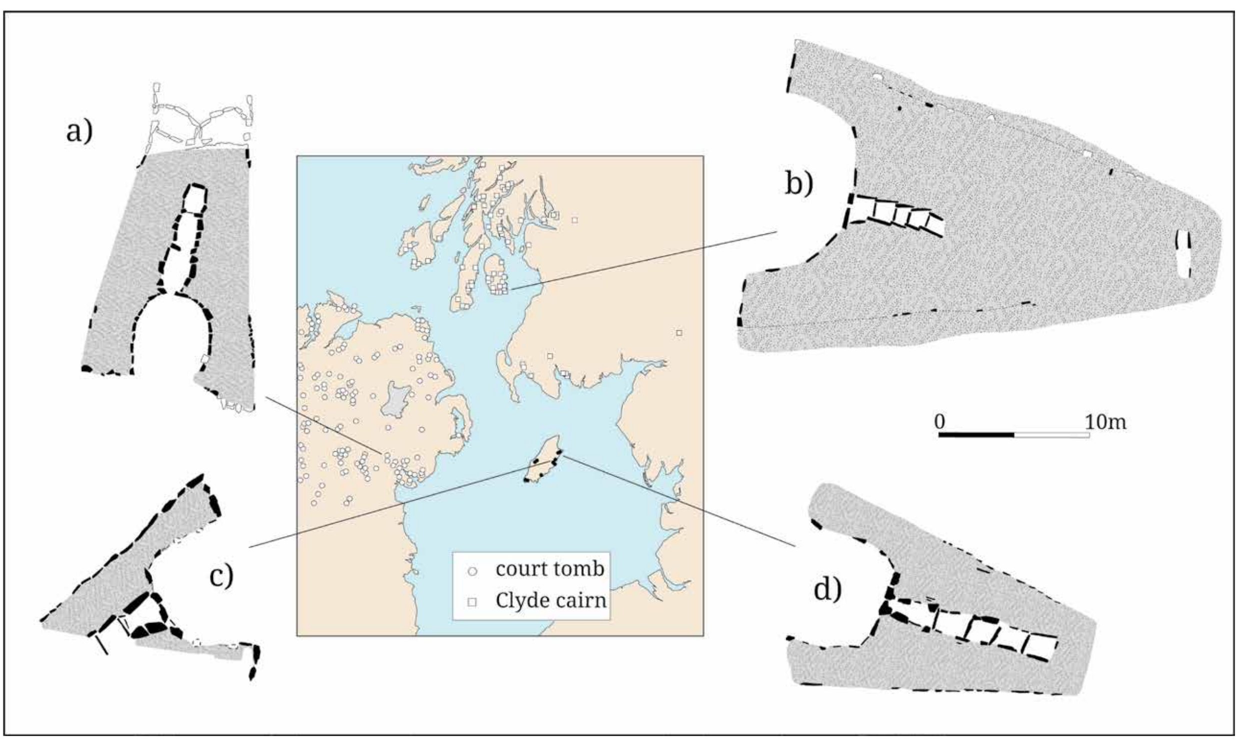

Figure 3. Chambered tombs on the Isle of Man with parallels in Scottish Clyde cairns and Irish court tombs: a) Annaghmare; b) East Bennan; c) King Orry's Grave NE; d) Cashtal yn Ard (after Henshall in Lynch and Davey 2017; Henshall 1972; Waterman 1965).

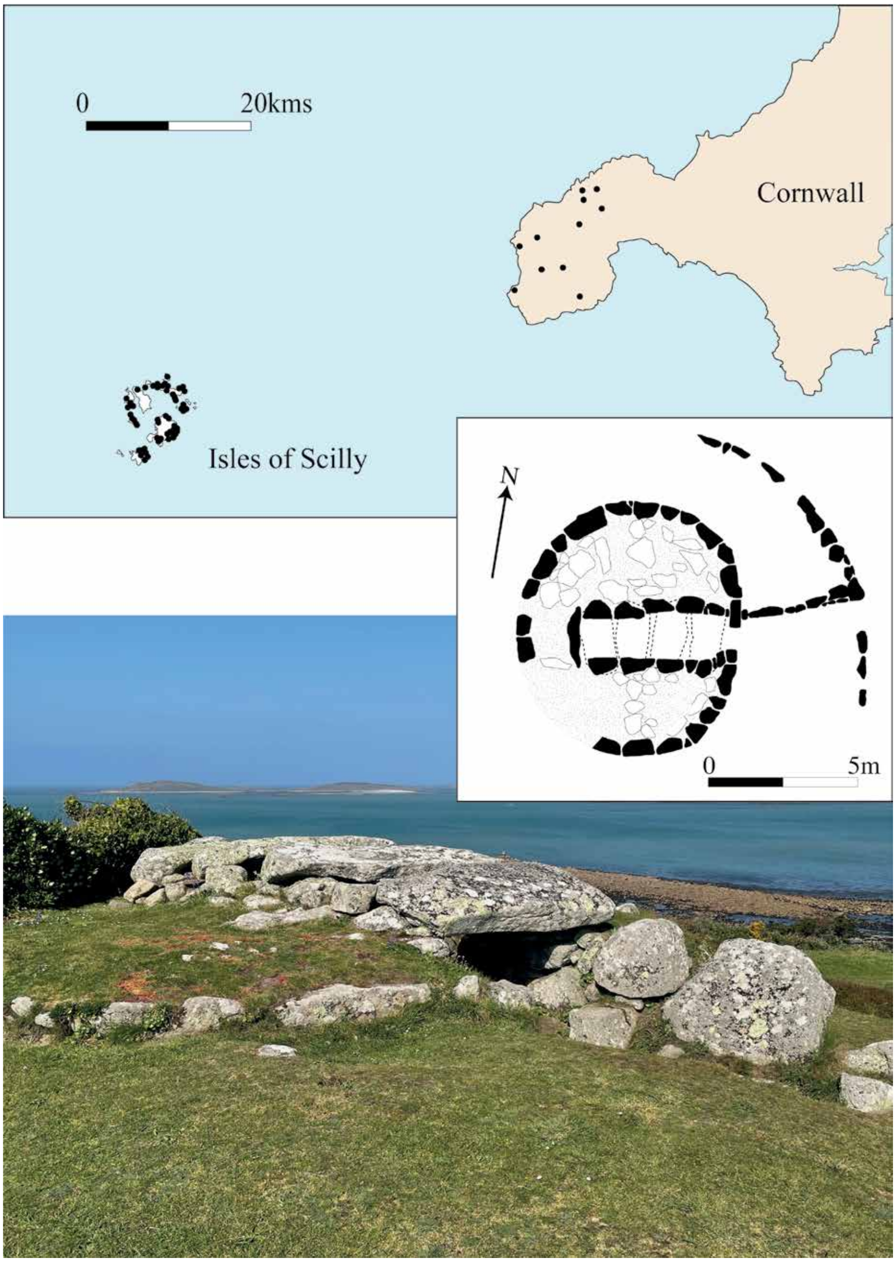

Figure 4. Entrance graves in Cornwall and the Isles of Scilly, with plan and photo of Bants Carn, St Mary's, Isles of Scilly (site distribution after Jones and Thomas 2010; Sawyer 2015; plan after Hencken 1933; photo: Chris Scarre).

of 80 km^2 before sea-level rise — may have been large enough to support a small permanent population, but the evidence would also be consistent with repeated visits or short-term occupations.

Neolithic activity is represented by a fourth millennium occupation at Old Quay and by Carinated Bowl or Early Neolithic pottery of Hembury style from other sites, although there is no Middle Neolithic Peterborough or Late Neolithic Grooved Ware, and only a single sherd of Beaker pottery (Charman *et al*. 2016, 201–5). Bayesian analysis of radiocarbon dates places the Old Quay Neolithic occupation (a cluster of pits and postholes) in the later fourth millennium BC (Garrow and Sturt 2017, 127). Whether it represents permanent settlement of Scilly at this period, and what we might mean by permanent, is difficult to assess. The excavators conclude that the duration of activity may have lasted two or three centuries but could have been as little as a decade. Connections with Cornwall are shown by the presence of materials such as gabbroic greenstone (notably a perforated shaft-hole adze). They conclude that 'people may well have been moving between different sites in Scilly, and between Scilly and the mainland, at variable intervals — some staying on the islands for months or even years, others moving about much more' (Garrow and Sturt 2017, 132).

It is clear that during the fourth millennium BC there was connectivity between all three island groups and their adjacent mainlands, but the evidence suggests that in terms of the regularity of contact, the Channel Islands and Isle of Man were more closely connected during this period than were the Isles of Scilly. Of the megalithic chambered tombs on the Channel Islands and the Isle of Man, several conform to types current on the adjacent mainlands: passage tombs (*c.* 4300–3800 BC) and *allées sépulcrales* (*c.* 3500–2800 BC) on the Channel Islands, court cairns or Clyde cairns (*c.* 3700–3300 BC) on the Isle of Man. The distributions of axeheads from the different British, Irish and continental sources are also significant in mapping interactions. There are axeheads of Alpine greenstone on the Channel Islands and the Isle of Man, but none (so far) from Scilly. Axeheads from the Isle of Man indicate connections around the Irish Sea. In addition to Alpine greenstone, the Channel Islands have axeheads from various sources in north-west France (dolerite, eclogite, fibrolite: Patton 1991). Scilly too was connected, although perhaps only with mainland south-west England, as shown by imports of greenstone, dolerite, flint, chert and gabbroic pottery (Charman *et al.* 2016, 201–3; Garrow and Sturt 2017).

For Scilly, the situation is very different in the second millennium BC when a significant number of megalithic tombs appear, of the type known as entrance graves (Sawyer 2015) (Figure 4). There are surviving remains of around 90 of these, and limited chronological evidence places them in the second quarter of the second millennium BC (burial at Knackyboy Cairn probably beginning in 1755–1565 cal BC (68% probability): Jones *et al.* 2023, fig. 8; charcoal outlier model). That chronology is supported by dates from the small number of entrance graves known in western Cornwall, notably Tregiffian and Bosiliack. Comparison has been made with Tramore tombs and Wedge tombs in southern Ireland, and perhaps with Bargrennan cairns in south-west Scotland, although in each of those cases the dating is somewhat earlier (Jones *et al.* 2023). Whether or not they owe their inspiration to late third millennium tomb traditions elsewhere, to earlier tombs in western Cornwall, or relate to a broader, more widely shared megalithic background, is uncertain. The large numbers of entrance graves on the Isles of Scilly must, however, reflect the presence of substantial permanent communities on the islands in the second millennium BC, in contrast perhaps to the character of Neolithic occupation.

Discussion

This comparison of these island groups indicates that all three were accessible to Mesolithic and Neolithic seafarers, but that patterns of contact — above all regularity of contact — were very variable. That variability may have depended on their attractiveness for permanent settlement — the size of the islands and their distance from the shore. It may also have been influenced by the relative difficulty and danger of making the necessary sea crossings in the period before the introduction of sewn-plank boats and the sail. The introduction of the sewn-plank boat may indeed have been the innovation that made regular contact with Scilly more reliable and encouraged the establishment of permanent settlements there. Remains of sewn-plank boats have been found at several locations around the coast of Britain, the earliest being the Ferriby 3 boat dated to 2030–1780 cal BC (95 % probability; weighted mean of two dates) (Wright *et al.* 2001; Van de Noort 2006). That date provides of course only a *terminus ante quem* for their introduction, and their origins may extend back into the third millennium BC. If we accept a third millennium origin, then their adoption may have been instrumental in the spread of Beaker ceramics and metals that seems to mark a new phase of internationalism in western Europe from around 2500 BC. Along the coast of Britain and Ireland, the Early Bronze Age appears to have seen a shift in the focus of maritime activity from enclosed estuaries to wider estuaries with fast-flowing rivers, associated perhaps with new kinds of watercraft and with the supply of metals from the Continent (Bradley 2022).

The sewn-plank boats date of course to a later period than the fifth/fourth millennium which is the focus of this discussion. Their relevance here lies in the implications that changing patterns of contact during the later third and second millennium BC might have for earlier periods. Neolithic seafaring was very probably less capable, and more subject to the constraints of weather and seasonality, than that of subsequent periods when sewn-plank boats were available. Those constraints will themselves have changed over time. Storminess would have created additional hazards for navigators and is known to have varied over timescales of one or two centuries. Atlantic storminess during the mid to late Holocene period has been an active focus of research over recent decades. Studies of north-west France, the English Channel, western Scotland and western Denmark have been combined to indicate a fluctuating pattern, with increased storminess in the second half of the fourth millennium BC (5500–5100 cal BP = European Atlantic Storm Event 5) and in the later second millennium (3500–3300 cal BP = European Atlantic Storm Event 4) (Pouzet *et al.* 2018). An alternative model identifies Holocene Storm Periods (HSPs) at 5800–5500 (HSP I), 4500–3950 (HSP II) and 3300–2400 cal BP (HSP III) (Sorrel *et al.* 2012) (Figure 5). Pollen and archaeological evidence from northern Brittany indicate the abandonment of human settlement around the Guidel marsh around 3500 cal BC, consistent with an episode of cooler, wetter and stormier conditions at that time (Fernane *et al.* 2015). Coastal dune mobility around Brittany indicates a further episode of increased storminess in the late third millennium BC (*c.* 4250–4100 BP) followed by another in the Late Bronze Age/Early Iron Age (*c.* 3250–2400 BP) (Gorczyńska *et al.* 2023).

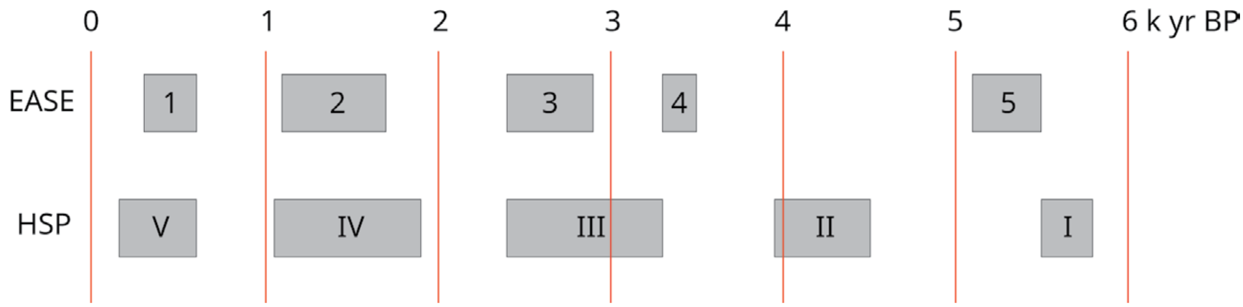

Figure 5. Episodes of storminess in north-west Europe. Above: European Atlantic Storm Events (EASE) (Pouzet *et al*. 2018); below: Holocene Storm Periods (HSP) (Sorrel *et al*. 2012).

In general, however, archaeological evidence suggests that maritime connections were active even during periods of increased storminess. It was, for example, during EASE 5 (later fourth millennium BC) that the Middle Neolithic settlement at Old Quay on the Isles of Scilly was established, and that connections between the Boyne Valley and Orkney were especially active. Nonetheless, it may be significant that the middle and later part of the fifth millennium BC, when Alpine greenstone axes and Iberian variscite may have been moving through Atlantic maritime networks, appears to have been a period of reduced storminess. The same is true for the earlier fourth millennium BC, when farmers from northern France crossed the Channel, bringing themselves and their livestock to southern Britain. Stable isotope analysis of individuals buried at Whitwell in Derbyshire and Penywyrlod in south Wales suggests that people may have continued to come to Britain from the continent throughout the first few centuries of the fourth millennium BC (Neil *et al.* 2017; 2022; cf. Thomas 2022). During the second half of the fourth millennium BC, cultural connections between Britain and the Continent became more distant, with new, specifically insular ceramic styles and monument forms (such as stone circles). Connections between Britain, Ireland, Orkney and indeed Scilly, however, do not suggest that the later fourth millennium BC was a period of relative inactivity within maritime networks. This is an issue that would merit further analysis.

Conclusion

Interpreting maritime mobility in Neolithic north-west Europe remains difficult, especially as there is uncertainty about the kinds of watercraft that may have been available. Archaeological evidence shows that most islands and island groups had already been visited by Mesolithic seafarers, but consideration must also be given to the intensity and regularity of that contact, and the reasons that may have lain behind such variations. That affects our understanding of issues such as the character of navigation between Iberia and Brittany, the limited evidence for cross-Channel contact between Britain and northern France in the Late Mesolithic period, the significance of a western maritime route linking north-west France and the lands around the Irish Sea, and the crossings of the North Sea that may have brought Scandinavian flint axes to Britain (Walker 2018). The evidence of artefact and raw material flows is supported by that of shared monument types: together they demonstrate, as might be expected, that most Neolithic island communities were closely connected to their adjacent mainlands. That includes those of the Channel Islands and the Isle of Man. The Orkney-Cromarty cairns of northern Scotland and Orkney provide another example of a monument tradition shared between islands and mainland (Henshall 1963). Island communities will indeed have been dependent on those connections not only for artefacts and materials, but also for access to the wider social and cultural world. This is true of the Channel Islands and the Isle of Man, and of other island groups around the coast of north-west France such as Belle-Île, Groix, Houat/Hœdic, and the Molène and Glénan archipelagos (Gehres 2023). There are exceptions, however, as Scilly demonstrates, which were clearly accessible by sea but not initially part of regular active networks of interaction. That raises the question as to what attracted Neolithic settlers to these islands. Despite the inherent constraints of an island location, they would have offered land for farming and livestock, and in the case of the Channel Islands and Isle of Man a source of hard stone for polished stone axeheads. They may also have been nodes of interaction and centres of exchange, as suggested for example for Belle Île off the southern coast of Brittany in the later Neolithic from the results of ceramic fabric analysis (Gehres 2023).

Neolithic maritime mobility was no doubt more limited than that of later periods, but it was nonetheless effective in facilitating movements of objects, people and ideas. Among those ideas was the practice of constructing megalithic tombs. On Jersey, the much greater size of La Hougue Bie relative to other tombs suggests that by the end of the fifth millennium BC a more complex social structure had established itself (Patton 1992), whereas no comparable size distinctions are evident among the megalithic tombs of the Isles of Scilly or the Isle of Man. That serves once again to underline the different prehistories of the different island groups.

These connections between islands and their adjacent mainlands of course form only one element within the much wider set of networks that underpinned the spread of megalithic traditions through Atlantic Europe in the fifth and fourth millennium BC. The role of seafaring in carrying those traditions from place to place remains a key component in understanding their origins and distribution. Islands help us to follow and assess those interconnections, since by definition the movements to and between them of materials, ideas and people demanded maritime skills and technologies. They hence throw light on what might have been possible at the broader scale, in crossing the North Sea, the English Channel or the Bay of Biscay. The emphasis here, however, has been not on what Neolithic seafarers *could* do, but what they *did* do. None of the island groups discussed above were beyond their reach, nor that of Mesolithic seafarers, but that does not imply that all of them were equally closely connected.

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THE END OF THE BEGINNING OF ARCHAEOGENOMICS

Beginnings and ends in Neolithic Britain

Tom Booth

Abstract
The methods used to analyse vast databases of archaeogenetic data generated over the last 15 years have continued to develop and mature. Methods of investigating genetic sex, ancestry and relationships between sampled individuals, all aspects of archaeogenetic research that were anticipated by archaeologists, are relatively stable and consistent. However, new methods of analysing ancient DNA data continue to emerge, covering aspects of ancient individuals and their environments that perhaps were less anticipated by archaeologists, such as the detection of distant genetic relatives, consanguineous reproduction and the dynamics of infectious disease. The beginning (*c.* 4000 BC) and the end (*c.* 2500 BC) of the Neolithic in Britain are both marked by exceptionally large shifts in ancestry, and an outstanding question is why Britain is exceptional in this regard compared to proximal regions of continental Europe. New analyses suggest that population dynamics and disease are likely to have had large roles in large-scale genetic ancestry shifts in Neolithic Britain, as well as across Neolithic Europe more generally. Both the Early and Late Neolithic in Britain see interactions between groups with different disease burdens. The different dynamics of mobility in this period, involving migration followed by relative isolation at the beginning of the Neolithic, and more multi-directional migrations which fostered interconnectedness at the end of the Neolithic, may have exacerbated the effects of disease in different ways. Relative isolation of resident populations of Britain from continental Europe before periods of migration and ancestry change may also have contributed to the scale of change. In addition, there are curious contradictions between evidence for biological and for cultural connectivity between Britain and other parts of continental Europe, as well as groups within Britain, emphasising the difficulties in unravelling the complexities of interactions between prehistoric human societies.

Keywords: ***Neolithic Britain; ancient DNA; disease; demography; migration; adaptation***

Introduction
Human archaeogenetics has reached a point of maturation as methods of processing samples, generating data and the bioinformatic techniques involved in analysing that data have stabilised. Human archaeogenetic papers now regularly use the same or similar sets of methods to investigate genetic sex, ancestry and close biological relationships between individuals, meaning archaeologists are becoming more familiar with what this analysis

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can do and the sorts of questions it can be used to address. In this sense we are at the 'end of the beginning' of the phase of archaeogenetics that was reinvigorated by the advent of Next Generation Sequencing (NGS). However, methods continue to develop, shedding light on aspects of the past in ways that archaeologists may not have anticipated. Here I discuss how developments in the analysis of ancient demography, genealogy and disease using ancient DNA are continuing to advance, with a focus on what developing methods are starting to say about the factors involved in the exceptionally large shifts in genetic ancestry that occur in Britain at the beginning (*c.* 4000 BC) and the end (*c.* 2500 BC) of the Neolithic.

I begin by outlining the genetic evidence for a particularly large-scale shift in ancestry at the beginning of the Neolithic and examine the similarities and differences with comparable shifts in Scandinavia. I go on to discuss the arguments around how this transition took place, emphasising that it was probably a process that took many generations and highlighting the curious inconsistencies in evidence for biological and cultural contact between certain populations. I then describe how new methods of analysing ancient DNA, which detect distant relatives and pathogen DNA, are providing evidence for the significant roles of demography and disease in driving genetic change, and why these factors may have been particularly impactful in Britain both at the beginning and the end of the Neolithic.

The beginning of the Neolithic in Britain

Genetic change in Britain through the first half of the fifth millennium BC is propagated by the arrival of people from continental Europe carrying 'Early European Farmer' (EEF) ancestries, which have distant origins in Anatolia, as well as minor 'Western European Hunter-Gatherer' (WHG) ancestries, related to populations who lived across Europe through the eighth to fifth millennia BC (Brace *et al.* 2019; Olalde *et al.* 2018; Sánchez-Quinto *et al.* 2019). Measures of population turnover in this period often rely on levels of excess ancestry related to local populations carrying WHG ancestries, and when this is applied to Britain they suggest that by *c.* 3500 BC there was an almost complete shift in genetic ancestries to a genetic profile most similar to what is observed in Neolithic-associated continental groups (Brunel *et al.* 2020; Olalde *et al.* 2018; Rivollat *et al.* 2020).

Admixture between groups carrying EEF-related ancestries and local ancestries varies across Europe. There is a trend in most of continental Europe for a period of limited admixture to be followed by a resurgence of local ancestries hundreds to sometimes thousands of years later. There are several ways of explaining this pattern: extended periods of time where groups with diverse ancestries were reproductively isolated from one another and practised different funerary rites before mixing more liberally later, alternatively a scenario where groups carrying local ancestries were largely displaced before returning and mixing with groups mostly descended from migrant communities, or the arrival of new communities with higher levels of (e.g. WHG) ancestry resembling the preceding 'local' signature (Bollongino *et al.* 2013; Brunel *et al.* 2020; Furtwängler *et al.* 2020; Haak *et al.* 2015; Lipson *et al.* 2017; Mathieson *et al.* 2018; Olalde *et al.* 2019; Rivollat *et al.* 2020). However, Britain bucks this trend. Levels of initial admixture between incoming and local groups in Britain are minimal compared to other parts of Europe, and there is no later resurgence in local WHG ancestries (Brace *et al.* 2019).

Populations of present-day Denmark undergo a similar large-scale genetic turnover in the same period (Allentoft *et al.* 2024a; Skoglund *et al.* 2014), although in coastal Denmark and other regions of Scandinavia on the Baltic Sea there is clear genetic and archaeological evidence for the persistence of people descended from Mesolithic coastal groups living hunter-fisher-gatherer lifestyles, which eventually characterise the late fourth-millennium BC Pitted Ware cultural traditions (Coutinho *et al.* 2020; Günther *et al.* 2018; Jensen *et al.* 2019; Skoglund *et al.* 2014). The genetic profile of these persistent hunter-fisher-gatherers is not the WHG-related ancestries derived from populations who initially inhabited Mesolithic Denmark, but a mix of WHG and 'Eastern European Hunter-Gatherer' (EHG) ancestries characterising Scandinavian Hunter-Gatherer (SHG) ancestries carried by people who had been based further east (Günther *et al.* 2018). Moreover, there is clear evidence for cultural and to a lesser extent biological interactions between these groups and groups of local farmers associated with the Funnel Beaker (TRB) culture, although this seems to have extended to reproductive interaction only occasionally (Coutinho *et al.* 2020; Fraser *et al.* 2018; Iversen 2010). However, even in Denmark, unlike in Britain, there is a slight resurgence of local Mesolithic-derived ancestry after 3400 BC (Allentoft *et al.* 2024a).

Interestingly, the earliest dated (4000–3710 cal BC; 95 % confidence; Allentoft *et al.* 2024a) typologically Neolithic Funnel Beaker grave, that from Dragsholm, contains the remains of a male (Dragsholm Man) who was entirely descended from local Mesolithic groups carrying WHG ancestries (Allentoft *et al.* 2024a). Yet stable isotope analysis of Dragsholm Man showed that his diet was typical of incoming farming populations. Collectively, this provides clear evidence for acculturation of individuals and potentially local populations just before or around the time of the arrival of the Neolithic in Denmark. It is difficult to say whether this individual was a single convert to the Funnel Beaker way of life or is representative of a whole community. Either way, this seems unlikely to have been a common occurrence in Denmark, given the small overall genetic impact of Mesolithic populations on Funnel Beaker groups. A contrasting example is that of Vittrup Man, who died around a thousand years later than Dragsholm Man, and whose remains were recovered from a bog in northern Jutland. Vittrup Man shows genetic affinities with later Pitted Ware-associated individuals from Gotland carrying predominantly SHG-related ancestries (Allentoft *et al.* 2024a). Stable isotope analysis suggested that he grew up in the Scandinavian peninsula and that his childhood diet was reliant on aquatic resources, while in later life he had shifted to a fully terrestrial diet, more characteristic of local Neolithic Funnel Beaker groups (Fischer *et al.* 2024). Vittrup Man died a violent death, with osteological evidence for at least seven blunt-force blows to the skull, interpreted as ritualised murder. When combined with the non-normative treatment of his body, particularly involving deposition in a marginal landscape, this raises the possibility that he was a captive or had been enslaved. However, given the wider context of contact and trade between groups associated with Pitted Ware and Funnel Beaker traditions, it is also possible that Vittrup Man had fully assimilated into a Funnel Beaker lifestyle and that his violent death was unrelated to his origins (Fischer *et al.* 2024). In either case this example shows that individual and potentially groups of hunter-gatherers continued to join farming populations over extended periods of time in different ways and in variable cultural and environmental conditions. The processes by which individual hunter-fisher-gatherers joined communities of farmers were probably highly variable over centuries to millennia and might not always have been peaceful.

In Britain, particularly present-day western Scotland, individuals buried in caves and shell middens show evidence for recent admixture with groups carrying local Mesolithic-derived ancestries (Brace and Booth 2023; Patterson *et al.* 2022). As in Denmark, these results indicate that enclave communities carrying substantial local Mesolithic-derived ancestries and practising variants of Mesolithic lifestyles persisted for hundreds of years alongside agricultural groups carrying EEF-related ancestries (Brace and Booth 2023; Patterson *et al.* 2022), consistent with some interpretations of the archaeological evidence (Finlay *et al.* 2019). Deposition of disarticulated human remains in shell middens is the only identified mortuary treatment in Britain in the late fifth millennium BC (Charlton *et al.* 2016; Milner and Craig 2009) and cave burial seems to have been a rite reintroduced to Britain by groups with EEF-related ancestries (Schulting 2007). There is evidence for cave burial in the late fifth millennium BC from Ireland, although the only similar dates from human remains in a cave (from Fox Hole Cave in Derbyshire; Hellewell and Milner 2011) are probably anomalously old because of contamination issues at the Oxford radiocarbon laboratory at the time the dates were acquired (Schulting 2020). Neolithic populations with mixed ancestries in western Scotland seem to have adopted a composite model of funerary treatment which incorporated both local and re-introduced traditions (Mithen 2022). However, these groups contributed little if any genetic ancestry to the Neolithic populations of Britain over the long term, suggesting they were relatively reproductively insular. Therefore, there are outstanding questions about why genetic change in Britain in the early fourth millennium BC, associated with the arrival of people carrying EEF-related ancestries, is exceptionally large and pervasive.

It bears repeating that a shift in genetic ancestry, no matter how large, cannot in and of itself be interpreted as reflecting a straightforward catastrophic wipeout of one population by another, whether it be by violence, disease or a mixture of both (Booth 2019). Of course, such extreme scenarios must be considered as possibilities, and it is reasonable to posit that these factors were likely to have been involved, but additional archaeological evidence is required to assess their influence and effects. At the most basic level, major shifts in genetic ancestries suggest that a population predominantly carrying one set of genetic ancestries produced more descendants over a period of time. If the period of time over which this shift occurs is long, i.e. centuries, then less dramatic causes could be responsible, for instance differences in lifestyle affecting birth rates or infant mortality (Booth *et al.* 2021). It should be noted, however, that such a scenario would require the existence of a relatively high degree of genetic structure between populations with different genetic ancestries, that is people who carried one set of ancestries having children who lived to adulthood more often and largely reproducing with people carrying similar ancestries rather than with people carrying different ancestries. In contrast, if reproduction was entirely random from the beginning, the two ancestries would become extensively mixed early on and it would be much less likely that one would come to predominate. Similarly, a slow replacement scenario would also require that people carrying particular ancestries more often engaged in practices which resulted in them producing more descendants. This may be explained by cultural practices being passed down amongst the populations, thereby broadly covarying with ancestries.

Lia Betti and colleagues (2020) noted an association between climate and levels of admixture between migrants carrying EEF-related ancestries and local groups with WHG-ancestries. Building on previous models of demographic change linked to the precariousness of agricultural lifestyles in different regions of Europe (Collard *et al.* 2010; Colledge *et al.* 2019; Silva and Vander Linden 2017; Timpson *et al.* 2014), Betti and co-authors (2020) interpret this association in terms of a decrease in rates of migration and proliferation due to difficulties in establishing agriculture in parts of Europe with wetter, colder climates. However, it is unclear how this explains the large-scale genetic change we see in Britain (Brace *et al.*

2019) as well as Scandinavia (Allentoft *et al.* 2024a; Skoglund *et al.* 2014), where climate would have been particularly inclement and where, under Betti and colleagues' (2020) model, we might predict substantial admixture with local Mesolithic-derived groups. One possibility is that there was some development in technology, lifestyle or social organisation which meant groups in continental Europe carrying EEF-related ancestries became better equipped to farm successfully in less favourable climatic conditions. Such developments would help to explain why there is a long delay before groups carrying EEF-related ancestries disperse relatively rapidly into Britain, Scandinavia and other parts of northern Europe.

One possibility is that social interactions between some Mesolithic communities in Britain and continental Europe, who themselves interacted with adjacent communities of Neolithic farmers from the sixth millennium BC onwards, indirectly acculturated Mesolithic communities in Britain to aspects of the Neolithic way of life (Lawrence *et al.* 2022; Thomas 2022). Subsequent interactions with both Mesolithic and Neolithic groups on the continent led to prolonged social negotiation, eventually leading to certain local Mesolithic groups helping to facilitate the migration and establishment of communities of people carrying EEF-related ancestries in Britain in the late fifth millennium BC. In this scenario, the local population's prior knowledge of Neolithic lifestyles, combined with their familiarity with landscape and environment, meant that their cooperation with migrants allowed the latter to flourish. The most obvious examples include the early exploitation of stone from Langdale, Cumbria, and the establishment of flint mines in Sussex, suggesting that incoming farmers became familiar with local resources very rapidly (Lawrence *et al.* 2022). A seventh-millennium date for wheat from Bouldnor's Cliff near the Isle of Wight (Smith *et al*. 2015a) has been used to argue for prolonged connections and exchange between hunter-gatherers in Britain and farmers in continental Europe, but there are persistent doubts about the veracity of the result (Smith *et al*. 2015b; Weiß *et al*. 2015). The faunal assemblage from the Coneybury Anomaly has been argued to reflect a direct meeting between groups of farmers and hunter-gatherers (Gron *et al*. 2018). Sites like the aforementioned Hazleton North long barrow in Gloucestershire, which sits on top of older Mesolithic layers (Saville 2013), and Fir Tree Field shaft in Dorset (Green and Allen 1997), where there seems to have been a largely continuous pattern of deposition from the late fifth and early fourth millennium BC, provide evidence for continuity in landscape use and cultural practice.

While this scenario of extensive social contact and cooperation between continental farmers and local hunter-gatherers is not precluded by the genetic evidence, the extensive ancestry shift we see in Britain in the fourth millennium BC means that any long-lived cultural interactions between Mesolithic groups in Britain and Neolithic groups in continental Europe through the fifth millennium BC would not have translated into any regular or consistent biological reproduction. This could be explained by social taboos (Lawrence *et al.* 2022). It is likely that there were disparities in the genetic and cultural legacies of different populations through the genetic shifts we see across Europe in prehistory, but in this model the scale of the genetic shift in Britain contrasts with the proposed centrality of local Mesolithic communities in the development of the Neolithic. It is difficult to gauge what level of interaction between different communities would be necessary to produce these apparent patterns of continuity and we cannot reject the possibility that communities descended from incoming continental farmers came to attach significance to older sites or identified useful resources with only minimal input from local Mesolithic-derived groups. For instance, while Hazelton North long barrow was built upon a Late Mesolithic midden, of the 35 individuals from the tomb whose DNA has been sequenced, none had much if any recent ancestry derived from local Mesolithic groups. Combined with the fact that tombs like Hazleton North were absent from Britain before the arrival of continental farmers, this paints a much more complicated picture of re-use or continued use of sites, one where sites were being understood more through the lens of incoming farmer populations than local hunter-gatherers. If there was a strict taboo on reproduction between local Mesolithic-derived groups and incoming populations it must have been exceptionally strongly adhered to in Britain, in spite of clear, albeit varied patterns of admixture in continental Europe (Bollongino *et al.* 2013; Furtwängler *et al.* 2020; Lipson *et al.* 2017; Olalde *et al.* 2019; Rivollat *et al.* 2020).

Insights from genetic genealogy

More recently, archaeogeneticists have turned their attention to investigating patterns of biological relatedness at archaeological sites in order to explore concepts of kinship linked to biology in different contexts (Booth *et al.* 2021; Cassidy *et al.* 2020; Fowler *et al.* 2022; Gretzinger *et al.* 2022; Mittnik *et al.* 2019; Rivollat *et al.* 2023). These sorts of studies can also reveal dynamics of migration and mobility on a local scale, which bring about broader demographic change (Booth *et al.* 2021; Gretzinger *et al.* 2022). The most spectacular example from Neolithic Britain is Hazleton North long barrow, where 27 identified relatives form five generations of an extended genealogy, showing patterns of biological reproduction, decisions around descent, who was permitted to be buried in the tomb and where their remains were placed (Cummings and Fowler 2023; Fowler 2022; Fowler *et al.* 2022). Notably, there was evidence for both men and women having children with at least two partners. The frequency with which this occurred suggests that these cases were unlikely to reflect misattributed paternity, although we cannot rule this out entirely. Instead, these results more likely reflect socially sanctioned polyamory or serial monogamy. As Vicki Cummings and Chris Fowler (2023) have noted, part of the interest in this result is how it differs from other tombs in Britain and Ireland where we have data from multiple individuals, which do not seem to show the same emphasis on social ties correlating with biological relatedness (Brace *et al.* 2019; Cassidy *et al.* 2020; Olalde *et al.* 2018; Sánchez-Quinto *et al.* 2019). Fowler (2022) suggests this indicates different contemporary communities may have organised themselves via variable systems and ideologies governing rules of descent and social units. These differences in ideology reflected in tombs might by related to forms of regional identity of groups or alternatively different rites afforded to people from different sections of society.

Gurgy 'les Noisats' flat grave cemetery in the Paris Basin is the only Neolithic funerary site that has produced comparable results so far, with dozens of genetic relatives belonging to two genealogies spanning five and seven generations respectively (Rivollat *et al.* 2023). In contrast to Hazleton North, there is no evidence at Gurgy for second-degree relatives likely to be half-siblings indicative of polyamory, serial monogamy or misattributed paternity. Given France is one of the most plausible putative sources of migrations to Britain (e.g. Rivollat *et al*. 2020; Sheridan 2010) it is interesting to consider whether movements of communities and developments of different tomb architectures, as well as movements of people across the Channel specifically, at least in part reflect desires to live by a different set of social rules (Cummings and Fowler 2023). There are some suggestions from both genetics and the archaeological record that groups from different parts of continental Europe entered western and eastern Britain (Brace *et al*. 2019; Rivollat *et al*. 2020; Sheridan 2010). Therefore, another explanation for the differences in organisation at Hazleton North and Gurgy 'les Noisats' is that these different groups entering variable regions of Britain lived by different social rules which were reflected in their funerary traditions. However, it is possible that the differences in organisation between Gurgy and Hazleton North may be more related to changes over time, given that the remains from Gurgy are *c*. 900 years older than those interred at Hazleton North (Fowler *et al.* 2022; Meadows *et al*. 2007; Rivollat *et al*. 2015; 2023; Rottier *et al*. 2005).

The results from Hazleton and Gurgy 'les Noisats' also show that both Neolithic societies had large families (Cummings and Fowler 2023; Fowler 2022; Fowler *et al.* 2022; Rivollat *et al.* 2023). Part of the solution to the larger genetic legacy of incoming farmers across Europe over centuries is that genetic measures of effective population size show much larger effective population sizes for groups carrying EEF-related ancestries than for Mesolithic and contemporary Mesolithic-derived hunter-fisher-gatherer groups (Brace *et al.* 2019; Ringbauer *et al*. 2021). Effective population size is not census population size and can be influenced by processes such as admixture and bottlenecks. However, as societies who practise hunter-gatherer subsistence strategies generally tend to live at lower density than those with agricultural systems of subsistence, it is plausible that the Mesolithic populations of Europe were smaller and lived at lower density than agriculturalist groups carrying EEF-related ancestries. Incoming groups carrying EEF-related ancestries likely had higher birth rates, which over time led to large populations and larger numbers of descendants. This could be particularly true for Britain if polyamory/serial monogamy was practised more broadly, potentially inflating disparities in birth rates even further.

With this in mind, a simple explanation for the size of ancestry change in Britain at the beginning of the fourth millennium BC is that by the end of the fifth millennium BC populations in Britain were relatively small and sparsely distributed. The exception may be the coasts where, in western Scotland at least, there is some genetic signal of continuity of Mesolithic groups (Brace and Booth 2023; Patterson *et al.* 2022).

Violence

Assessment of the extent to which violence may have played a part in large-scale genetic shifts must largely come from the osteological evidence. The lack of human remains from Britain dating to the late fifth millennium BC as well as human remains derived ancestrally from local Mesolithic populations throughout the fourth millennium BC makes it difficult to assess the extent to which inter-group violence may have been involved in ancestry change. None of the very few individuals from western Scotland showing elevated levels of Mesolithic-derived ancestries display signs of violent trauma or having lived particularly deprived lives (Connock *et al*. 1991; Pickard and Bonsall 2022; Schulting and Richards 2002). As discussed above there is no prior reason to assume that violence was involved just because genetic change is large, particularly as there is evidence that this genetic change occurs over a timescale of centuries, in western Scotland at least. Certainly there is evidence for a relatively high rate of violence, particularly blunt force trauma, amongst burials from Neolithic tombs in Britain (Fibiger *et al.* 2023; Schulting and Fibiger 2012), but as this continues well into the fourth millennium BC and is similar to what is observed amongst Neolithic communities in continental Europe, it more likely represents conflict between different groups of farmers with EEF-related ancestries (Fibiger *et al.* 2023). This is not to say that this sort of violence could not also have been directed at Mesolithic-derived groups, only that there is no direct evidence of this having happened in Britain. Given that groups with EEF and WHG ancestries appear to have exploited largely separate resources and landscapes (Charlton *et al.* 2016; Richards and Schulting 2006), it is reasonable to think there may have been more violence within than between them.

Disease

Agricultural lifestyles will usually involve more intense interactions with (particularly domesticated) animals and higher levels of sedentism, both of which are likely to have exposed human populations to higher disease burdens, including novel zoonotic diseases. Therefore it is reasonable to hypothesise that disease may have played some role in population change with the transition to farming in different regions of Europe. Martin Sikora and colleagues (2023) recently looked at incidences of pathogen DNA detected in samples from prehistoric western Eurasia. Positive hits for pathogen DNA suggest that the live disease was in the person's bloodstream at the time they died. Sikora and co-authors (2023) found a generally higher occurrence (and presumably higher burden) of disease after 4500 BC and that zoonotic disease only appeared in remains which post-dated 4500 BC. This date almost certainly represents the latest point when disease burdens increased or specific zoonotic diseases first began to affect humans in Europe, given the low likelihood of catching the earliest such cases, but it is notable that this happens a few centuries to a millennium before large-scale ancestry shifts in Britain, Ireland and Scandinavia. When groups carrying EEF ancestries did eventually arrive in these regions, they potentially carried a heavier burden of particularly zoonotic diseases than similar, earlier groups who had moved into other parts of Europe. This raises the possibility that differential exposure and genetic and/or cultural adaptation to disease may have played a role in driving the large-scale ancestry changes in Britain and other regions of northern Europe.

Sikora and colleagues' (2023) paper is still awaiting peer-review and its observations and conclusions must be regarded with some caution. Analysis of pathogen DNA from fourteenth century AD mass graves known to predominantly contain the remains of people who died of plague (*Yersinia pestis*) suggests false negative rates of pathogen detection are likely to be high (Bos *et al.* 2011). It is unclear what factors influence the survival of pathogen DNA in archaeological human remains, so we cannot estimate any underlying biases in preservation. In addition, differences in the time depth of funerary deposits, funerary treatment and related survival into the archaeological record means that there are many more DNA samples from later farming populations than groups who lived hunter-fisher-gatherer lifestyles. While this would not affect the rate of disease in each of these groups, it does raise the problem of comparability. Even if we take the current conclusions of Sikora and co-authors' (2023) study at face value, evidence for differential exposure to disease does not necessarily mean that one population was better adapted to disease than another. However, this is certainly a plausible scenario given that Neolithic populations with distant origins in Neolithic Anatolia may have an ancestral history of exposure to these diseases spanning at least 2000 years before they arrived in Britain.

One factor which could have exacerbated the effects of novel disease burdens is if the populations of Britain in the fifth millennium BC were relatively isolated from their continental neighbours (Elliott *et al.* 2020; Jacobi 1976; Schulting and Borić 2017). Any diseases associated with groups carrying EEF ancestries as they moved across Europe would to some extent spread ahead of the moving populations, giving Mesolithic-derived groups across continental Europe the chance to adapt culturally or genetically, potentially reducing the demographic impact of disease. This may have been particularly true if Mesolithic-derived groups persisted in certain regions after groups carrying EEF ancestries arrived, and if they still interacted with Mesolithic groups beyond the farming boundary (Conneller 2021). If these processes did not include populations in Britain and Ireland, Mesolithic populations there may have been at a disadvantage.

Genetic analysis of available Mesolithic populations in Ireland suggests they were relatively reproductively insular, having children with other Mesolithic groups in Ireland but not with people from Britain or proximal regions of continental Europe (Cassidy *et al.* 2020). By 4000 BC, Britain had been an island for at least 2000 years (Sharrocks and Hill 2023; Weninger *et al.* 2008), but the lack of high-quality Late Mesolithic human genomes from Britain, specifically from the late fifth millennium BC, means it is currently impossible to assess whether Late Mesolithic populations in Britain were similarly reproductively insular (Brace *et al.* 2019; Cassidy *et al.* 2020). In addition, reproductive isolation does not necessarily indicate an absence of any other kind of interaction and the extent of cultural contact between Mesolithic communities in Britain and continental Europe remains debated (Elliott *et al.* 2020; Garrow and Sturt 2011; Lawrence *et al.* 2022; Sheridan 2010; Sheridan and Whittle 2022; Sturt and Garrow 2017; Thomas 2022). However, if the Mesolithic populations of Britain were comparatively isolated before the arrival of communities carrying EEF-related ancestries, then they may have been biologically and culturally naive to incoming disease burdens, particularly to zoonotic disease, which could have had a disproportionately large impact compared to other regions of Europe.

Further DNA sequencing may bring some clarity to these issues. Pathogen DNA more often survives in teeth, whereas the majority of human bones sampled for

DNA comprise petrous temporals, where pathogen DNA tends to persist less well. In addition, most of the data from prehistoric Britain has been generated via targeted in-solution capture arrays, which effectively remove non-human DNA. Add to this the likelihood of high false negative rates of pathogen detection, and it is likely that we do not yet have a good impression of the pathogenic landscape in Neolithic Britain and perhaps Neolithic Europe more widely. Future resequencing of uncaptured libraries and new samples, including more samples of teeth, could provide further clarity.

From a genetic point a view, it would be ideal to sample further late fifth millennium Mesolithic human burials from Britain to look for signs of reproductive insularity, demographic decline (e.g. drop in effective population size) and disease burdens. Unfortunately, given the rarity of these sorts of discoveries, and the uncertainties surrounding dates of human bones recovered from caves, we cannot necessarily rely on this happening any time soon. However, advances in sequencing of human DNA from sources other than human bone may help. The WHG ancestries associated with the Mesolithic in Britain are divergent enough from later ancestries that it may be possible to pick up signals in sedimentary/environmental sedi/eDNA (Kjær *et al.* 2022; Massilani *et al.* 2022; Slon *et al.* 2017; Vernot *et al.* 2021; Zavala *et al.* 2021). There are questions about the reliability of eDNA at different types of site, and particularly the possibility of DNA moving between sedimentary units, but assuming this can be resolved to an extent, eDNA may be able to give us a sense of the distribution and density of Mesolithic groups in Britain in the late fifth millennium BC. Similarly, recovery of human and pathogen DNA from artefacts such as bone pendants (Essel *et al.* 2023) or birch tar chewed by an ancient human (Jensen *et al.* 2019) may provide alternative ways forward, although at present it seems that DNA survival is only likely in very specific circumstances and materials. Inevitably it will not be possible to fully address the question of why genetic turnover in Britain post-4000 BC was particularly large without better syntheses of the genetic, archaeological and environmental evidence resolving some of the contradictions in the models for contact, isolation and disease.

Insights from identity-by-descent segments

There are multiple proposed models for the continental origins of the groups who settled Britain and Ireland *c.* 4000 BC, often involving multi-stranded migration routes from different parts of northern continental Europe (Lawrence *et al.* 2022; Sheridan 2010; Sheridan and Whittle 2022; Whittle *et al.* 2011). There are also questions about dynamics of related groups in Britain, Ireland and continental Europe in the centuries after settlement. One of the difficulties in resolving these questions with genetics is that all these populations are relatively similar to one another in their genetic ancestries as measured using standard techniques of allele sharing. One new technique which might help to resolve these questions is analysis of identity-by-descent (IBD) segments of DNA shared between ancient individuals and populations (Ringbauer *et al.* 2024). IBD segments are inherited together. Recombination in each generation breaks up these segments in predictable ways. Therefore, if two individuals share an IBD segment, this tells us that they are direct ancestors/descendants or share a common ancestor, and the length of the segment tells us the number of generations between them or how many generations back in time this common ancestor existed. IBD analyses have already been utilised to show the broad relationships between different populations of Neolithic Europe and different dynamics of migration, e.g. relative isolation of groups in Mediterranean and Atlantic Europe and especially on islands (Allentoft *et al.* 2024a; Ariano *et al.* 2022). For Britain and Ireland, this type of analysis suggests that populations were descended from similar populations and that they may have maintained some reproductive links with each other and not with continental Europe (Ariano *et al.* 2022). Similarly, Neolithic populations in the Orkney Isles were also reproductively insular, consistent with a pattern across western Europe of movement and isolation of groups carrying EEF-related ancestries, particularly on islands.

Harald Ringbauer and colleagues (2024) recently developed a method which uses IBD sharing to identify distant genetic relatives (sharing at least three IBD segments up to 20 centimorgans (cM) long, consistent with genetic relatives up to sixth degree), as well as broader genealogical connections between individuals and populations throughout European prehistory (Ringbauer *et al.* 2024). Establishing the exact nature of these relationships is more difficult. For instance, it is currently difficult to know from the genetics alone whether a genetic sixth-degree relationship between two individuals is because one is the distant direct ancestor of the other (vertical relationship, e.g. 4x great-grandparent–grandchild), they are distant cousins (horizontal relationship), or a complex combination of vertical and horizontal relations (e.g. cousins removed or great avuncular). Radiocarbon dates, particularly ones that can be refined through chronological modelling, should help to refine these likely relationships, particularly the likely generational separation of distant relatives. While these sorts of relationships could be useful for exploring the long-term use of funerary sites by particular lineages or families, or the curation of human remains (Booth and Brück 2020), they would probably have limited applicability for understanding kinship on a social basis, as the relatives were likely too distant for a perceived close relationship. However, the potentially greater utility of IBD segment sharing is in finding connections between individuals or groups in the context of broader movements of people to better pinpoint the sources and dynamics of migrations. Ringbauer and colleagues (2024) use the example of a skeleton from a Yamnaya cultural context in present-day southern Russia, who they find to be a fifth-degree relative, likely a distant ancestor, of a person whose remains were found in an Afanasievo cultural context in present-day Mongolia, indicative of movement of thousands of kilometres within a few generations. This result sits in a broader context of high IBD segment sharing between individuals associated with Yamnaya and Afanasievo, indicating that Afanasievo-associated individuals can trace at least some descent from Yamnaya-associated communities. These distant connections can also provide a sense of the networks of biological reproduction in which ancient individuals were embedded.

Both Ringbauer and co-authors (2024) and Morten Allentoft and colleagues (2024b) also include results from Neolithic Europe, including Britain and Ireland. The results of Allentoft and colleagues (2024b) largely replicated earlier findings (Ariano *et al.* 2022) suggesting a high degree of insularity within Britain and Ireland, and distant connections to groups in continental Europe. Indications of more distant relatives beyond the sixth degree should be taken with caution, as the precision is dependent on the quality of the DNA from each sample, and quality combined with distance will increase the chances of false positives. If population sizes in the past were quite small, we can approach general levels of background relatedness amongst a population, rendering extremely distant relationships meaningless.

However, with these caveats in mind, interrogating the specifics of this data brings out tantalising detail (Ringbauer *et al.* 2024). An individual buried in Carding Bay Mill shell midden near Oban in western Scotland is a possible seventh-degree relative (sumIBD > 30cM, 1–2 segments > 20cM) of two individuals buried in the nearby Raschoille Cave. This adds to the impression of diverse treatment following different Mesolithic- and Neolithic-derived traditions for people with mixed ancestries in western Scotland (Brace and Booth 2023). The burials from Carding Mill Bay are also potentially eighth- to ninth-degree relatives (IBD sharing of single segments >20cM) of people whose remains were deposited in the Isbister tomb, South Ronaldsay, and the Giants Ring passage tomb at Ballynahatty, County Down, Northern Ireland. Individuals buried in the Hazleton North chambered cairn show possible eighth- to ninth-degree relationships with remains deposited at sites across Britain and Ireland, including Fussell's Lodge, Wiltshire, Burn Ground, Gloucestershire, Holm of Papa Westray, Orkney, Tulloch of Assery, Caithness, Carsington Pasture Cave, Derbyshire, Aveline's Hole, Somerset, Primrose Grange, County Sligo and Parknabinna court tomb, County Clare. Individuals buried in Fussell's Lodge also appear to share potential eighth- to ninth-degree relationships with individuals from Primrose Grange and Poulnabrone, County Clare. An individual from Upper Swell, Gloucestershire, was possibly an eighth- to ninth-degree relative of a woman buried in Cissbury flint mine.

Given the genetic evidence that populations carrying EEF-related ancestries quickly grew and expanded in Britain and Ireland, as well as the relative genetic insularity of populations in Britain (Ariano *et al.* 2022), these relationships may not be far above the general background level of relatedness amongst the populations as a whole. Most of the individuals for whom we have genetic data date to the first half of the fourth millennium BC and so these patterns of relatedness could simply derive from the general relatedness of groups who arrived in Britain from adjacent areas of continental Europe. However, they could alternatively indicate specific genetic connections between south-western Britain and Ireland and to a lesser extent between northern Britain, northern Ireland and Orkney. This could be because of more intense social networks between these regions, or because these groups recently derived from a common population, but in either case they suggest intense biological connections across the Irish Sea. These kinds of networks and connections across the Irish Sea have long been hypothesised based on similar practices and monuments across these regions (Cummings 2017; Fowler 2022; Sheridan 2004).

The end of the Neolithic: genetic change in the mid-third millennium BC

Genetic change in Britain beginning in the mid-third millennium BC, and seemingly completed by the beginning of the second millennium BC, is driven by the arrival of groups of migrants carrying genetic ancestries observed in burials associated with Bell Beaker-using communities in continental Europe (Olalde *et al.* 2018). These continental Beaker groups carry ancestries with distant origins on the western Pontic-Caspian steppe: Western Steppe Herder (WSH)-related ancestries, as well as ancestries picked up from Neolithic groups with mixed EEF- and WHG-related ancestries from across eastern and central Europe (Olalde *et al.* 2018). There is a main stream of migration into Britain that probably originates in the Lower Rhine Valley, but beyond that there is clear evidence for a more minor contribution from individuals or smaller Beaker-using groups from diverse parts of continental Europe (Booth *et al.* 2021). The dynamics of migrations and interactions between incoming and local populations result in a >95 % shift in genetic ancestries between *c.* 2500–2000 BC. As in the early fourth millennium BC, this genetic shift in Britain is larger than for most other regions of Europe at this time (Allentoft *et al.* 2015; 2024a; Brunel *et al.* 2020; Furtwängler *et al.* 2020; Gamba *et al.* 2014; Haak *et al.* 2015; Lazaridis *et al.* 2022; Mathieson *et al.* 2018; Olalde *et al.* 2019; Villalba-Mouco *et al.* 2021). Also similar to 4000 BC, there is evidence from patterns of genetic admixture that groups largely derived from the Late Neolithic populations of Britain persist in enclaves alongside communities carrying WSH-related ancestries (Booth *et al.* 2021). As Late Neolithic funerary rites in Britain more often involved cremation or rites which left no archaeological record, there is a clear explanation for why these populations are missing from the archaeogenetic record. The finding that a substantial proportion of skeletons from particular regions, especially Wessex, have been found to be close genetic relatives (up to third degree) provides some evidence for bias in who was buried in these highly visible ways. As people who are closely related to one another are more likely to carry similar genetic ancestries, a bias towards people who were more likely to have been genetic relatives may have also had the knock-on effect of creating a bias towards particular ancestries. However, it is clear that a large-scale genetic shift does occur eventually, and while the dynamics of migration, interaction and genetic admixture were very different in the late third millennium BC than the early fourth, there may be similar factors at play involving demography and disease which may explain why genetic change in Britain was so large.

Population density in Late Neolithic Britain

Similar to the beginning of the Neolithic, one of the main factors discussed for the size of the genetic shift in Britain at the end of the Neolithic is that population sizes were relatively small, with groups distributed sporadically across the landscape with low overall density (Booth *et al.* 2021). These theories are largely driven by suggestions that there was a significant reduction in the population through the first half of the third millennium BC, accompanied by a shift from a mixed pastoral-agrarian subsistence to one that was more focused on mobile pastoralism (Colledge *et al.* 2019; Downey *et al.* 2016; Timpson *et al.* 2014). In these circumstances slightly higher rates of descendants of incoming groups would have had a big effect over the long term. However, the extent of any demographic decline and how it might have varied regionally across Britain is a matter of ongoing debate. After all, this is a period during which some of the biggest and most labour-intensive prehistoric monuments in Britain were built, including Silbury Hill, the largest artificial prehistoric mound in Europe (Bayliss *et al.* 2007). It is important to consider that what looks like a sudden demographic collapse in the archaeological data was a process that occurred over centuries and was probably regionally variable, and so may not have been all that tangible to people in their everyday lives. There was not necessarily a sudden universal collapse of entire societies. More likely, groups gradually adapted to lower population densities and the precarity of agrarian agriculture in Britain's climate, for instance in moving more towards mobile pastoralism (Colledge *et al.* 2019; Downey *et al.* 2016; Snoeck *et al.* 2018; Timpson *et al.* 2014). Increased mobility as a norm for communities of Late Neolithic Britain makes it easier to envision how labour could have been mobilised to build large monuments at a time when populations were sparsely distributed, but could have assembled to build large monuments.

The lack of high-quality genomes from Britain dating to the first half of the third millennium BC means it has not been possible to assess genetic proxies of demographic decline. Ringbauer and colleagues (2021) found that an unaccompanied juvenile burial (Sk 5856) from a single grave at Eton Rowing Course, Dorney, Berkshire, carried long runs of homozygosity in their genome. Homozygosity in this context refers to long stretches of the same variants on a chromosome pair. As we inherit one of each of these chromosome pairs from each of our parents, the extent to which variants across pairs of chromosomes are the same is a measure of parental relatedness. Short runs of homozygosity suggest an individual originates from a population that had a high degree of background relatedness, whether because of a bottleneck or inbreeding. Long runs of homozygosity suggest that recent ancestors were closely related, allowing for the identification of recent consanguineous reproduction in an individual's ancestry history (Cassidy *et al.* 2020; Ringbauer *et al.* 2021).

The runs of homozygosity Ringbauer and colleagues (2021) identified in Individual Sk 5856 suggest that Sk 5856's parents were probably third-degree relatives, most likely first cousins.

This result is notable given children of consanguineous relationships seem to have been uncommon across Neolithic Europe generally (Ringbauer *et al.* 2021). Sk 5856 has been directly radiocarbon dated to 3370–3020 cal BC (95 % confidence; Allen *et al.* 2004), too early for this to be directly relevant to discussions of demography in the early third millennium BC, but setting the scene in terms of the possible practices that may be relevant. We cannot know whether first-cousin marriage was something specific to the social context of the Eton Rowing Course site. In addition Sk 5856 does not show the shorter, more frequent lengths of homozygous segments indicative of having come from a closely-related and therefore potentially small population. However, it is interesting to speculate, given the apparent rarity of these unions, that first-cousin marriage might have occurred because some populations in Middle–Late Neolithic Britain were shrinking and becoming more sparsely distributed (Colledge *et al.* 2019). This is very far from a genetic 'smoking gun' for the idea of demographic decline at this time, but an interesting data point that will hopefully be built upon with future sampling of the (admittedly sparse) Middle–Late Neolithic human remains.

Violence

The arguments around violence or domination as a major driver of population change in Late Neolithic Britain are very similar to those made for the beginning of the Neolithic. While a substantial genetic shift certainly increases the probability that the population with the largest overall genetic legacy committed violence against those with a smaller legacy, any such model needs supporting archaeological evidence. People may point to the accompanying turnover of paternal lineages (Y-chromosome haplogroups) in Britain and regions of Europe more generally as indicative of deadly violence against local men (Kristiansen *et al.* 2017; Sjögren *et al.* 2020), but such changes can also occur as a result of (potentially peaceful) competition between patrilineally organised groups (Guyon *et al.* 2024; Zeng *et al.* 2018). In Early Bronze Age Bohemia, the available data suggest there was a steady homogenisation of paternal lineages through time, without any apparent external migration. In this context at least, the organisation of societies itself apparently reduced the diversity of paternal lineages (Papac *et al.* 2021). While violence was inevitably a prominent feature of life in Britain during the late third millennium BC, there is no relative increase in attested rates of trauma, as might be expected if violence was primarily driving genetic change (Armit 2011; Parker Pearson *et al.* 2019; Thorpe 2009). The idea that young male warbands drove the shift to WSH-related ancestries (Kristiansen *et al.* 2017) in Britain is challenged by the substantial ancestry shift in the Orkney Islands after 2500 BC, which was not accompanied by a comparable shift in paternal lineages (Dulias *et al.* 2022). Interpreted using previous models, this finding would suggest a scenario of raiding females from mainland Britain sailing to Orkney, killing the local women and carrying off the men. While we cannot rule this out entirely, it seems more plausible that socio-political negotiation, social structures and marriage alliances were responsible for the distinctive characteristics of ancestry change across Britain and its associated islands.

Disease

As in the fourth millennium BC, one of the ideas explaining the demographic impact of migrations into Britain (and the rest of Europe) during the third millennium BC has been the potential impact of disease, particularly a plague caused by *Yersinia pestis* bacteria, often named the Late Neolithic–Bronze Age (LNBA) plague (Rascovan *et al.* 2019; Rasmussen *et al.* 2015; Slavin and Sebbane 2022; Valtueña *et al.* 2022). In all cases, the first studies of LNBA plague found it to be associated with people who carried WSH-related ancestries, and so it was natural to hypothesise that migrations of groups from the Pontic steppe had spread plague across Europe. Differences in lifestyle or even biological susceptibility to disease may have led to higher fatality rates amongst peoples who carried predominantly local ancestries persisting from the Neolithic. This idea made some historical sense in that it had been proposed that the steppe and/or central Asia was a reservoir for *Yersinia pestis* (Slavin and Sebbane 2022).

However, the association between ancestry change and the plague was challenged by the detection of *Yersinia pestis* in two individuals from the Frälsegården Neolithic passage grave in present-day Sweden (Rascovan *et al.* 2019). Frälsegården dates to *c.* 2900 BC and neither individual carried any WSH-related ancestries, instead harbouring only EEF- and WHG-related ancestries typical of Neolithic European populations. Rather than focusing on migrations from the steppe as the vector of disease, Nicolás Rascovan and co-authors (2019) hypothesised that *Yersinia pestis* emerged amongst groups living in Trypllian 'mega-site' settlements in eastern Europe and radiated out from there, contributing to demographic fluctuations noted in various regions of Neolithic Europe (Colledge *et al.* 2019; Downey *et al.* 2016; Timpson *et al.* 2014). Evidence for both cultural and genetic interactions between Trypillia-associated populations in eastern Europe and groups inhabiting the steppe regions suggests that groups carrying WSH-related ancestries could have picked up plague from Trypillian communities and spread it westwards (Immel *et al.* 2020; Nikitin *et al.* 2023).

There have been persistent questions about the virulence and morbidity associated with the LNBA plague. Notably, detailed analysis of the Neolithic–Bronze Age plague genome showed that it lacked a gene (known as YMT) which facilitates flea transmission (Rasmussen *et al.* 2015). This suggests that the this early form of *Yersinia pestis* probably could have only been spread either by person-to-person or animal-human contact via respiratory droplets (pneumonic plague), which is a relatively rare form of transmission today, or through animal bites or blood contact (septicaemic plague), which would make human-to-human transmission unlikely (Susat *et al.* 2021). Therefore, this variant of *Yersinia pestis* was potentially much less transmissible than variants behind later pandemics, such as the Black Death. This is backed up by a lack of evidence for widespread fatal outbreaks in the third millennium BC, for instance in the form of mass or multiple graves indicative of sudden high mortality (Susat *et al.* 2021). This led Julian Susat and colleagues (2021) to argue that cases of *Yersinia pestis* observed in Europe through the late fourth and third millennia BC more likely reflect isolated zoonotic spillover events rather than endemicity or pervasive transmission across human communities.

Susat and co-authors (2021) identified what was then the earliest *Yersinia pestis* genome from Europe in an individual from the Rinnukalns shell midden in present-day Latvia, who showed significant consumption of aquatic resources. Notably, and in common with other individuals from Pitted Ware contexts, this individual was primarily descended from populations who inhabited regions around the Baltic Sea during the Mesolithic with a minor component of ancestry from Neolithic groups carrying EEF-related ancestries. The Rinnukalns skeleton dated to *c.* 3000 BC, before the earliest evidence for groups carrying steppe-related ancestries in the Baltic and Scandinavia. This further supports the scenario of sporadic animal spillovers, making it unlikely that outbreaks of *Yersinia pestis* had a major impact on the population of Europe in the third millennium BC. The counter-argument is that it is not entirely clear in this scenario how LNBA plague spread from the steppe into north-eastern Europe without substantial movements of people and associated shifts in ancestry. Evidence for cultural and reproductive interaction between groups on the steppe and around the Baltic, specifically groups associated with the Globular Amphora family of cultures, mean that we cannot rule out the possibility that LNBA plague still spread from the Pontic-Caspian steppe as a result of earlier archaeologically invisible movements or through chains of interaction between communities (Allentoft *et al.* 2024a; Rasmussen *et al.* 2015). The occasional spillover theory also cannot explain that multiple individuals from the same site were infected with plague at the Frälsegården passage tomb and in remains dating to *c.* 2000 BC from Charterhouse Warren Cave in Somerset, south-western Britain (Rascovan *et al.* 2019; Swali *et al.* 2023).

Sikora and colleagues (2023) reinforce the idea that disease played a significant role in the demographic changes of the third millennium BC. While disease loads generally and incidences of zoonotic disease specifically were higher after *c.* 4500 BC in Europe and were associated with Neolithic farming lifestyles, they peak around 3000 BC and this rise is largely a result of pathogens associated with individuals carrying WSH-related ancestries. Notwithstanding the caveats associated with a preprint discussed above, this does provide stronger evidence that links migrations of people carrying WSH-related ancestries and disease burdens generally, as well as incidences of *Yersinia pestis* more specifically, and the case is stronger that there was significant community transmission rather than cases representing random spillover events.

Sikora and co-authors (2023) propose that this higher pathogen load could be responsible for higher rates of Multiple Sclerosis (MS) found in living people who carry higher levels of WSH-related ancestries, particularly people with recent ancestry from northern Europe. MS is an autoimmune disease and these types of disease are thought to have developed as an adaptation to environments which exposed humans to higher, particularly zoonotic, pathogen loads, especially in the context of agriculture. Over time the genetics underlying immune responses adapted to deal with these more intense disease loads, but with the side effect of making the immune system 'oversensitive' to threats, sometimes attacking the body itself. Sikora and colleagues (2023) found that people who lived in Europe in the third and second millennia BC and carried WSH-related ancestries had a higher genetic risk of MS. This is significant in discussing the role of disease in demographic change in third millennium BC Europe, as it would suggest that populations who harboured steppe ancestries were potentially adapted genetically to higher disease loads than groups who did not. Any disparities in immune response, particularly if affecting factors like infant mortality, need not have been large to have had a large impact over a few centuries. Related disparities in rates of disease or morbidity would then help to explain large-scale transformations in ancestry across Europe in the third millennium BC.

However, there are some inconsistencies which mean this story cannot be so straightforward. Firstly, there is no clear reason why pastoralists who lived on the Pontic steppe, as well as their descendants in parts of Europe outside the steppe, would be exposed to higher disease loads than agriculturalist groups. Sikora and colleagues (2023) suggest that the pastoralist focus of groups carrying WSH-related ancestries led to more intense interactions with animals than for groups to the west with a more mixed agrarian/pastoralist economy. However, as there certainly was a substantial pastoralist component to the lifestyles of Neolithic farmers outside of the steppe, is it likely the difference in subsistence practices was extreme enough to produce these sorts of changes?

In addition, individuals associated with the Yamnaya and related cultures, often thought to be the source of dispersals off the steppe, do not show an enhanced predisposition to MS (Sikora *et al.* 2023). So far, the heightened genetic susceptibility is only observed in groups carrying steppe-related ancestries who lived outside the steppe and who were admixed with Neolithic populations carrying EEF- and WHG-related ancestries. In fact, the earliest ancient individual showing heightened susceptibility to MS comes from the fifth millennium BC Italian peninsula. While one individual may not have much bearing on the broader trend, this shows that the process is more complicated than Sikora and colleagues (2023) suggest.

One possibility is that Yamnaya-associated populations were not the ultimate source of migrations into Europe, with this role played by an un- or undersampled population to their west (Allentoft *et al.* 2024b). Another possibility is that the MS-risk variants were picked up by populations carrying steppe ancestries early on as they migrated across Europe, perhaps from Neolithic populations associated with the Trypillia culture, and then dispersed by subsequent migrations of these admixed populations. The potentially proto-urban environment of the Trypillia settlements could provide a better explanation of higher disease exposure and genetic adaptation in the form of MS-susceptibility than a pastoralist lifestyle on the steppe (Immel *et al.* 2020; Nikitin *et al.* 2023).

With respect to Late Neolithic Britain, the most consequential finding of Sikora and colleagues (2023) may be *Yersinia pestis* in a burial from the Banks chambered tomb on the Orkney Isles, radiocarbon dated to 3010–2880 cal BC. This is a striking result, especially given that the plague had not been previously detected in Neolithic remains from mainland Britain (although, as discussed above, this may be because most data from Britain have been generated using petrous bones and targeted in-solution capture arrays, decreasing the chances of picking up pathogens; Hansen *et al.* 2017; Margaryan *et al.* 2018). The individuals from the Banks tomb died at least 500 years before the first arrival of individuals carrying steppe-related ancestries in the Orkney Isles (Dulias *et al.* 2022; Olalde *et al.* 2018) and there is no plausible cultural connection to the Pontic-Caspian steppe. As discussed above, analysis of patterns of IBD segment sharing suggests populations in Neolithic Britain and Ireland were relatively reproductively insular, and this was especially true for the Orkney Isles (Allentoft *et al.* 2024b; Ariano *et al.* 2022; Ringbauer *et al.* 2024). This raises the question of how plague got into Orkney in the first place.

One possibility is that populations of Britain and Orkney did in fact maintain connections and networks with continental Europe, but that this did not extend to intermarriage. Another possibility is that *Yersinia pestis* was already endemic to populations carrying EEF-related ancestries when they moved into Britain. This would imply that *Yersinia pestis* was already circulating around Neolithic societies in Europe before 4000 BC, one thousand years before the currently earliest recovered *Yersinia pestis* genome. *Yersinia pestis* would then not have emerged out of the proto-urban Trypillia settlements, although the living conditions there could still have driven outbreaks of plague throughout the third millennium BC (Rascovan *et al.* 2019). As for the early fourth millennium BC, issues of disease, insularity and the plausibility of regular person-to-person contact without signals of biological reproduction lurk around questions of the scale of ancestry change in Britain in the third millennium BC. One of the obvious arguments for the role of disease is the evidence for the relative isolation of Late Neolithic Britain, meaning its inhabitants may have been culturally and biologically ill-prepared to deal with the effects of plague (Booth *et al.* 2021). However, if plague was already endemic within these communities, and had been for millennia, then this explanation is less plausible.

Mobility

One factor which might have created different dynamics of disease before and after the arrival of groups with WSH-related ancestries in Britain and Europe more widely relates to the different dynamics of mobility in each period. Patterns of IBD segment sharing indicate different dynamics for migrations associated with the people carrying EEF-related and WSH-related ancestries (Allentoft *et al.* 2024b; Ariano *et al.* 2022). Communities carrying EEF-related ancestries, particularly those who dispersed along the Mediterranean and into Atlantic Europe, became relatively reproductively isolated from their source population after they moved (Ariano *et al.* 2022). This seems to have been especially true of groups who moved onto islands. In contrast, later migrations of people carrying WSH-related ancestries resulted in connections being maintained across relatively far-flung communities, with regular movement between them (see Allentoft *et al.* 2024b, fig. 6). The kind of mobility associated with people carrying EEF-related ancestries would mean that diseases like *Yersinia pestis* could have big local impacts occasionally, but that these outbreaks stayed relatively contained. The dynamism in mobility in the third millennium BC would theoretically have made it much easier for diseases like *Yersinia pestis* to spread and reinfect communities repeatedly.

However, this dynamism in mobility does not explain why genetic change in Britain through the late third millennium BC was comparatively large. The genetics of the Early and Middle Neolithic inhabitants of Britain and Ireland suggest a certain level of reproductive isolation (Ariano *et al.* 2022), while insular Late Neolithic cultural developments such as Grooved Ware pottery and henge monuments have been used to suggest that this isolation continued into the third millennium BC (Cleal 1999; Madgwick *et al.* 2019). This relative isolation from populations in continental Europe, combined with possible demographic decline in Britain, may have meant that periodic outbreaks of plague had disproportionate effects on the overall population. Perhaps related to this is evidence for the recent (since 3000 BC) rise in frequency of genetic variants linked to both lighter skin pigmentation and lactase persistence in Europe (Ju and Mathieson 2021; Mathieson *et al.* 2015; Patterson *et al.* 2022). It has been suggested that both of these adaptations are related to vitamin D and calcium deficiency (Mathieson and Terhorst 2022). Milk contains high quantities of calcium and our skin absorbs UV light from the sun to synthesise vitamin D, which is crucial to our ability to absorb calcium. Modelling of the selection pressures for lactase persistence in prehistoric Europe suggests that lactase persistence provided a significant advantage in times of drought, famine or disease, when even marginal effects of dietary intolerance can be fatal (Evershed *et al.* 2022). From the available data, genetic variants linked to lactase persistence rise to high frequency in Britain potentially several centuries before they become common in other parts of continental Europe at lower latitudes (Patterson *et al.* 2022).

Putting these observations together, this might suggest that the selective pressures brought on by drought, famine or disease were higher in Britain than in other parts of Europe, producing more rapid genetic adaptations towards lactose tolerance. Therefore, it is reasonable to speculate that Britain's climate, with relatively lower levels of sunlight, meant that populations were already more likely to have been vitamin D-deficient, and that consequently the impacts of disease may have been more acute, leading to larger-scale demographic changes when populations with greater genetic and cultural resistance to disease arrived. This cannot be the full picture, and there are certainly likely to be a myriad of complex cultural, environmental and social factors at play, but it provides some foundation to explore these factors in more detail. It would be interesting in future to investigate whether there is evidence for similar processes in parts of Europe at higher latitudes than Britain where there is less sunlight, such as parts of Scandinavia and regions around the Baltic.

Conclusions

The maturity of archaeogenetics has meant that methods of analysis have stabilised somewhat and are being used regularly to investigate genetic sex, ancestry and close relatedness in ancient populations. However, methods of analysis continue to advance and explore features of the data that may not have been envisioned previously by archaeologists. This is providing increasing insights into the complexity of demographic changes in prehistoric Britain and Europe more generally. There is now evidence to suggest that at the beginning and the end of the Neolithic in Britain, dynamics of demography and disease helped to precipitate substantial demographic change that was often larger than in other regions of Europe. Genetic results related both to humans and associated infectious diseases hint at complex interactions between past populations where cultural interaction did not always translate into biological connectivity, which forces us to think more carefully about straightforwardly inferring one from the other.

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ACTIVE ARTEFACTS AND MUTABLE IDENTITIES

The role of material things in the formation of the British Neolithic

Julian Thomas

Abstract

The study of whole-genome ancient DNA has enhanced our appreciation of the extent of human mobility in the Neolithic. Unfortunately, this has sometimes come at the cost of a return to culture-historic narratives of 'massive migrations' and abrupt cultural change. Equally, material culture is sometimes still understood as passively reflecting changes of population. In the case of Britain, interactions between Neolithic migrants and indigenous hunter-gatherers may have been more complex and intricate than models of 'population replacement' allow, and artefacts and architecture may have played an active role in the establishment of new communities composed of individuals drawn from different points of origin.

Keywords: Neolithic Britain; material culture; monumentality; archaeogenetics

Introduction

The introduction of whole-genome ancient DNA analysis has had a revolutionary impact on European prehistory, and has dramatically increased the perceived importance of population movement, not least in the beginning of the Neolithic (e.g. Bramanti *et al.* 2009; Haak *et al.* 2010; Kristiansen 2022; Lipson *et al.* 2017). This has certainly been the case in Britain, where a discontinuity in the proportions of Western Hunter-Gatherer (WHG) and Anatolian Neolithic Farmer (ANF) genetic inheritance (Booth, this volume, prefers EEF or Early European Farmer) has been identified amongst human genomes of Mesolithic and Neolithic date, suggesting an episode of 'population replacement' associated with the arrival of Neolithic things and practices from the Continent from the end of the fifth millennium BC onwards (Brace *et al.* 2019, 769). However, some commentators have expressed a feeling of 'two steps forward, one step back', as the contemplation of large-scale displacements of people has sometimes (if not always) prompted an implicit return to culture-historic modes of interpretation (e.g. Crellin and Harris 2020, 39; Furholt 2020, 54). Ironically, this comes just as Gary Feinman and Jill Neitzel (2020, 8) have enjoined us to erase culture history from archaeology altogether, on the grounds that it unavoidably promotes a series of misconceptions about human societies and their material manifestations. They argue that archaeological 'cultures' are understood as holistic packages of normative traits that express the underlying essence of a 'folk'. These can be identified using a

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methodology that employs the similarities and differences between artefactual assemblages to delineate internally homogeneous spatiotemporal units. The assumption is that the human populations thereby defined are equally homogeneous and mutually exclusive, and that their shared identity may be grounded in a biological coherence that prefigures the ethnic identities of the modern world.

In the normative archaeologies of the mid-twentieth century, cultural groupings that had been established using principles similar to those of Linnaean classification were identified as the collective historical actors of the world stage, bringing about abrupt and discontinuous change through processes of invasion, migration and mutual influence (see Crellin 2020, 28–32). These perspectives were formative of our existing understanding of the European Neolithic (Brami 2019, 340), and although the explicit equation of 'cultures' with 'people' has been eroded by the arguments of both processual and post-processual archaeologies, culture-history has arguably endured at a latent level in the way that we still organise our evidence spatially and temporally (Feinman and Neitzel 2020, 3). Thus Martin Furholt (2018; 2021) has drawn attention to the way that some recent interpretations of aDNA results have assumed that widespread material assemblages can be identified with a single cultural group, obscuring more complex manifestations of human identity. It follows that such studies have often favoured models of massive and abrupt migrations, where a more nuanced appreciation of the relationship between people and things might allow us to explore more intricate and protracted social processes.

The legacy of culture history in Neolithic archaeology may therefore be a rather complicated one. Having been alerted to the significant scale of population displacements by archaeogenetics, we may be tempted to employ stylistic affinities in material culture to identify the movements of discrete and substantial groups of people. In doing this, we effectively accept that artefacts and monuments passively reflect the pre-given identities of bounded groups of migrants. Over the past 40 years archaeology has developed the proposition that material things may be active rather than inert, in a variety of different ways. Objects may be employed by people in crafting identities or negotiating social positions for themselves (Hodder 1982; 1992). Alternatively, they may be understood as capable of having effects and consequences of their own, sometimes possessing a kind of agency, or embodying the deferred agency of human beings (Gell 1998; A. Jones and Boivin 2010). Finally, it can be argued that human beings never achieve any outcome in isolation, and that entities of various kinds always find themselves working together in heterogeneous assemblies. In other words, people do not simply act upon dead matter, they always find themselves cooperating with forces and materials within an animate world (Bennett 2010; Jervis 2018). In this contribution I would like to consider how the beginning of the Neolithic in Britain might appear if we recognised that material things represented an active constituent of social processes. In other words, what does material culture *do* in migrating societies? In their recent article, Vicki Cummings and colleagues (2022, 6) affirm that material culture constructs identities and bundles communities together, and I hope to be able to build on that argument. Similarly, I intend to explore the implications of Douglas Price's (2016, 81) observation that a Neolithic transition involving significant movements of people is likely to have been a time of turbulence, risk and instability, in which new patterns would emerge out of flux and chaos.

Pioneer folk migrants, or the intensification of existing relationships?

As David Anthony (1990, 896; 2023, 2) has consistently argued, migration is a social process, generally engaged in by a self-selecting minority rather than entire communities, and often played out over lengthy periods of time. Migration is inherently risky and stressful, more often undertaken by highly motivated people in pursuit of perceived advantages than forced by demographic or environmental pressures. Migrants are generally the young, the disenfranchised, the ambitious and the outcast, rather than those who enjoy positions of wealth and authority in their existing circumstances. These people usually relocate to places about which they have established knowledge, and where they already have existing contacts, developed through visiting, exchange, cooperation or marriage. And as Stefan Burmeister (2000, 540) points out, the migrants who coalesce to form hybrid communities may not share the same original ethnicity. Nor need they all hail from a single narrowly-defined geographical region. Migration rarely fits the stereotype of 'folk movement', in which a complete, bounded social group relocates itself in a single abrupt episode. In this connection it is significant that Lara Cassidy (2023, 159) suggests that the initial Neolithic arrivals in Britain may have been drawn from the entire area between Normandy and the Nord-Pas de Calais. Indeed, persons from an even wider catchment might easily have passed through these points of embarkation.

Igor Kopytoff (1987, 121) provides some especially pertinent observations of how migration facilitates the emergence of new societies out of the 'bits and pieces' of existing ones, through processes of fission and fusion. He notes that migrants may be disgruntled or disinherited people, who leave their home settlement with a handful of companions to establish themselves in more sparsely-populated areas. Here their status as founders confers a position of authority upon them, and they recruit followers, initially on an indiscriminate basis, whom they transform into kin. While we should not imagine that Neolithic systems of kinship and descent were uniform, there are hints that patrilineality and patrilocality were not uncommon (Rivollat *et al*. 2023, 601; Whittle and Bickle 2013, 390). Under such conditions, the possibilities for men in particular to achieve influence and authority are often connected with establishing themselves as lineage founders (King and Stone 2010, 328). It is conceivable that Britain and Ireland might have provided contexts in which ambitious and disaffected individuals within existing Neolithic communities on the Continent might have sought this kind of advancement.

There is now a growing body of evidence that Late Mesolithic Britain and Ireland were not culturally isolated from the Continent in the period following the inundation of the English Channel (as originally argued by Jacobi 1976), and that there may have been sporadic contact throughout the period. For example, Later Mesolithic T-shaped antler axes from southern and western Scotland appear to have affinities in locations around the North Sea Basin and beyond (B. Elliott 2015, 16). Terrestrial Brown-lipped Snails in Ireland have a genetic haplotype that belongs to a lineage found in Iberia, and it has been speculated that they may have been introduced by sea during the Mesolithic (Carlsson *et al*. 2014, 18). The microlithic assemblage from St Martin's Quay in the Scilly Isles is most closely paralleled in northern France, Belgium and the Netherlands, and this may be indicative of maritime interaction around the coasts of Britain in the Later Mesolithic (Garrow and Sturt 2017, 130). Similarly, Bexhill points, a type of microlith found at a number of sites in south-east England, find their closest parallels in northern Spain and north-west France (Lawrence *et al*. 2022, 568). Domesticated cattle bones from the Mesolithic site of Ferriter's Cove in County Kerry appear to date to a pre-Neolithic horizon, again suggesting an episode of contact with the Continent (Woodman 2016, 17). An even earlier appearance of domesticates in Britain is suggested by the disputed (but perhaps now more widely accepted) DNA of wheat from the submerged Mesolithic site of Bouldnor Cliff in Sussex (Smith *et al*. 2015, 999; Watson 2018, 232). Also dated by radiocarbon to the Later Mesolithic is a wooden post with decoration that recalls Breton megalithic art, discovered in waterlogged peat deposits at the Maerdy Windfarm site near Treherbert in Glamorgan (R. Jones 2014).

Many of the jadeitite axes from the Italian Alps that have been found in Britain, such as the Altenstadt/Greenlaw and Durrington types, appear to have been manufactured centuries before the start of the British Neolithic (Pétrequin *et al*. 2008, 270). It is conceivable that they were brought by Neolithic migrants as treasured and already-ancient heirlooms (Sheridan 2007, 25). However, this conflicts with the evidence that there was little 'long-lived transmission of axeheads across the generations' on the Continent, and that they did not remain in circulation for long (Pétrequin *et al*. 2008, 265). Some at least of the axes may have crossed the Channel when they were still new, acquired by Mesolithic communities in exchange transactions. A few of these axes, such as those from the Sweet Track in Somerset (Coles *et al*. 1974) and Cairnholy I chambered tomb in Dumfries and Galloway (Piggott and Powell 1951, 121), have come from closed Neolithic contexts. Since none have been found in clear Mesolithic contexts either, Katharine Walker (2018, 56) prefers to argue that all were deposited during the Neolithic, although she acknowledges that 'definitive Neolithic links are not abundant'. She also suggests that they may have been purposefully deposited in remote parts of the landscape, and this may be characteristic of some aspects of Mesolithic depositional practice (Blinkhorn and Little 2018, 411; Bradley 2000, 154).

None of these indications of pre-Neolithic contact between Britain, Ireland and Atlantic Europe are conclusive, and it is possible to be sceptical about each one individually (Sheridan and Whittle 2023, 177). But taken collectively the balance of probabilities is that there was infrequent and perhaps escalating interaction across the Channel in the centuries before 4000 BC (Garrow and Sturt 2011, 66). Accepting Anthony's (1990, 901) point that migration is most likely to occur when there is contact between donor and receptor regions, we might see the transfer of population between the Continent and Britain as an intensification of existing visiting relationships between communities of different kinds.

Population replacement or intricate inter-relationships?

This raises the question of what the character of the relationship between continental migrants and indigenous hunter-gatherers might have been in the initial centuries of the Neolithic. It is entirely possible that there might have been contact, interaction and even cooperation between the two without their ever having intermarried and produced offspring. This would suggest some kind of deliberate cultural avoidance or proscription of interbreeding on the part of one or other group. However, it is notable that the WHG genetic inheritance of Neolithic people in Britain is rather greater than that amongst the communities in northern and western France which might arguably represent their donor populations. The 14 % WHG component that Cassidy (2023, 157) proposes for Michelsberg populations in the Paris Basin is significantly exceeded by the 22 % WHG for southern British and 23 % for northern British genomes of Neolithic date (Patterson *et al*. 2022, online tab. 5, discussed in Brace and Booth 2023, 130). The Michelsberg figure cited by Cassidy (2023) is in line with the WHG ancestry in genomes from fifth-millennium northern France reported by Maïté Rivollat and colleagues (2020, fig. 2), and those from the chambered tombs of Le Déhus and The Common on Guernsey (Brace and Booth 2023, 134). However, Cassidy does present two

French genomes from the fifth millennium BC that have higher WHG components than this. One of these is from Le Pirou, a Chasséen site on the southern coast of Languedoc. The other came from the causewayed enclosure at Escalles in the Pas-de-Calais and has a WHG ancestry of 24 %, but it has an entirely different set of mitochondrial haplotypes from British Neolithic people, and may therefore be unrelated to British populations (Brunel 2020, 133). It is likely, of course, that hunter-gatherers were continuing to be assimilated by continental Neolithic populations after the start of the Neolithic in Britain, and this appears to have been the case with the Guernsey sites, where WHG ancestry had further increased by the end of the fourth millennium. Selina Brace and Tom Booth (2023, 131) also note that Samantha Brunel and colleagues (2020, 12792) present a series of Middle Neolithic genomes from France that have a WHG ancestry that is more in line with the British examples. One of these is the one from Escalles, noted above, but the others are from areas to the south and east of the Paris Basin (in the Ardennes and Alsace), which may be less directly relevant to population processes on the Atlantic and Channel coasts.

It is also potentially significant that the proportion of hunter-gatherer ancestry amongst Neolithic genomes in Britain appears to vary on a geographical basis. Especially high concentrations occur in both western and north-eastern Scotland, including Orkney and Caithness, where genomes from Holm of Papa Westray North, Isbister and Tulloch of Assery B all have WHG ancestry in excess of 30 %. Those in south-east England (Whitehawk, Cissbury and Coldrum) are all over 25 %, while those in the areas around the Bristol Channel are a little lower (Brace *et al.* 2019, supplementary fig. S8). This might be argued to represent the arrival of communities with a greater WHG genetic inheritance, from different parts of the Continent, in separate areas of Britain. But alternatively, we might expect more WHG ancestry to have been acquired in the area of initial contact and the very slow establishment of Neolithic communities (the south-east of England), and where incomers arrived two to five centuries later, after protracted interactions with native people (western Scotland and Orkney). The gradual assimilation of hunter-gatherers in Britain would then be an extension of processes documented throughout much of Europe: 'population replacement' would actually represent a very unusual phenomenon (Tsoupas *et al.* 2024, 7).

Brace and colleagues (2019) point out that only a small number of British Neolithic genomes, recovered from the west of Scotland, appear to have had hunter-gatherer ancestors within their past ten generations. At Raschoille Cave near Oban two individuals appear to have had WHG ancestors one to seven generations in the past. These individuals are dated to 3350–2950 cal BC (95 % probability), so the inbreeding probably occurred between 3725 and 2975 BC (Bownes 2018, 180; Susan Greaney *pers. comm.*). This suggests that coexistence and sporadic interbreeding between Mesolithic and Neolithic communities may have continued in some areas through much of the fourth millennium BC (Mithen 2022, 14; see also Griffiths 2021, 36). Nonetheless, this may have been the exception rather than the rule, and if there was more widespread merging of migrant Neolithic and local forager populations it may have taken place quite early within the British sequence, generations before the dates assigned to most British Neolithic genomes (Brace *et al.* 2019, 768). This might mean either that a large proportion of a very small hunter-gatherer population was swiftly assimilated by much more numerous incomers, or that unions with local people were principally sought at an initial stage, to build up viable populations, acquire local knowledge, provide legitimacy for settlement on the part of arrivals, and to swell the kin and followers of aspiring lineage heads. If such connections became progressively more exceptional as time went on (represented by the likes of Raschoille Cave, which may not be entirely unique), it may be that continental Neolithic migrants were not so much 'strangers in a strange land' as 'cuckoos in the nest', and that Mesolithic groups were subsequently marginalised as migrant numbers grew.

These possibilities appear to be negated by the work of Rivollat and her colleagues (2020, 3–8), who employed the progressive breakdown of longer strands of DNA over time to calculate the number of generations since Neolithic populations in Britain and Ireland had experienced admixture with European hunter-gatherers. They estimated that this admixture had probably taken place around 5376 BC in Scotland, 5103 BC in Ireland, 5030 BC in England and 4347 BC in Wales. In practice, this is more likely to have taken place over a period rather than as a discrete episode of population mixing. That is, it represents a palimpsest of numerous unions rather than a single event of fusion (Brace and Booth 2023, 126). On the basis of these calculated dates, Rivollat and co-authors (2020) argue that these groups had already acquired all of their hunter-gatherer ancestry before they arrived in these islands. However, there may be a problem with this analysis. Rivollat and colleagues (2020, fig. 5 caption) calculated the dates when admixture had taken place 'according to the oldest date of the radiocarbon interval for each group' across which the genomes that had been investigated were dispersed. Yet in practice the genomes are distributed throughout this chronological interval, and there is a preponderance in the later fourth and third millennia BC. Calculating admixture from the *start* of the radiocarbon interval will thus give an inaccurately early estimate of introgression. An alternative is to calculate the *mean* radiocarbon values for the dated genomes cited in Rivollat and colleagues' (2020) table S10. These are 3610 BC for Ireland, 3492 BC for England, and 3351 BC for Scotland.

The dates for Wales are missing from table S10, but using the radiocarbon data from Brace and colleagues (2019, supplementary data 6) gives a mean radiocarbon date of 3133 BC. Adding the year estimates that Rivollat and co-authors (2020, tab. S17) employ based on the number of generations since admixture then gives admixture dates of 4923 BC for Ireland, 4779 BC for Scotland, 4767 BC for England and 4400 BC for Wales.

It is instructive to repeat this procedure for the French Middle Neolithic admixture estimates cited by Rivollat and colleagues (2020). These produce a mean admixture date of 5061 BC, appreciably earlier than the dates for Britain, although interestingly less so for Ireland. Bearing in mind that these estimated dates represent an aggregate of the timings of multiple episodes of interbreeding between hunter-gatherer and continental Neolithic populations, over the period since the first incursions of Near Eastern populations into Europe, the contrast between the French and British figures is significant. It is surely arguable that the latter document processes of admixture that continued for longer, and which extended into the period when these populations found themselves in England, Scotland and Wales.

The precise character of interactions between established Mesolithic groups and Neolithic arrivals may not have been uniform, and may have varied from region to region, since the scale and speed of incursions may have differed. In some areas there are indications of protracted coexistence. Seren Griffiths (2014, 24) constructed a Bayesian radiocarbon chronology for northern Britain which suggested that hunter-gatherer ways of life persisted in the Pennine Hills long after Neolithic activity began in the Yorkshire Wolds and the Vale of York. Steven Mithen (2022, 58) discusses a series of different potential scenarios to account for the apparent survival of Mesolithic communities until well into the fourth millennium BC in western Scotland. In Wiltshire, Kurt Gron and colleagues (2018, 134) have hypothesised that the deposits in the large pit known as the Coneybury Anomaly, which dates to the thirty-eighth century BC, may be a product of cooperative activities on the part of hunting and herding communities operating in different parts of the landscape. There is more widespread evidence for the re-use of Mesolithic sites of various kinds early in the Neolithic, which may indicate that they were recognised as 'ancestral places', contradicting the notion of absolute cultural discontinuity between the two. Chambered tombs were sometimes constructed over places of Mesolithic occupation or shell middens (Britnell and Savory 1984, 41; Saville 1990, 14; Scott *et al.* 1963); Neolithic burials were introduced into caves and shell middens containing Mesolithic deposits (Milner and Craig 2009); Mesolithic pits and pit alignments were recut during the Neolithic (Brophy and Noble 2011; Brophy and Wright 2021, 23); conspicuous landscape features such as the Fir Tree Field shaft on Down Farm in Dorset attracted activity across the boundary between the two periods (Green and Allen 1997). At Windy Habour on the Fylde Peninsula in Lancashire there are indications of the continued occupation of locations across the Mesolithic/Neolithic boundary (F. Brown 2020). This preoccupation with places and structures that might be decades or centuries old might potentially have represented a form of legitimation on the part of newly-formed and hybrid communities. Indeed, it is entirely possible that such groups might have sought to claim *both* descent from indigenous ancestors and connections with prestigious overseas lineages. So although the material equipment of Neolithic communities in Britain and Ireland was primarily derived from continental sources, their cultural inheritance also included a familiarity with place and landscape that had been accumulated by hunting people over many centuries.

One reason for caution regarding the argument that 'the appearance of Neolithic practices and domesticates in Britain circa 4000 BC was mediated overwhelmingly by immigration of farmers from continental Europe' (Brace *et al.* 2019, 769) lies in the possibility that migrants may have filtered into the islands over a considerable period, rather than in an abrupt and bounded colonisation event. This much is suggested by the strontium isotope values from human remains recovered from the megalithic long cairns of Whitwell in Derbyshire and Penywyrlod in Powys (Neil *et al.* 2017; 2020, 10). Several of the Whitwell individuals and one of the Penywyrlod ones produced values that are rarely found in Britain, and are more in keeping with biosphere strontium isotope values found in Lower Normandy and Brittany (Neil 2022, 214). Yet the bones concerned, in both cases, date to the period at the end of the thirty-eighth and the start of the thirty-seventh centuries BC, three centuries or so after the first Neolithic activity in Britain. This implies that the process of migration was not abrupt, and that no more than a few hundred people of continental origin may have been arriving in any given year, although the rate was probably not constant throughout. None the less, a 'massive migration' (Furholt 2018) may not have been involved. While protracted, moderately-scaled movement might have involved the establishment of enduring migration streams (Anthony 1990, 902), it is interesting that it has been argued on the basis of the aDNA evidence that there was little continuing intermarriage across the Channel during the Neolithic (Brace and Booth 2023, 137). Equally, little Early Neolithic material culture of British or Irish origin occurs in northern France or the Low Countries. This may suggest that there was little return migration, which in turn implies that the process was rather unstructured, composed of innumerable individual journeys rather than repeated movements back and forth between established foci.

Recently, Nick Patterson and colleagues (2022, 591) have used runs of homozygosity (possession of identical forms of a particular gene) as a means of calculating the effective size of the British population at various stages in prehistory. Their estimates (an effective population size of between 2500 and 10,000 individuals) are appreciably lower than those that might be achieved by other means (e.g. Müller 2015), although Brace and Booth (2023, 137) suggest a much higher census population of around 100,000 people for fourth millennium BC Britain. This still implies a population density for Earlier Neolithic Britain which is very much lower than figures for horticulturalists that have been documented by ethnography in various parts of the world (for example, P. Brown and Padolefsky 1976; Steward and Faron 1959). If this is the case, we should be very wary of using arguments based on population pressure and resource stress to explain social and economic developments during the period, since these would appear to have been social units that were operating well below the carrying capacity of the landscapes in which they established themselves. Equally, if this density of occupation also applied to northern France and Belgium, it would be very difficult to claim that the movement of population across the Channel had been forced by pressure on land. Alasdair Whittle, Frances Healy and Alex Bayliss (2011, 858) argue that 'there is probably no compelling evidence for unmanageably populous landscapes along the breadth of the continent facing Britain', but it would be instructive to apply the methodology of Patterson and co-authors (2022) to genomes from these areas. Collectively, these arguments suggest that small numbers of people drawn from dispersed locations across northern France and Belgium filtered into Britain in a relatively unstructured way from the forty-first century onwards, initially enjoying fraternal relationships with local hunter-gatherers, with whom they had long-established but diffuse relationships. From the point of view of those who sought to benefit from these movements the crucial imperative at this point would have been to bind these various disparate population fragments, incomers of diverse origin and indigenes, into coherent social entities. This, perhaps, explains the key role of many material things in the primary phases of the Neolithic.

The place of material things

Since Grahame Clark reflected on the 'invasion hypothesis' afflicting British prehistory in 1966 it has often been noted that while close continental parallels can be cited for specific artefacts and monuments in Neolithic Britain, they tend to get mixed up and hybridised (Clark 1966, 178; see also Whittle 1977, 241). They are also sometimes anachronistic, having been constructed or employed some while after the demise of their continental models. Equally, they are sometimes selected from more extensive assemblages. For instance, Hembury pottery of Norman affinity is found with leaf-shaped arrowheads that may be drawn from the Michelsberg (Anderson-Whymark and Garrow 2015, 70), while transepted chambers of south Breton affinity were introduced into long cairns that might be more at home in Normandy, although the British monuments are later than either (Scarre 2015, 81; Whittle *et al.* 2022, 271). Diverse strands and connections were drawn on in order to fulfil localised requirements, and this may be connected with both the existing Mesolithic background and the mixing and merging of people with different continental ancestries. As Vicki Cummings and Oliver Harris (2011, 364) argued, this was a not a period of 'pure' identities, but of 'mixtures of mixtures'.

Alistair Barclay (2008) notes that the earliest pottery in south-east England is composed almost exclusively of carinated forms, neglecting the other elements of Chasséo-Michelsberg assemblages. In the south-west, too, carinated forms were only gradually supplemented by other north French Middle Neolithic forms (Barclay *et al.* 2018, 14). I have suggested elsewhere that in the primary Neolithic context carinated vessels served as 'boundary objects', recognisable across cultural boundaries, and providing a common framework for cooperation and integration in contexts involving hospitality and the sharing of food (Thomas 2022, 518). While culture-historic approaches present the form and decoration of pottery vessels as a manifestation or reflection of the identities of extant social groups, my suggestion is that this distinctive style of ceramics had an active role in the formation of new communities. Similarly, large timber halls, which have few precise continental parallels (and appeared after the decline of longhouse villages in northern and western Europe), manifested first in south-east England and later occurred in Oxfordshire, the Welsh borders, north Wales and the Scottish Lowlands. Over time they became progressively more massively constructed, shorter-lived and more likely to be deliberately destroyed by fire (Thomas 2013, 296–306). They may or may not have been built by classic Lévi-Straussian 'house societies', but this outbreak of what Susan Gillespie (2000, 34) calls 'housiness' demonstrates an imperative to construct not simply a physical structure but a moral community, presided over by a household head. It is interesting that Barclay and Harris (2017, 230) have suggested that large Early Neolithic pits like those at Roughridge Hill in Wiltshire, Rowden in Dorset and Coneybury Hill (also in Wiltshire), perhaps the products of large feasting events, may have served a similar integrating function in areas that lacked halls, since as we have seen, Gron and colleagues (2018, 137) have argued that the Coneybury pit marked a meeting between Neolithic and Mesolithic groups. Might such a feast have represented a demonstration of largesse on the part of an aspiring leader? And might some of these other pit sites also document gatherings at which disparate communities were brought together, whether these were partly of local origin or drawn principally from multiple continental sources?

Figure 1. Rock crystal blade from Dorstone Hill, Herefordshire (photo: Adam Stanford, Aerial-Cam).

Other artefacts, too, may have had a role in building communities, and structuring social relationships. Rock crystal, from sources in Wales and Ireland, has been found at several timber halls in England, Wales and Ireland (such as Llandygai, Parc Cwbi, Lismore Fields, Corbally and Ballyglass) and early mortuary sites including Achnacreebeag, Parc le Breos Cwm and Kilnagarns Lower. It may indeed have formed one element of a network of contacts between nascent Neolithic social groups around the Irish Sea (whatever their composition), in a period prior to the emergence of causewayed enclosures and decorated pottery. At Dorstone Hill in Herefordshire, it had been worked and deposited in pit contexts associated with the dead, in and around a group of three long mounds that had each been built on the footprint of a timber hall destroyed by fire (Ray *et al*. 2023) (Figure 1). There was extensive debris from the knapping of prismatic crystals on the site, especially in a pit located immediately beside one of the long mounds, but it was rarely worked into formal artefacts, in contrast with the worked flint that was recovered from

Figure 2. Rock crystal working debris from Dorstone Hill, Herefordshire (photo: Irene Garcia Rovira).

the same contexts (Figure 2). Later, rock crystal fragments were also deposited in the ditch of a causewayed enclosure located on the same hilltop. Nick Overton and colleagues (2023, 70) suggest that the clarity, refraction of light and triboluminescence associated with rock crystal created distinctive events that drew people together and forged links between the living and the dead.

Monuments that made relationships

It is in the light of these arguments that we can briefly reconsider the timber mortuary structures found beneath long barrows in Britain, Denmark and northern Germany (Madsen 1979). It may be a mistake to see these as part of a coherent and integrated material assemblage taken from one area to another by a migrating population. Rather, they speak to us of wider networks of interaction that nonetheless provided materials that could be employed in the foundation and legitimation of social groups. Many of these structures are composed of a massive oak trunk that has been split in two, and the halves placed facing each other at the two ends of a linear space reserved for the deposition of human bodies, often if not always initially in a fleshed condition (Figure 3). Indeed, at Giant's Hill 2 in Lincolnshire only a small, compact mass of human bone was present in the chamber, presumably brought to the site in a disarticulated state (Evans and Simpson 1991, 14). This almost 'tokenistic' deposit suggests that in some cases the mortuary function was subsidiary to the monumental role of the site, complementing or activating a structure that was more than simply a mortuary facility. Sometimes they form part of a suite of pre-barrow features, including façades, post avenues and forecourts. However, in several British examples, such as Streethouse in North Yorkshire and Haddenham in Cambridgeshire, the posts had been standing for lengthy periods before the chamber was constructed and bodies introduced (Noble 2017, 157). Indeed, Whittle and colleagues (1991, 71; 2007, 104) perceptively suggested that the uprights at Wayland's Smithy might initially have represented a 'shrine' rather than a chamber as such.

While the post arrangements are closely similar in Britain and Scandinavia, the long mounds constructed over them are often quite different in form, and the mortuary practices conducted inside are also distinct. Where the Danish chambers generally only contain a single articulated burial, the British examples are dominated by multiple rearranged and in some cases incomplete skeletons (Ahlers 2018, 214; Rassman 2010, 7). Moreover, some of the British structures were incorporated into round barrows, long cairns, round cairns or low oval mounds, while the Danish examples at Konens Høj, Hedegårde and Søgarde appeared to have been covered by no major mound at all (Madsen 1979, 305–8). Their unity lay in the primary form, and what happened to them afterwards was quite variable.

Figure 3. Split-trunk mortuary structure beneath the eastern long mound, Dorstone Hill, Herefordshire. The postholes are the deeper features at either end of the linear mortuary feature, which is surrounded by a U-shaped ditch (photo: Adam Stanford, Aerial-Cam).

Richard Bradley (2020, 8) has recently drawn attention to the difference between those monuments whose structural histories converge on a homogeneous form, and those that diverge from initial similarity. It is interesting that although he cites earthen long barrows as an example of the former, in which pre-barrow structures of diverse kinds (façades, fore-structures, arrangements of bays, simple wooden chambers, pit graves) are covered by rather similar linear mounds, split-post mortuary structures can be the first step toward a variety of monumental structures. In this respect, we might compare these structures with the Carinated Bowl vessels. In both cases, the object is something immediately recognisable around which a community can cohere. They might be employed in different ways in different settings, and the composition of the groups that used them could be highly variable, in terms of both genetic inheritance and cultural identity.

We can compare this material with Vicki Cummings and Colin Richards' treatment of dolmens in their book *Monuments in the making* (2021). They suggest that dolmens, chambered tombs distinguished by a massive capstone supported by a series of orthostats, were in the first instance installations of display and wonder, to which human bodies were later added. As with timber mortuary structures, Cummings and Richards (2021) note that dolmens might eventually be incorporated into other structures of various kinds. For example, recent excavation by the author, Keith Ray and Nick Overton has demonstrated that the massive stone chamber within the Cotswold-Severn long barrow of Arthur's Stone in Herefordshire was originally a free-standing dolmen surrounded by a 'doughnut'-shaped ring of coarse, cobbly cairn material that did not cover the capstone. Later, the long cairn with its structural walls of fine, quarried sandstone was constructed around this chamber, with a blind forecourt facing southward where the dolmen had opened to the north (Figure 4). And as with the split-post 'shrines', mortuary practice in dolmens was a function that was attracted to already-existing structures. The flat, cloven inner sides of the dolmen stones are argued to have formed a permeable membrane through which the

Figure 4. Excavation of Arthur's Stone, 2023. The 'doughnut'-shaped cairn surrounding the dolmen chamber is visible in the upper left of the picture; the walling of the surrounding long cairn can be seen bottom left (photo: Adam Stanford, Aerial-Cam).

substance of bodies was absorbed, lending vibrancy and life-force to the monument (Cummings and Richards 2021, 170). In a similar way, the cloven-trunk structures were also architecture that was intended to be seen. But like the dolmen, the bark–outside, heartwood–inside arrangement could receive the substance of rotting bodies, incorporating it into the architecture. Dolmens and timber pairs were constructed early in the Neolithic, and rendered the materials of the earth and the forest in striking and unfamiliar ways. Later, both absorbed the substance of very particular groups of people, forming an indissoluble connection between lineage and the earth.

As Chris Fowler (2022, 84) has recently argued, the architecture of megalithic tombs does not simply reflect kinship amongst the deceased, it articulates it (see also Cummings and Fowler 2023). Indeed, we could argue that to some degree it brought kinship into being, by instituting a community of founding ancestors, from whom a social unit in the process of concrescence might reckon its descent. At Hazleton North, it is arguable that such a lineage had been first established in the generation before the construction of the tomb, and that the use of the monument both celebrated and reinforced the emerging group's identity, even as it continued to absorb outsiders (Fowler *et al.* 2021, 586). In this sense, the tomb and the lineage make each other. Like Hazleton, other chambered cairns and long barrows in Britain and Ireland in which genetic relatedness has been identified amongst those buried together (such as Fussell's Lodge, Trumpington Meadows and Primrose Grange) all date to the period from the end of the thirty-eighth century BC onwards (E. Elliott *et al.* 2023, 204). As further evidence accumulates it will be interesting to see whether there is variation in this pattern: might earlier tombs contain persons who were entirely genetically unrelated, for instance? Or might we see the exclusion of people who were not descended from key ancestors later on?

Conclusion

The enduring influence of culture history on the archaeology of the Neolithic means not only that we often imagine migration to be a sudden event rather than a slow process, affecting entire social groups rather than motivated individuals, and forced by climatic, population or environmental imbalances rather than encouraged by perceived advantages and opportunities. It also often implicitly suggests that material things are a reflection of already established identities. But if the beginning of the Neolithic was a chaotic, messy, risky period in which new people from different locations were slowly filtering into the land, meeting up and forming unstable associations (including with local people), trying out new ways of living, what then would have been the role of material things? The artefacts and architecture that were borrowed from continental sources in these early decades and centuries were a 'cut down' or minimal Neolithic assemblage, and what they appear to have in common is the capacity to draw people together and forge new social identities. Timber halls and 'shrines', pottery vessels, rock crystal and early megalithic structures were all active in bringing people together, often in performances and gatherings of various kinds. The earliest Neolithic in Britain did not consist of a simple transfer of existing Neolithic things and practices: it was crafted out of people, animals and things.

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A PROVISIONAL MODEL FOR THE MESOLITHIC–NEOLITHIC TRANSITION IN BRITAIN

Alasdair Whittle

Abstract

I sketch notes towards the outline of a possible model for the Mesolithic–Neolithic transition in Britain, with reference also to the Early Neolithic sequence in Ireland. I propose an overall gradualist model, in the context of a resetting of debate and research questions in the wake of recent game-changing isotopic and aDNA investigations. I envisage enhanced connections between Britain and Ireland on the one hand and the adjacent continent on the other in the later fifth millennium cal BC, rather than distinct episodes of contact. This was the bow wave for sustained migration and colonisation from the forty-first century cal BC onwards. I caution against seeing a single migration event, and the process may have played out over a period of time. Within an overall gradualist framework, I note various proposals in the literature for some kind of minimal earliest Neolithic, but I think these suggestions can be over-played, with differences in scale mistaken for absence. The pace and visibility of things seem to pick up further by the thirty-eighth century cal BC, at a time when there are still varied possible signs of individual and group migration.

Keywords: Britain; Ireland; Final Mesolithic; Early Neolithic; migration events; gradual change

Questions for the future

Long archaeological debate about the overall character of the adoption of Neolithic lifestyles in Britain, and beyond across Europe as a whole, appears now to have been settled. What Kristian Kristiansen (2014; 2022) has called the Third Scientific Revolution has seen to that. First, isotopic analyses since around the turn of the millennium (Schulting 2008; Schulting and Richards 2002) and then, decisively over the last decade, aDNA investigations (from a much longer list: Brace and Booth 2023; Brace *et al.* 2019; Cassidy 2023; Cassidy *et al.* 2016; 2020; Olalde *et al.* 2018; Reich 2018; and see Booth, this volume) have demonstrated that it was incoming people who did the heavy lifting in the establishment of new lifestyles and practices. Those who proposed a major role for indigenous communities in this process have been proven wrong (myself included, in the 1990s and 2000s: Sheridan and Whittle 2023, 170; Whittle 1996; 2007; cf. Ray and Thomas 2018; Thomas 2013), and those who argued consistently for colonisation as the overall dominant process (Rowley-Conwy 2011; Sheridan 2003; 2007; 2010; Sheridan and Schulting 2020) have been shown to be right.

This shift, however, does not serve to end debate, but rather to reset it, and many questions, some old and some new, remain. Where did new people come from, and why?

In D. Hofmann, V. Cummings, M. Bjørnevad-Ahlqvist and R. Iversen (eds) 2025, *The early Neolithic of Northern Europe. New approaches to migration, movement and social connection*, 113–124. Leiden: Sidestone Press.

Can different sources and strands be teased out across Britain, and indeed Ireland? What was the character and density of indigenous communities in the centuries leading up to the onset of the Neolithic, and does their evidently low input into Early Neolithic genetic signatures obviate significant contributions in terms of knowledge of the landscape and existing resources? Given that many aDNA investigations have been carried out within a rather broad and imprecise chronological framework, what were the timescales involved? When did new people, things and practices appear, and did they do so all at once? If there were continuing migration streams, for how long did they go on? What does a more detailed picture of the Mesolithic–Neolithic transition and the subsequent development of the Neolithic in its early centuries look like, as opposed to the broad-brush picture of colonisation as the dominant process overall? On what should future research be concentrating? This paper advocates continuing attention to the detail, not least of sequence, and proposes, provisionally, a gradualist model of change and development.

Given my own involvement in helping to roll out chronological revolution (Bayliss 2009) since the early 2000s, in close cooperation with Alex Bayliss, Frances Healy and many others (Bayliss and Whittle 2007; Whittle 2018; Whittle *et al.* 2011), it will come as no surprise that attention to the detail of the sequence is one of my principal interests (though not the only one). From the first pilot study on a small sample of southern British long cairns and barrows (Bayliss and Whittle 2007) to the wider study of the chronology of causewayed enclosures in southern Britain and Ireland, and of the accompanying broader Early Neolithic context (Whittle *et al.* 2011), came the realisation that through formal chronological modelling in a Bayesian framework date estimates for Early Neolithic monuments and other activity could be achieved to the scale of centuries, half-centuries, and even generations or decades — if all went well and if robust procedures (Bayliss 2015; Bayliss *et al.* 2007; 2016) were rigorously followed. It is probably fair to say that for Britain high-precision estimates have been most successful from the thirty-eighth century cal BC onwards, and it should be our ambition to extend those to earlier times.

The Bayesian process is iterative, and further studies have both filled in spatial gaps left by *Gathering Time* (Whittle *et al.* 2011), principally in the Midlands and the north of England (Griffiths 2011; 2021), and supplied further estimates for some western regions and for Ireland (Griffiths 2022; McClatchie and Potito 2020; McClatchie *et al.* 2014; Smyth *et al.* 2020; Whitehouse *et al.* 2014; see also Whittle 2024b). An upgrade of *Gathering Time* for England and Wales is underway, in collaboration with Alex Bayliss and Frances Healy, and with wonderful support across the whole archaeological community, not least the commercial sector, which has enabled hundreds of new radiocarbon dates to be tabled. So far we have published revised date estimates for enclosures themselves (Whittle *et al.* 2022; 2024). Wider revisions for the whole Early Neolithic context in England and Wales will follow in due course. For that reason, what I sketch here below is personal and provisional, and subject to alteration and correction as formal remodelling develops, but I hope it has some predictive value.

Outline of a personal and provisional model

Table 1 sets out the main features of the sequence as I interpret things in advance of the remodelling described above. My principal focus here runs from the forty-first to the thirty-seventh century cal BC, but the later fifth millennium cal BC is also of key interest; the thirty-sixth century cal BC is also relevant though I do not have space here to treat it in full. It is also useful to take a longer view and cast an eye back as far as the later sixth millennium cal BC and the earlier fifth millennium cal BC. That brings in the first farmers of the adjacent continent, as well as the last millennium of the Mesolithic in Britain, which Chantal Conneller (2022) has labelled the Final Mesolithic (for Ireland, see Cooney 2023; Warren 2022; Woodman 2015). Having taken almost a thousand pages to set out our findings in *Gathering Time*, my treatment here is necessarily extremely brief and very selective. I have arranged it chronologically.

The later sixth millennium cal BC

Earliest LBK communities reached the Rhine, perhaps in the fifty-fourth century cal BC, though the precise date is still a matter for debate (Bánffy *et al.* 2018; Denaire *et al.* 2017; Jakucs *et al.* 2016; Strien 2017), and were present in Limburg in the southernmost Netherlands perhaps from *c.* 5300 cal BC onwards (Van Wijk and Amkreutz 2022) and in parts of the Paris Basin soon after (Dubouloz 2003). Though there are signs of contact with Late Mesolithic communities in the lower river valleys and coastal estuaries of the Netherlands, there is no sign of any contact with Britain, and LBK life appears to have been concentrated into particular parts of the landscape (see Van Wijk and Amkreutz 2022 for the Graetheide in southern Limburg). I am very suspicious of the sedimentary aDNA results from Bouldnor on the south coast of England, which could suggest cereal cultivation *c.* 6000 cal BC (Smith *et al.* 2015; cf. Calloway 2015), a date substantially earlier than even the most optimistic informal estimates for the start of the LBK, and broadly equivalent to the arrival of Starčevo-Körös populations in northern Serbia and southernmost Hungary. It is worth noting, however, the recent claim for cereal cultivation in north-west lowland Poland as far back as the fifty-eighth or fifty-seventh centuries cal BC, before the arrival of established LBK communities (Czerniak *et al.* 2023).

Date	*Contacts and processes*
Later 6th mill. cal BC	LBK: no visible contact (Bouldnor too early, and problematic).
Earlier 5th mill. cal BC	BVSG/Cerny: no visible contact (??Old Quay, St Martin's, Scilly, if not much earlier or later).
Later 5th mill. cal BC	? Phase of enhanced contacts (one- or two-way?): including Ferriter's Cove, Bexhill, Maerdy, Achnacreebeag pot. Michelsberg-northern Chasséen etc. expansion (including enclosures), in area where aDNA could suggest most dense contacts with Britain and Ireland.
41st century cal BC onwards	Start Neolithic things and practices in SE Britain, acc. GT 1.0 (subject to revision by GT 2.0). Time-transgressive spread to W and N (subject to revision by GT 2.0); revised estimates already for Wales and NW England; note late arrival in Orkney (Bayliss *et al*. 2017).
41st–39th centuries cal BC	For some, 'minimal' or even 'invisible' earliest Neolithic. Founder lineages? First monuments. Small-scale cereal cultivation?
38th century cal BC onwards	More frequent construction of barrows and other constructions related to/involving the dead. Ongoing migration streams? GT 1.0 'surge' in material connections and innovations. More visible signs of agriculture.
37th century cal BC	Rapid spread of enclosures in S Britain from late 38th cent. Simple earliest forms, then more complex subsequently. Some kind of ancestral connection with N France? Regional decorated pottery styles.
36th century cal BC	Peak of enclosure use. Archaising forms of burial monuments. Beginnings of shifts/decline in agriculture?

Table 1. Summary outline of suggested contacts and processes. (GT 1.0 = *Gathering Time*: Whittle *et al*. 2011; GT 2.0 = ongoing revision for England and Wales (see text)).

The earlier fifth millennium cal BC

At this time, Neolithic settlement in the Paris Basin on the adjacent continent expanded further, whatever the details of the chronology (Praud *et al*. 2018, fig. 55). By the Cerny phase, there were Passy-style monuments in Normandy, for example at Fleury-sur-Orne *c*. 4700 cal BC (Rivollat *et al*. 2022). Though the chronology is still uncertain in detail, Neolithic monuments also appeared in Brittany at some point in the earlier fifth millennium cal BC (Laporte, this volume; Scarre 2011). New aDNA evidence indicates that the populations of Hoëdic and Téviec, probably dated within the first half of the fifth millennium cal BC, were still genetically separate from the incoming farming population (Simões *et al*. 2024). Though there is evidence in the lower river valleys and coastal estuaries of the Netherlands of step-by-step acculturation and adoption of some Neolithic practices by local, indigenous communities (Amkreutz 2013; Dreshaj *et al*. 2023; Louwe Kooijmans 2007; Raemaekers 2014), there are still no signs in Britain or Ireland at this date of contact (but see below, for one possible qualification) or adoption.

The later fifth millennium cal BC

It is in this timespan that things start to get interesting for the process of change in Britain and Ireland. We are hampered by poor chronology for the whole of the Final Mesolithic in Britain, and especially for its second half, though some recent regional projects could give grounds for greater optimism. The well-known and much discussed example of Ferriter's Cove in south-west Ireland (Woodman *et al*. 1999) is widely agreed to indicate short-lived contact from or with the continent in the middle or later fifth millennium cal BC. In Alison Sheridan's much published but little varying model of successive strands of Neolithisation (Sheridan 2003; 2007; 2010), that episode is indicative of the prevailing isolation of Britain and Ireland in the Final Mesolithic, and was succeeded by a Breton, Atlantic strand of probably small-scale movement from Brittany at a time of perceived social disruption, manifested in the building of a scatter of Breton-style monuments with polygonal chambers in parts of western Britain (cf. F. Lynch 1975), including at Achnacreebeag in Argyll; there, a secondary phase of the simple monument contains a decorated pot claimed to be of Late Castellic style, potentially either later fifth or earliest fourth millennium cal BC in date.

Previously, discussion in *Gathering Time* (Whittle *et al*. 2011, chapters 14–15) and elsewhere has countered that an identifiable Breton strand is implausible, and too early. The identification of diagnostic Breton style among simple monuments is problematic, and the Achnacreebeag pot may better be seen as part of a regional style of decorated bowl pottery, as proposed long ago by Graham Ritchie (1970) and Audrey Henshall (1972). This sceptical view also doubts an early date for the enclosure and its associated material culture at Magheraboy (Carlin and Cooney 2017; Cooney *et al*. 2011; see also Whittle *et al*. 2024, fig. 4). Given the apparently wide distribution of other instances of Late Castellic pottery, however, including in north-west Spain, it is not impossible that the Achnacreebeag pot represents some kind of contact after all. I would prefer now to add it to a list of other possible indicators of contact between Britain and Ireland on the one hand and the adjacent continent on the other, in the later fifth millennium cal BC: a phase of perhaps intensifying contacts rather than separate or distinct episodes. There is not space here to discuss all the possible examples in detail, but the list includes not just Ferriter's Cove and Achnacreebeag, but also claims (much disputed, it should be noted: cf. Behre 2007) for later-fifth millennium cal BC upland cereal cultivation in north-east England (Albert and Innes 2020; Waddington 2021) and perhaps north-west England (Innes *et al.* 2024), microliths with continental affinities at Bexhill in East Sussex (Lawrence *et al.* 2022), the late-fifth millennium cal BC Maerdy post in south Wales decorated in a style akin to that found on Breton megaliths (Ray and Thomas 2018, 52, fig. 2.1), claims for early transfers of jadeitite axes (Ray and Thomas 2018, 308), the continental-style microliths at Old Quay, St Martin's, Scilly, though these could be significantly earlier than the later fifth millennium cal BC (Garrow and Sturt 2017), and finally T-axes of continental inspiration in insular Mesolithic contexts (Conneller 2022, 383–4).

This suggested phase of increased contact also coincides with the further expansion of Neolithic settlement on the adjacent continent (Praud *et al.* 2018, fig. 55), represented by northern Chasséen, Michelsberg and other cultural groups in northern France in the Néolithique moyen II; the chronology of the start date of this is still imprecisely established, but perhaps falls *c.* 4300 or 4200 cal BC. There seem to be more sites in the landscape, including enclosures in a range of sizes (Dubouloz *et al.* 2023; Lietar 2016), now appearing on the edges of interfluves as well as in river valleys themselves. There are also processes of settlement expansion in the Low Countries (Crombé 2005; Crombé and Robinson 2014; Crombé and Vanmontfort 2007), the now fuller adoption of agriculture and pottery in the lower river valleys and coastal estuaries of the Netherlands, and continuing if not intensifying monument construction in Brittany. This seems to me to give a plausible context not only for claimed cross-Channel contacts in the later fifth millennium cal BC, but also for what was to follow from the forty-first century cal BC.

The forty-first century cal BC onwards

According to the results of *Gathering Time*, Neolithic things and practices — and in the light of aDNA results I would now gloss that as Neolithic people, things and practices — appeared in Britain probably from the forty-first century cal BC (Whittle *et al.* 2011, chapter 14). A time-progressive process was proposed, beginning in the south-east and spreading to the north and west, over two to three centuries. Whether that pattern stands up to the modelling of further dates remains to be seen. Other modelling has already indicated start dates for the Neolithic in some regions earlier than those proposed by *Gathering Time*, for example in the north-west of England and in south Wales and the Marches (Griffiths 2021; 2022; Ray *et al.* 2023). Our initial models for the spread of the later phenomenon of enclosures proposed a clear east–west spread, whereas revised models now strongly suggest widespread early occurrences in southern Britain, from the turn of the thirty-eighth century cal BC, in areas within reach of the coast, and then rapid spread inland (Whittle *et al.* 2022; 2024). Time will show if something similar proves to be the case with the remodelling of the timescales for colonisation and establishment. It seems unlikely that the whole edifice proposed by *Gathering Time* will alter. Overlap between the Final Mesolithic and Neolithic has been demonstrated in Yorkshire in the earliest centuries of the fourth millennium cal BC (Griffiths 2014); convincing evidence for Neolithic activity in Ireland before *c.* 3800 cal BC or even later is very scarce, even after the major *Cultivating Societies* project (Cooney 2023; McClatchie and Potito 2020; McClatchie *et al.* 2014; Smyth *et al.* 2020; Whitehouse *et al.* 2014; but note A. Lynch (2014) for Poulnabrone and Schulting *et al.* (2017) for Baltinglass); and while *Gathering Time* only considered evidence in Scotland as far north as the Great Glen, subsequent modelling of the sequence in Orkney suggests a Neolithic start there comfortably into the fourth millennium cal BC (Bayliss *et al.* 2017; Bunting *et al.* 2022). So some elements of a time-progressive process seem likely to stand up to further modelling.

In *Gathering Time*, we proposed an initial colonisation into south-east England, with subsequent mixing with indigenous people as Neolithic things and practices spread across Britain and Ireland (Whittle *et al.* 2011, chapters 14–15). We did not really discuss the degree of admixture. This position agreed in most aspects with the Carinated Bowl strand of Sheridan's model. I currently see, as emphasised above, this phase from the forty-first century cal BC onwards as the time of the beginnings of arrival of new people, as now demonstrated by the aDNA research discussed above. The aDNA evidence suggests the closest contacts with northern France (Booth, this volume; Brace and Booth 2023; Brace *et al.* 2019; Cassidy 2023; Cassidy *et al.* 2016; 2020; Rivollat *et al.* 2020; Sheridan and Whittle 2023), which accords with the settlement evidence in the Paris Basin and surrounds as discussed above. It has been surprising to me that the 'Danubian' element in Early Neolithic genetic signatures in Britain should be relatively muted (Brace and Booth 2023, 127; Brace *et al.* 2019), but results suggest that aspects of the Carinated Bowl Neolithic, especially elements of ceramic and lithic styles, could be derived variously from the northern Chasséen, the early Michelsberg of the Paris Basin, the Groupe de Spiere in northernmost France and adjacent Belgium, and the early Michelsberg of the Low Countries (Praud *et al.* 2018, fig. 55; Vanmontfort 2001). One of the obstinate obstacles to our understanding of what was going on is the continuing general lack of aDNA evidence from Brittany (Cassidy 2023, 160; Sheridan and Whittle 2023, 173; note, however, Simões *et al.* 2024 for Late Mesolithic Brittany, briefly discussed above). Megaliths in Brittany and long cairns in Normandy could well suggest general connections (note Laporte, this volume, on problems of dating), but monuments with more distinctive form such as Broadsands, Devon (Sheridan *et al.* 2008), are rare in southern Britain (see also below). In another direction, it seems to me more likely that there was little direct connection between southern Scandinavia on the one hand and Britain and Ireland on the other, and not just because of distance; the respective trajectories seem to be cousinly, on not dissimilar, parallel tracks of development (*contra* Cummings *et al.* 2022; cf. Allentoft *et al.* 2024a; 2024b).

Forty-first to thirty-ninth centuries cal BC: a minimal earliest Neolithic?

The recent aDNA results could be taken to imply a single event of migration and colonisation. There are certainly indications that the Early Neolithic population was on a considerably larger scale than that of indigenous people, probably in both Britain and Ireland (Booth, this volume; Brace and Booth 2023, 136; Cassidy 2023, 151–2, 158). On the other hand, there are signs of different strands, western and eastern, within Britain, and possible variation in the degree of indigenous admixture (Brace and Booth 2023, 133; Brace *et al.* 2019). The so far relatively limited sample of analysed individuals also spans a range of time within the Early Neolithic (Brace *et al.* 2019). The notion of continuing migration schemes over a period of time (Thomas 2022) is therefore attractive, though it needs a lot more work to be done on it. The evidence is varied. On the one hand, there are individuals identified as outliers and thus potentially migrants by isotopic analysis, as at Penywyrlod, south Wales, and Whitwell, Derbyshire, neither probably earlier than the thirty-eighth century cal BC (Neil 2022; Neil *et al.* 2017; 2020). On the other hand, there are interesting possibilities among groups of monuments. It seems to me that such putative longer-lasting connections could extend at least as far in time as the emergence of enclosures from the late thirty-eighth century cal BC onwards, with their undoubted continental ancestry (Whittle *et al.* 2011; 2024). There are other possible links seen for example in the architecture of barrows and cairns with transepted chambers, dubbed the Pornic-Notgrove type by Stuart Piggott (1962, 59, fig. 20; cf. Laporte and Tinévez 2004); these are unlikely to be earlier than the thirty-eighth century cal BC in southern Britain, and could belong to the thirty-seventh. The very range of monument forms, which has made it so difficult over the years to pin down specific sources for the British (and indeed Irish) Neolithic, summed up in the title of Stuart Piggott's classic paper 'Windmill Hill — east or west?' (1955), may also best be explained by a series of migration events and continuing connections.

Discussion of these possibilities can still usefully be framed by the suggestions by Humphrey Case (1969) for the conditions of initial exploration, contact and the establishment of settlement, and by David Anthony (1990; 1997) on scouting, pioneering, colonisation by budding-off groups and continuing connections between motherlands and new areas. There have been continuing suggestions of a gradual start to things, and these have proliferated in recent times. Humphrey Case (1969, 180–1) envisaged piecemeal establishment of the agricultural economy. Ros Cleal (2004) proposed an earliest or contact phase before an early or developing stage. Seren Griffiths (2018) has documented the scarcity of cereal remains before *c.* 3800 cal BC (though I wonder if that reflects the situation in southern Britain more than in western Britain), while Vicki Cummings and Oliver Harris (2011; cf. Gron *et al.* 2018) have claimed continuities in hunting practices well into the Early Neolithic. On that note, we would do well to reflect whether there were also significant indigenous contributions in terms of knowledge of the landscape and other resources, including lithics — part of the set of previous arguments in favour of a major role for indigenous people (cf. Edmonds 1999; Ray and Thomas 2018) — even if not directly reflected in the proportions of genetic signatures. Julian Thomas (2022) recently has argued for an initial 'minimal' Neolithic in the first century or two, with subsequent consolidation of founder lineages (for comment on those, see Whittle 2024a) and reinforcing migration on a larger scale (without quite specifying where the evidence for that may reside). One recent review of the Irish evidence toys with the idea of an 'invisible earliest Neolithic' in the ENI phase of *c.* 4000–3750 cal BC, with the 'earliest clear evidence for farming' coming in the ENII phase of *c.* 3750–3600 cal BC (Smyth *et al.* 2020, 428, 432).

While the overall trend may be for growth in numbers of people on the ground over the generations, increasing clearance with time, the building of more monuments as the years passed, and the steady enhancement of material connections — the basis for claiming a gradualist pattern of development — it is important to keep the scale of things in mind. Claimed absence of evidence, for example for cereal cultivation or use, may speak rather to the small scale of a dispersed initial population and its varied activities across the landscape (see Table 1). For example, continuing pollen analysis connected to the project on the Caerau enclosure, on the edge of Cardiff in south Wales (Davis and Sharples 2017), is investigating the possibility of surprisingly early cereal cultivation, potentially as early as the fortieth century cal BC (Oliver Davis, Tudur Davies and Niall Sharples, *pers. comm.*). Continuing research in south Wales and the Marches generally has already revised the picture proposed in *Gathering Time*, with indications of settlement at least as early as the thirty-ninth century cal BC (Britnell and Whittle 2022; Griffiths 2022; Ray *et al.* 2023;

Whittle 2024b). New dates from Cornwall, from sites like Tregurra (Taylor 2022), have yet to be formally modelled in comparison, but could go at least as early. A similar picture has emerged in north-west England (Griffiths 2021), and it remains to be seen how early the Neolithic occupation of sites like Windy Harbour, Lancashire (Fraser Brown and Anthony Dickson, *pers. comm.*), may go. It is also worth stressing in passing that there is little support from recent and ongoing projects in western Britain as a whole and indeed in Ireland (as seen for example in the results of the numerous road schemes) for activity as early as that proposed by Alison Sheridan for her Breton or Atlantic strand. And it is also worth noting recurrent cases where a Final Mesolithic presence was followed, at varying intervals, by an Early Neolithic occupation, as at Windy Harbour. Digging of flint mines in Sussex appears to have begun early in the Neolithic sequence (Whittle *et al.* 2011, chapters 5 and 14). And while more monuments appear to belong to the times after *c.* 3800 cal BC, there are also candidates for earlier monument constructions (Whittle *et al.* 2011, chapters 14–15, with varying probabilities attached), including Coldrum, Kent (Wysocki *et al.* 2013), the Raunds Avenue (Harding and Healy 2007), the 'banana barrow' on Crickley Hill (Whittle *et al.* 2011, chapter 9), Burn Ground, Gloucestershire (Darvill 2004), and Broadsands, Devon (Sheridan *et al.* 2008). We should be careful, therefore, not to underplay the evidence for the early stages of the Neolithic in southern Britain, while agreeing that the evidence becomes more abundant as the sequence moves on. In these various ways, while I agree with Julian Thomas's (2022) general notion of an overall gradualist trajectory in the early stages of the Neolithic sequence, I see a greater range of early practices than he allows, including possible cereal cultivation and initial monument building; small scale and thus low visibility should not be equated with absence.

The thirty-eighth century cal BC onwards

On present indications, and subject to future remodelling, the pace of things seems to quicken from the thirty-eighth century cal BC onwards (Whittle *et al.* 2011). This is not the place to document this in detail. Headlines include the probably more frequent construction of barrows, cairns and related monuments from *c.* 3800 cal BC onwards, a 'surge' in material connections and innovations from the thirty-eighth century cal BC, a more visible presence of agriculture (Griffiths 2018; Rowley-Conwy *et al.* 2020; Treasure *et al.* 2019; cf. Smyth *et al.* 2020 for Ireland) and the appearance of enclosures probably from the late thirty-eighth century cal BC onwards (Whittle *et al.* 2022); new discoveries of enclosures in eastern Ireland (summarised in Whittle *et al.* 2024) seem to fall well after that date, and underline the anomalously early date initially proposed for Magheraboy. There is a case now for the earliest enclosures being simple in layout, with more complex arrangements coming from the thirty-seventh century cal BC, as the practice rapidly proliferated, reaching a peak of use in the thirty-sixth century cal BC (Whittle *et al.* 2022).

Much of this may speak to insular development as settlement and practices became established and embedded (cf. Case 1969). I have already noted above possibilities for continuing movement by individuals and groups as late as this date. The case of enclosures itself is directly relevant. Given the presence of related forms of construction on the adjacent continent from the later fifth millennium cal BC onwards, it is hard not to see the enclosure idea as of continental derivation. It remains unclear whether any or many enclosures were still being built in the Paris Basin and surrounds at this date, and what was adopted in southern Britain could have been on the basis of memory of past practice. Was this just the revival of an old idea, along old ancestral connections from the days of initial colonisation and suiting the purposes of innovators (perhaps lineage leaders) in Britain, or could there have been actual further migration at this point? Given the scarcity of aDNA studies so far connected with enclosures (Booth, this volume; Brace and Booth 2023, 140; Cassidy 2023, 158), it is hard to say. Alison Sheridan (2010; Sheridan *et al.* 2008) has also proposed a specific late intrusive strand, deriving especially from Normandy, her 'Trans-Manche Ouest', comprising both pottery and tomb architecture (as at Broadsands), arriving *c.* 3800 cal BC into south-west Britain (Sheridan and Whittle 2023, 170), with claimed support from aDNA analysis (Sheridan and Whittle 2023, 173; cf. Rivollat *et al.* 2020). Whether this is an identifiable separate strand as such, as opposed to another area in adjacent northern France from which individual movements could have been possible, is in my view open to question. Changes in pottery in south-west Britain may owe by that date as much to insular development as injection from the outside (Barclay *et al.* 2018), and Broadsands, as noted above, is both distinctive and therefore a rare case, and may be earlier.

Further developments in the thirty-seventh and thirty-sixth centuries cal BC are very relevant to the overall character and trajectory of the Early Neolithic (Table 1), but detailed discussion of these is beyond the scope of this chapter.

Conclusions

I have sketched, on a personal and provisional basis in advance of further formal remodelling of radiocarbon dates for the Early Neolithic in England and Wales, notes towards the outline of a possible model for the Mesolithic–Neolithic transition in Britain. I have also made reference to the Early Neolithic sequence in Ireland. I have proposed an overall gradualist model, in the context of a resetting of debate and research questions in the wake of recent game-changing isotopic and aDNA investigations. I envisage enhanced connections between Britain and Ireland on the one hand and the adjacent continent on the other in the later fifth millennium cal BC, rather than distinct episodes of contact. This was the bow wave for sustained migration and colonisation from the forty-first century cal BC onwards. I caution against seeing a single migration event, and the process may have played out over a period of time; the detail of this, however, is yet to be worked out and we must wait among other things for the completion of revised chronological remodelling for England and Wales. Within an overall gradualist framework, I have noted various proposals in the literature for some kind of minimal earliest Neolithic, but I think these suggestions can be over-played, with differences in scale mistaken for absence. The pace and visibility of things seem to pick up further by the thirty-eighth century cal BC, at a time when there are still varied possible signs of individual and group migration. Time will tell whether all these possibilities stand up to further modelling and analysis.

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THE MATERIAL CULTURE OF LONG-DISTANCE CONNECTIONS

The lithic evidence from Neolithic Orkney

Hugo Anderson-Whymark

Abstract

Orkney, in the far north of Scotland, is often portrayed as a distant and remote place, separated from mainland Britain by a treacherous stretch of water. Yet in the Neolithic it was home to a thriving and well-connected community. This paper explores the material culture that bears witness to these long-distance connections and examines what the distribution of these artefacts in Orkney can tell us about the role of the Stenness-Brodgar monument complex and how the community within it created and maintained these connections. It is argued that the distinct concentration of imported artefacts found in the Stenness-Brodgar monument complex indicates that this area was the final destination of many long-distance journeys.

Keywords: Orkney; material culture; movement; mobility; monument complexes

Introduction

This paper characterises flint and stone artefacts that arrived in Orkney during the Neolithic from distant shores, exploring their biographies and common trends. These artefacts are intimately connected to wider movements of people and spheres of influence that developed in the period, complex networks that ebbed and flowed over time. The biographies of individual artefacts will be unique and differ in their complexity; some tools may have arrived from their point of origin in a single move, while others will have passed through many hands, potentially over generations, before reaching Orkney. Indeed, some artefacts will have been manufactured or reworked over the course of their journey, taking on the forms and characteristics of different places. The stories of these artefacts was no doubt woven into a rich oral history that unfortunately has been lost in the mists of time. However, traces of these narratives can be found in the archaeological record, with raw materials, manufacturing techniques, typologies, distribution patterns and deposition practices providing insights to broad patterns of contact and movement between places.

Background to Neolithic Orkney

Orkney is an archipelago of some 70 islands located 10 km off the northern tip of Britain. These islands are separated from the mainland by the Pentland Firth, a treacherous stretch of water with some of the most extreme tidal currents around Britain (Figure 1). The earliest evidence in Orkney for Neolithic tombs and houses dates from 3730–3480 cal BC

In D. Hofmann, V. Cummings, M. Bjørnevad-Ahlqvist and R. Iversen (eds) 2025, *The early Neolithic of Northern Europe. New approaches to migration, movement and social connection*, 125–134. Leiden: Sidestone Press.

Figure 1. Source locations for objects mentioned in the text. Left: 1. Yorkshire (polished discoidal knife); 2. Den of Boddam Quarries, Aberdeenshire (flint); 3. Arran (pitchstone); 4. Langdale, Cumbria (tuff axeheads); 5. Rathlin Island/Tievebulliagh (porcellanite axehead); 6. NW Scotland and Outer Hebrides (Lewisian gneiss axeheads and maceheads); 7. Shetland (riebeckite felsite axehead and macehead); 8. Northern Ireland? (red/white flint macehead). Right: find locations in Orkney mentioned in the text.

(95 % probability), but there are some indications that the Neolithic may have begun on a small scale a century or more earlier (Garrow *et al.* 2017, 23–5; Griffiths 2016). A rich history of antiquarian investigation and archaeological excavation has revealed an exceptionally large number of Neolithic settlements and funerary monuments on islands across the archipelago. In the heart of West Mainland, a monument complex is situated on a narrow peninsula between Loch Stenness and Loch Harray. This includes two stone circles: the Stones of Stenness, constructed shortly after 3000 BC, which is one of the earliest stone circles in Britian, and the Ring of Brodgar, one of the largest stone circles in Britain but more poorly dated, although the ditch was silting by *c.* 2500 cal BC (Downes *et al.* 2013). Further monuments include the substantial passage grave of Maes Howe, the Dyke of Sean (a large stone wall built across the Brodgar peninsular) and the enigmatic Ring of Bookan, which appears to be a substantial stone structure encircled by a deep ditch and covered by a large mound. Substantial buildings and evidence of occupation have also been located among these monuments at Barnhouse, Bookan and the Ness of Brodgar. Barnhouse was discovered in the 1980s and a significant portion of the site was excavated over several seasons, while the site at Bookan is known only from surface finds made from the early twentieth century onwards and geophysical survey (Brend *et al.* 2020; Richards 2005). Excavations at the Ness of Brodgar over the last 20 years have revealed numerous substantial buildings that were built and rebuilt over the period from 3200 to 2300 cal BC. Glimpses of earlier phases of activity indicate that buildings much larger than at other settlement sites in Orkney may have stood on the site from potentially as early as 3500 cal BC (Card *et al.* 2020). Collectively this area is known as the Stenness-Brodgar monument complex.

The monument complex has witnessed considerable excavation and survey in recent decades, but it should be noted that it lies within a wider landscape rich in Neolithic archaeology that has also been subject to fieldwork. This includes settlements at Skara Brae, Rinyo, Pool, Tofts Ness, Stonehall and Smerquoy, to name but a few, and numerous tombs, such as Cuween, Taversoe Tuick, Quoyness, Quanterness, Unstan and Tresness. The archaeological dataset available for Orkney is, therefore, particularly broad, allowing this paper to contrast finds made within the Stenness-Brodgar monument complex with those identified elsewhere in Orkney in the confidence of a representative dataset.

Figure 2. The Crudwell-Smerrick type axehead of imported flint found at Folsetter, West Mainland, Orkney (NMS X.AF 59). Image: Hugo Anderson-Whymark, courtesy of National Museums Scotland.

Material connections

Orkney has a rich and varied geology, but it has long been known that raw materials for certain Neolithic stone tools originated outwith the islands. A review of almost all available lithic assemblages from Orkney as part of the *Working Stone, Building Communities* project (2013–2016), directed by Prof Mark Edmonds, University of York, refined this picture, with data made available through www.orkneystonetools.org.uk. The data presented below were principally collected as part of this project, with supplementary information from more recent research.

Flint

Throughout the twentieth century it was considered that flint was a scarce resource in Orkney and most would have been imported from distant sources. Recent fieldwork has, however, demonstrated abundant flint resources in the glacial till and nearby beach deposits where this material is eroded, to the east of Orkney, particularly in Deerness, Stronsay, Sanday and Eday (Anderson-Whymark *et al.* 2016a; Edmonds *et al.* 2017). Broad assertions that the majority of flint (particularly grey flint) was imported to Orkney from the mainland can no longer be justified (*contra* Ballin 2013). Two flint artefacts and a cache of flint raw materials are, however, demonstrably long-distance imports that highlight connections along the east coast of Britain.

The first imported flint artefact is an exceptional all-over-polished axehead that was found at Folsetter, West Mainland in the mid-nineteenth century during agricultural improvement (NMS X.AF 59; Figure 2). Unfortunately, the precise location and context of discovery are not recorded, but the farm is situated on low-lying ground near a loch, indicating that it may have been a wetland deposit. This assertion is supported by the heavy orange-brown surface iron staining of the grey flint axehead. This axehead is one of *c.*10 examples of Crudwell-Smerrick type known from Scotland. Alison Sheridan (1992) highlighted that all of the known examples of this axehead type are found on Scotland's east coast, with few found any distance inland. The precise origins of these axeheads remains unclear, but raw materials of a size suitable for their manufacture are not found in northern Britain and the coastal distribution extends along Britain's North Sea coastline to Norfolk and Kent, where raw materials of this size are plentiful. Katharine Walker (2018, 90–6) recently proposed Lincolnshire as likely source, without entirely ruling out the possibility that these axeheads are long-distance Scandinavian imports that have been reground and highly polished in the course of their journey (see also Saville 1999). This artefact originates in excess of 600 km from Orkney.

A fragment of a polished discoidal knife from the Ness of Brodgar is the second long-distance flint import in Orkney. This artefact was reworked at the end of its life and survives as a bipolar flake (58 mm long by 6.5 mm wide and 9 mm thick) struck through the centre of the artefact. It is therefore impossible to determine the original form of the polished discoidal knife, although it is clear that it was partially ground and exhibited the characteristic waxy high-gloss polish on the original flake scars (Anderson-Whymark 2020a). Grahame Clark's (1929) seminal publication highlights that only a small number of polished discoidal knives are known in Scotland and, while this research is dated and requires updating, it demonstrates a largely easterly distribution for the Scottish finds. However, these objects are notably found further inland than Crudwell-Smerrick type axeheads. Polished discoidal knives were manufactured at several localities in southern Britain, but the area around Flamborough Head in Yorkshire, which has yielded evidence of specialist manufacture, is the closest source area to Scotland and some 575 km from Orkney (Durden 1995; Gardiner 1990; 2008; Manby 1974). Seamer axeheads and Duggleby adzes, which also arguably originate in Yorkshire, have been found in small numbers in Scotland, but to date none have been identified in Orkney.

The final example of the long-distance movement of flint to Orkney is from the Neolithic settlement at Barnhouse. During the 1990 excavation season at Barnhouse, several small pits were revealed in the north-east corner of Structure 8, a large Late Neolithic building set within a circular enclosure. The vast majority of these pits were devoid of finds, but one — pit 802 — contained 16 large bipolar split flint cobbles and a large flake of silicified sandstone. This feature had already attracted attention before it was dug; while a yellow clay floor sealed most of the pits, a circular 0.16 m diameter gap was present over pit 802. The excavator speculated that this was because the cobbles were put into the pit through the floor, or that the location of the deposit was marked with a stone (Richards 2005).

This cache of stone immediately caught the attention of the excavators as the near-identical cobbles were much larger than all other flints from the excavation, measuring between 61 mm and 79 mm long and weighing between 95 g and 199 g. Indeed, the combined weight of the 16 split cobbles from this pit (2244 g) is more than the other 692 lithic artefacts, excluding chips, recovered from the entire excavation (2186 g; author's data, see also Middleton 2005, 397). It was not just the size of these cobbles that was unusual. While mottled grey flint is commonly found in Orcadian archaeological assemblages, these cobbles fade to white towards their heavily chattered and well-rounded cortical surfaces; field collection from more than 300 beaches on 21 islands in Orkney has not located a single comparable cobble among over 60 kg of flint collected (Anderson-Whymark *et al.* 2016a). However, the form of these cobbles and their distinctive surface colouration compares well with raw material quarried in vast quantities some 190 km to the south at the Den of Boddam, Aberdeenshire, during the Later Neolithic (Saville 2005).

Intriguingly, detailed re-examination by the author of the other flints in the Barnhouse assemblage revealed just five flints and three examples from fieldwalking that were of a comparable raw material (0.7 % of the assemblage by count). Two of these were found in Structure 8 and another, from topsoil, was a substantial 53.6 g Levallois-like core manufactured on a split cobble like those in pit 802. This indicates that while a few pieces of imported flint may have been worked and utilised, most appear to have been deliberated deposited, potentially as an offering. Den of Boddam-type raw material has not been identified in any other assemblage from Orkney.

Pitchstone

Pitchstone is a volcanic glass that was extensively exploited on the Isle of Arran, on the west coast of Britain, from the Mesolithic onwards (Ballin 2009). During the Neolithic this material was distributed widely across Scotland, with Orkney being the most distant documented findspot some 400 km from source as the crow flies, although the material most likely travelled a much longer route around the western seaways to Orkney. Across Scotland, the distribution of pitchstone declines with distance from source, with few pieces documented from more distant localities, such as Caithness and Sutherland. However, over 31 pieces of pitchstone have been recovered from the Ness of Brodgar and a further 26 from the nearby site at Barnhouse (Anderson-Whymark 2020a; Ballin 2013; Middleton 2005 and author's data). Re-examination of assemblages from other Neolithic sites across Orkney revealed no further examples of this material.

Stone axeheads

The vast majority of stone axeheads found in Orkney are manufactured from locally available raw materials including camptonite, siltstones and igneous and metamorphic erratics from the glacial till. Comparatively few axeheads appear to have been imported to Orkney and the available evidence for most is equivocal, as considered below.

Langdale tuff (IPG Group VI) was extensively quarried in Cumbria, England, during the Earlier Neolithic, with recent research indicating that quarrying began between 3955 and 3711 cal BC (95 % probability) and ended between 3696 and 3484 cal BC (95 % probability; Edinborough *et al.* 2020, 94). In excess of 200 axeheads of Langdale tuff are known from Scotland with the majority being found in the south-west towards the source region. In Orkney a few possible examples have been tentatively recorded on visual attributes, but these require scientific analysis to confirm their source (Mark Edmonds, *pers. comm.*). These examples include two axeheads provenanced only to 'Orkney', an axehead from the settlement at Tofts Ness, Sanday, and a large unworked flake from the Ness of Brodgar (Figure 3). Significantly, the only provenanced finds in Orkney are from Later Neolithic occupation sites dating many centuries after the main periods of quarrying in Cumbria. It may be that these are curated tools or they are re-used and reworked artefacts; the form of the axehead from Pool is comparable to many axeheads of Orcadian materials. It is equally possible that the stone will prove to be from a different source.

The evidence for porcellanite axeheads (Group IX), quarried at Tievebulliagh or Rathlin Island, Ireland, some 450 km from Orkney, is similarly slight. A single axehead (NMS X.AF 592) of this material has been attributed to Orkney. Unfortunately, the provenance of this axehead is not entirely secure, as it was purchased by the National Museum of

Figure 3. A small axehead, probably of Langdale Tuff from Cumbria, England, found in excavations at Tofts Ness, Sanday (OM TN3740). Image: Hugo Anderson-Whymark, courtesy of The Orkney Museum, Orkney Islands Council.

Antiquities of Scotland in 1909 from an unknown vendor with several other artefacts considered 'probably from Orkney'.

Orcadian evidence for axeheads from felsite quarries in Shetland is similarly weak. A single axehead, provenanced only to 'Orkney', has been identified in a museum catalogue as being manufactured from riebeckite felsite (GLAHM B.1914.852). This axehead is of an unusual form, having blade edges at both ends and a flattened waist, but more concerningly it is from the collection of James Walls Cursiter of Kirkwall, who collected extensively in both Orkney and Shetland.

The evidence for imported axeheads of Lewisian Gneiss is more compelling, with several examples recorded among the assemblage from the Ness of Brodgar, including two with forms comparable to cushion maceheads, potentially indicating an unfinished or broken macehead was re-used as an axehead (Clarke 2020 and author's data, cf. Johnson 2018). The precise source of this Lewisian gneiss is, however, uncertain and requires further research. The material is not comparable to the Basement Complex found in Orkney, but a broad potential source region exists in north-west Scotland and the Outer Hebrides.

Maceheads

Maceheads are a common feature of the Late Neolithic in Orkney, with 111 examples known, representing approximately 20 % of the *c.* 500 maceheads known from Britain and Ireland (Anderson-Whymark *et al.* 2017; Roe 1968). Few maceheads have to date been geologically characterised and provenanced to source, and this topic warrants further research. However, among the Orcadian maceheads a significant proportion are manufactured from raw materials originating outside the archipelago.

Figure 4. Fragmentary cushion macehead manufactured of riebeckite felsite from Shetland, found at Millfield, Stronsay, Orkney (OM 1981.163). Image: Hugo Anderson-Whymark, courtesy of The Orkney Museum, Orkney Islands Council.

A single Orcadian macehead — half of a cushion form — is manufactured from riebeckite felsite from Shetland. The provenance of this artefact is more secure than the axehead of this material, as it was discovered in the early twentieth century as a surface find at Millfield, Stronsay and presented to Orkney Museum by descendants of the finder (OM 1981.163; Figure 4). Another macehead without parallel in Orkney is a fragment of a pestle form of red and white flint, which now appears grey and reddish-brown as the artefact has been burnt at some point. This fragment was found, along with several others, in the 1920s and 1930s in ploughsoil over the Neolithic settlement at Bookan (NMS X.AH 180a). No source of flint of this character is known in Orkney, but significantly this raw material has been used for other maceheads, most notably the finely decorated pestle macehead from Knowth, Ireland (now in the National Museum of Ireland), but also Urquhart, Moray (NMS X.AH 37). The source of this flint has yet to be identified, but it may lie in Northern Ireland.

At least ten maceheads are manufactured from Lewisian Gneiss (Anderson-Whymark 2020b; Anderson-

Figure 5. A Late Neolithic pestle macehead of Lewisian gneiss from north-west Scotland, found in a cist at Dounby Farm, West Mainland, in 1838 (SM A 187). Image: Hugo Anderson-Whymark, courtesy of Stromness Museum.

Whymark *et al.* 2017; author's data). Five of these exhibit banding, with three being highly folded and reminiscent of outcrops in north-west Scotland or the Outer Hebrides. Significantly all five of these maceheads have secure findspots within or in close proximity to the Stenness-Brodgar monument complex: two were found in midden deposits at the Ness of Brodgar, one was found at the Bookan settlement and two were found at Dounby. The only complete example of this macehead form was found in a cist containing an inhumation on Dounby Farm in 1838 (Figure 5); this form of cist may date from the Late Neolithic or Bronze Age.

A further five maceheads were manufactured from a distinctive form of Lewisian gneiss, which may be described as a mafic rock with retrograde symplectic textures around garnet porphyroblasts (Rachel Walcott, *pers. comm.*). This rock outcrops at Ness, Lewis, and around Scourie, south of Ullapool on the Scottish mainland; pieces would also be available as erratics in the surrounding environs (Anderson-Whymark 2020c). Two of these maceheads were discovered in the Stenness-Brodgar monument complex: an unfinished cushion macehead was found in midden deposits at the Ness of Brodgar and a fragment of a pestle macehead was found in ploughsoil in a field adjacent to the Stones of Stenness. A further example of a pestle form was excavated from the Late Neolithic settlement at Tofts Ness, Sanday (Dockrill 2007), and two examples lack secure provenances, although one may have been found in a Maes-Howe-type passage grave at Blomuir, Holm.

Discussion: moving things, moving ideas

At a broad scale three distinct trends are clear. Firstly, remarkably few artefacts appear to travel from Shetland to Orkney in the Neolithic, supporting the picture of Shetland being largely insular during this period. Secondly, the small number of flint artefacts appear to indicate intermittent, but long-distance material connections along the eastern North Sea coast of Britain. Thirdly, there are strong material connections around the western seaways, particularly to north-west Scotland and the Outer Hebrides, but potentially as far as Ireland if the tentative evidence from the porcellanite and red/white flint is accepted. These points are unsurprising and conform to a broader picture generated by other aspects of material culture (e.g. Unstan Bowls) and the distribution of passage graves and passage grave art.

The value in the current approach of considering stone tools imported into Orkney is, however, more apparent when the distribution of these artefacts is considered within Orkney (Table 1; Figure 1). This reveals a striking pattern, with the vast majority of imported artefacts being found within the immediate environs of the Stenness-Brodgar monument complex. Indeed, the handful of artefacts that fall outside this pattern are worthy of individual note. The most striking artefact found beyond the monument complex is the Crudwell-Smerrick type flint axehead found at Folsetter to the north-west of Mainland Orkney, and it a great shame that we lack secure details of the find and close dating of this artefact type. It is also notable that the only riebeckite felsite macehead from Shetland was found at Millfield, Stronsay, on one of Orkney's North Isles, rather than within the monument complex. The possible Landale tuff axehead from Tofts Ness, Sanday, presents a challenge to interpret given the ambiguity over the provenance of this raw material in Orkney, but if the identification is correct it is significant that this artefact is likely to have been an heirloom of considerable age when finally deposited and may have arrived in Orkney from the beginning of the Neolithic onwards. The Lewisian gneiss macehead from Tofts Ness and the possible example from the Blomuir passage grave are significant as these sites are contemporary with the activity within the monument complex. Their occurrence therefore demonstrates that whilst the majority of imported artefacts are found within the confines of the Stenness-Brodgar monument complex, a small proportion extend outside this area in the Middle to Late Neolithic.

It is perhaps useful at this juncture to briefly consider developments in lithic technology in Later Neolithic Orkney, specifically Levallois and Levallois-like knapping techniques, as this mode of production was not a localised development, but itself 'imported'. These distinctive styles of lithic working, characterised by careful core preparation, appear to originate in southern Britain during the Middle Neolithic, with a preferential discoidal model of production, principally creating flakes for chisel arrowheads. In northern Britain, presumably following the adoption of the preferential discoidal technique, a recurrent, non-discoidal 'Levallois-like' reduction was more widely adopted (Anderson-Whymark 2020a; Ballin 2011). In Orkney, Levallois and Levallois-like working are documented at the Ness of Brodgar and Barnhouse in assemblages dating from *c.* 3200–3100 cal BC onwards. Significantly, these two sites also provide the only evidence in Orkney for knapping Levallois/Levallois-like cores, with the proportion of flakes with facetted butts indicating that the mode of production was a significant part of the reduction strategy (8.6 % and 10.7 % respectively). Outside of the monument complex, no evidence for the knapping of these cores has been located and the proportion of flints with facetted butts (principally scrapers and knives) declines to 2.6 % of the assemblage at Stonehall, 6 km distant, and 0.4 % of the assemblage (five flints) at Skara Brae, 10 km distant (Anderson-Whymark *et al.* 2016b; author's data). At 31 km away as the crow flies, in the North Isles at Green, Eday, just three facetted butts were recorded in an assemblage of over 23,000 lithics, representing 0.01 % of

Imported artefact type	Stenness-Brodgar monument complex	Rest of Orkney	Unknown Orcadian findspot
Crudwell-Smerrick type flint axehead		1	
Polished discoidal knife	1		
Den of Boddam flint	16		
Arran pitchstone	77		
Langdale axehead/flake	1?	1	1+
Porcellanite axehead			1?
Riebeckite felsite axehead			1?
Riebeckite felsite macehead		1	
Red/white flint macehead	1		
Lewisian gneiss axehead	3+		
Banded Lewisian gneiss macehead	5		
Garnet Lewisian gneiss macehead	2	1 (+1?)	1

Table 1. Number of imported stone artefacts in relation to their findspot.

the assemblage (Anderson-Whymark 2016). This pattern appears to indicate that the individuals practicing this non-local working technique were located solely within the monument complex, and only a limited number of artefacts, predominately tools, produced by this technique travelled beyond the monument complex into wider Orcadian communities.

A small collection of seven pieces of pitchstone recovered from the floor deposits of Structure 8, a 22 m long and 9.5 m wide building at Ness of Brodgar, also assist with our interpretation of the movement of objects to Orkney (Anderson-Whymark 2020a). The raw material alone provides no indication of the manner in which this stone arrived in Orkney and many alternatives may be postulated: was it brought from source by long-distance travellers attending important events? Was it a trophy brought back by a Neolithic Orcadian who travelled south? Or did pieces of this raw material pass through many hands on its way north?

Analysis of the pitchstone recovered from floor deposits in Structure 8 assists with our interpretation of this process. This small cluster of artefacts included three pieces of micro-debitage, indicating that pitchstone was knapped in this structure, and four larger pieces comprise a flake and three bladelets all seemingly struck from the same piece of stone, although none refit. The production of bladelets is significant, as pitchstone is commonly worked into small blades further south in Scotland during the Late Neolithic, but the production of blades is not a feature of Orcadian reduction techniques in the Late Neolithic. This perhaps indicates that the person who worked the pitchstone in Structure 8 was armed with both the knowledge and skills of how this material was worked closer to source and may indicate that the pitchstone arrived with travellers from distant shores. In combination, given the evidence from Levallois reduction strategies and the production of blades of pitchstone in a non-Orcadian style, we may consider that both people and artefacts from outwith Orkney were present within the Stenness-Brodgar monument complex.

Conclusions

The range and variety of imported stone artefacts in Orkney demonstrate that it was a connected and significant place in the Neolithic. The correlation between the remarkable monumental architecture of the Stenness-Brodgar landscape and the concentration of imported artefacts highlights the significance of this place in both local and wider circles.

The distribution of imported artefacts within Orkney can be read in different ways. It may indicate that the monument complex was the desired destination, above other places in Orkney, for many long-distance travellers. The reasons behind these journeys may have been varied, but it is plausible that these journeys were pilgrimages to a special transformative place. Equally, it is possible that the monument complex was related to individuals or lineages of people with elevated social status, who perhaps influenced or restricted the movement of people and objects beyond the environs of the monuments.

This paper has focused on material coming into Orkney, creating a simplistic picture as people, ideas and objects also flowed from Orkney to other parts of Britain and Ireland. Moreover, as the complex sequences of rebuilding at the Ness of Brodgar demonstrate, the importance of the Stenness-Brodgar monument complex, its significance and influence, and levels of activity ebb and flow through the Neolithic. For most of the objects considered, the overall distribution of the artefact class is much broader than the distance travelled by the individual objects, indicating that they are circulating in wider spheres of shared ideas or practices. The patterns observed indicate Orkney's connections stretched across much of Britain and Ireland in the Neolithic, with particularly strong links from Orkney along the western seaboard to Ireland (cf. Garrow and Sturt 2011).

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BRÚ NA BÓINNE IN THE EARLY(ISH) NEOLITHIC

Stephen Davis

Abstract

This paper focuses on human activity in the Brú na Bóinne area before the construction of the famous passage tombs, which have been the largely uncontested focus of research for many years. The earliest Holocene landscape is described, and the virtual absence of Late Mesolithic material noted, although this may be a consequence of a lack of targeted fieldwork. In spite of the fact that such features are often hard to spot through remote sensing, concerted efforts in recent years, in several cases backed by excavation, have revealed Early and Middle Neolithic settlement and other activity traces associated with several of the later passage tombs and their satellites. These range from likely domestic buildings and artefact spreads to pits, wall trenches, palisades and enclosures. Due to the relatively small archaeological interventions, and bearing in mind the difficulties often encountered in dating such structures (also as a result of the destruction incurred by later monument building), this shows that the Brú na Bóinne landscape was far from empty. Whether the siting of the later monuments directly and consciously references this earlier activity must be the subject of future research.

Keywords: Brú na Bóinne / Bend of the Boyne; Early Neolithic; pre-passage tomb activity; settlement; remote sensing

Introduction

Brú na Bóinne — the Bend in the Boyne — is one of Europe's most significant prehistoric archaeological landscapes, and one of only two current UNESCO World Heritage sites in the Republic of Ireland (cf. Smyth 2009). It is internationally recognised for its Middle Neolithic passage tomb cemetery — including the megatombs of Knowth, Dowth and Newgrange (e.g. Eogan 1986; Herity 1974), and for both the quantity and range of its megalithic art (Eogan and Shee-Twohig 2022; Shee-Twohig 1981). At Knowth alone there are *c.* 400 decorated stones (Smyth 2009, 29). However, the passage tomb complex at Brú na Bóinne represents only one phase in a long and varied landscape narrative. After the passage tombs came a diverse group of earthen henges and timber monuments (Davis and Rassman 2021; Stout 1991) and a Bronze Age landscape of funerary monuments and field systems (largely identified in unpublished geophysical surveys, but with a number of sites previously identified through aerial survey, especially at Oldbridge, south of the Boyne and also north of the WHS boundaries). But what about the pre-passage tomb landscape of Brú na Bóinne? This paper reviews the archaeology and development of Brú na Bóinne from the earliest Holocene to the construction of the passage tombs. There are gaps — both spatial and temporal — in this story, but these offer useful pointers for future research.

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A word about dating

In recent years there have been attempts to standardise the timing of the Neolithic in Ireland (Table 1). As is usually the case, these are based on a very discontinuous dataset (see for example maps in McLoughlin *et al.* 2016 and Whitehouse *et al.* 2014). The current best model is probably that of Nicki Whitehouse and colleagues (2014). While the EN I phase is still really quite poorly defined, EN II includes within it a distinct 'house horizon' (Whitehouse *et al.* 2014, 186), marking the short-lived construction phase for rectilinear Neolithic houses (Cooney *et al.* 2011; McSparron 2008; Smyth 2006; 2010; 2013, 306; 2014, 41–50).

It seems likely that the Middle Neolithic phases in particular need further definition. In neither period are domestic structures well-defined, and their division seems to be largely concerned with funerary architecture, despite difficulties in establishing dates for construction versus the use of megalithic structures (McLoughlin *et al.* 2016, 126–30). In this case there are somewhat circular arguments made by automatically assigning monuments of a particular class (e.g. most passage tombs) to MN II while also acknowledging that some belong in MN I, and similarly by assigning undated pit complexes to MN I without them having the chance to extend their range to MN II.

With regard to the chronology of passage tombs in Ireland, significant work is currently in progress, but a number of early dates have been published in recent years including from Carrowmore (Bergh and Hensey 2013) and Baltinglass (Schulting *et al.* 2017), suggesting at least some construction in EN II, with a floruit in the Middle Neolithic (e.g. dates in Cody 2019; Eogan and Cleary 2017; Kador *et al.* 2015; 2018; Smyth 2009).

Most of the recorded archaeology we are considering within Brú na Bóinne runs from EN II to MN I, although in some cases the radiocarbon dates certainly extend back to the earliest Neolithic. In fact, some of these dates potentially push back into the Late Mesolithic, but this may well be due to early dates that would benefit from modern refinement or to the presence of residual charcoal (the dates are almost universally charcoal dates) either from natural fires or genuine Late Mesolithic activity.

Period	Short name	Dates
Early Neolithic I	EN I	≥4000–3750 cal BC
Early Neolithic II	EN II	3750–3600 cal BC
Middle Neolithic I	MN I	3600–3400 cal BC
Middle Neolithic II	MN II	3400–3100 cal BC
Late Neolithic	LN	3100–2500 cal BC

Table 1. Chronological categories defined by Whitehouse *et al.* (2014).

In the beginning — Brú na Bóinne after the ice

Brú na Bóinne (Figure 1) is a landscape created by water. Some of that water was frozen — the glacial scour marks are clearly visible in large-scale topographic (LiDAR) datasets showing the movement of the ice sheet out over the Boyne Valley towards the Irish Sea (Clark *et al.* 2017; Meehan and Warren 1999; Michel *et al.* 2023). However, most of the building blocks of the physical landscape of Brú na Bóinne relate to the period of deglaciation. At this time, as the ice retreated north-west, significant volumes of meltwater created a series of substantial palaeochannels and terraces within the Carboniferous shales, before the river settled in its current rock-cut channel, most likely early in the post-glacial period (Lewis *et al.* 2017; Mitchell 1984). The channel sequence that divides the landscape into a series of smaller islands is up to 40 m higher than the current channel — most of these earlier channels have been dry for a very long time, and there are very few signs of Holocene mobility at Brú na Bóinne. At Site B, the lowest-lying passage tomb on the current floodplain, a henge monument has been constructed overlying what is probably the least elevated palaeochannel in the current landscape, suggesting that even this has not actively held flow since the Late Neolithic (Davis and Rassmann 2021; Davis *et al.* 2013).

Elsewhere there are small infilled basins, again left by the ice and most likely terrestrialised by the time the Neolithic tombs were constructed. To the north of Newgrange there is a large, shallow basin at Balfeddock that preserves undated organic silts and marl at its base; to the west the Early Medieval settlement cemetery of Site M (Stout and Stout 2008) is also built within a former lake basin, with marl at its base, and further west still, just beyond the boundaries of the World Heritage Site, a small basin at Crewbane held both peat and marl. The marl to peat transition at Crewbane has been dated to the Early Mesolithic (8542–8294 cal BC; UBA-12948; 9186±41 BP: all dates have been recalibrated using Calib v. 8.20 (Stuiver and Reimer 1993) and the IntCal20 calibration curve), while at Site M a Late Mesolithic date (4344–4225 cal BC; UB-7021; 5398±38 BP) suggests the site was at least seasonal wetland at this time. One of these basins — Ballyboy Lake, to the north of Newgrange — still holds water and was suggested by David Weir (1996) to preserve a full Holocene sequence, ideal for pollen analysis. As it stands, the only pollen analysis at Brú na Bóinne is from spot samples from within the passage tomb excavations themselves (e.g. Groenman-van Waateringe 1984; Groenman van Waateringe and Pals 1982) — interesting in providing a snapshot of the immediate pre-passage tomb landscape but not long-term landscape dynamics — and the undated diagram from south of Brú na Bóinne at Thomastown Bog (Davis 2017). This seems to suggest a pre-Neolithic regional landscape of mixed oak and elm woodland, in keeping with

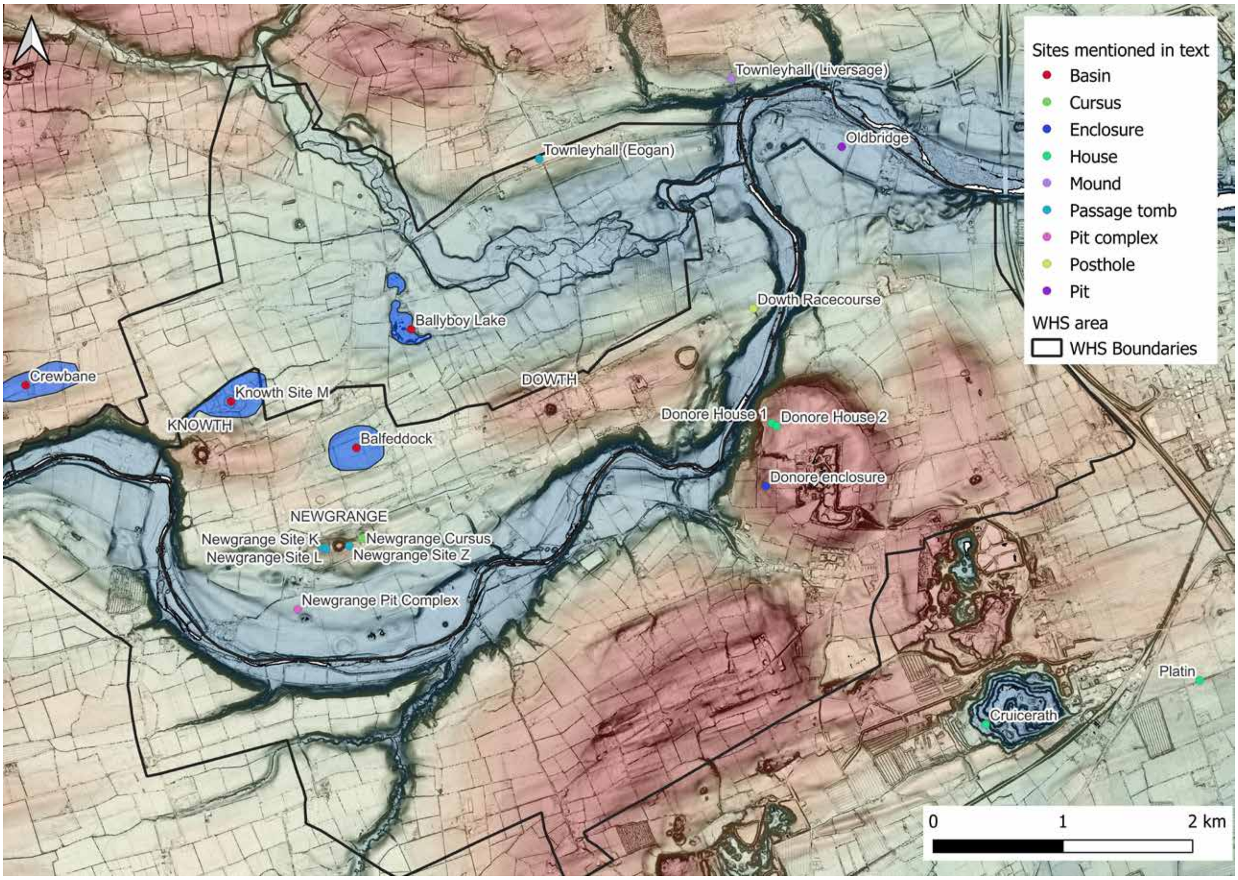

Figure 1. Location map of main sites mentioned in the article, superimposed on elevation model of the Brú na Bóinne landscape.

the slightly more distant analysis by Weir (1995) at several sites in Co. Louth.

The first visitors to Brú na Bóinne would likely have found a landscape both familiar but also different to that of today, although the shale outcrops on which the great tombs were later constructed would have been clearly visible prominences, watching over the river at Brú na Bóinne. Similarly, the river Boyne itself settled into its current position very early in the Holocene and has hardly moved since; however, the vegetation is likely to have been quite different, with at least a mosaic of woodland types, and there would have been significantly more standing water or marshland than today. Even if the basins were well on the way to terrestrialisation, they may have held seasonal water. This would likely have been an attractive landscape for hunter-gatherer communities as seen at similar terrestrialising basins elsewhere in Meath, like at Clowanstown (Fitzgerald 2007), where activity continued into the Early Neolithic (EN I). Graeme Warren (2022, 159) suggests that such temporal continuity might indicate 'interaction between existing communities and new practices and/or people'.

The archaeological evidence for a Mesolithic presence in Brú na Bóinne is quite scant. At Newgrange, excavations in front of the mound yielded a small number of characteristic Late Mesolithic stone tools (M. O'Kelly *et al.* 1983, 144–7). While these are presumably of Late Mesolithic origin, George Eogan (1991) suggests they could represent later re-use of material. At Oldbridge, charcoal from one of a large number of tree throws identified through geophysical survey provided a date of 6565–6272 cal BC (UBA-45327; 7584±44 BP; Seaver and Davis 2017). While these contained a small number of non-diagnostic lithics and a small fragment of Beaker pottery, they are located in an area of intense Bronze Age funerary activity; as such the Mesolithic date may well date the long-vanished woodland cover. At Knowth, charcoal recovered from a spread north-east of house trench 3 (see below) yielded a date of 4891–4615 cal BC (5885±45 BP; GrN-18773). While there is of course the potential for residual charcoal, and George Eogan and Helen Roche (1997, 15) suggest possible contamination, this could perhaps relate to a genuinely early archaeological feature[1].

1 Two recent 'official' guided tours at Knowth have both referred to the earliest activity as being Mesolithic in date. While this is not necessarily true, it is certainly now within the greater narrative of Knowth as a site.

Evidence from geophysics/remote sensing

The nature of pre-megalithic archaeology at Brú na Bóinne, coupled with the predominantly pastoral agricultural landscape, means that identifying potential Early Neolithic structures using aerial approaches is not straightforward. This could be argued to be the case for much of Ireland really — while significant numbers of Early Neolithic rectangular houses have been identified from road schemes, identification of these prior to excavation has been vanishingly rare. These houses have been reviewed in detail by Jessica Smyth (2013; 2014), following earlier work by Cormac McSparron (2003; 2008) and Eoin Grogan (1996; 2002; 2004), but are probably ripe for revisiting considering the new construction boom across Ireland in the last decade. Hints of the potential of lowland Co. Meath can be seen from the M3 Navan–Kells road scheme (Walsh 2021, 52; see also Walsh *et al.* 2011), where at least five Early Neolithic rectangular houses of varying construction were identified. These sit alongside other sites identified within the M3 scheme as a whole (Walsh *et al.* 2011, 78) and classic excavated examples at Newtown, Co. Meath (Gowen and Halpin 1992), Coolfore, Co. Louth (O'Drisceoil 2007) and other less well-researched examples (e.g. at Cruicerath, Co. Meath — OCarroll 2005; Richardstown, Co. Meath — Byrnes 2000; Platin, Co. Meath — Moore 2003a).

Since 2010 Brú na Bóinne has seen significant remote sensing and geophysical survey (Condit and Keegan 2018; Davis and Rassmann 2021; Davis *et al.* 2013; Rassmann *et al.* 2019), focused primarily on LiDAR, aerial photography (especially in the hot, dry summer of 2018) and geomagnetic survey (Davis *et al.* 2019). There have been some hints of potential early structures in recent years but evidence from non-invasive methods remains quite scant.

The Newgrange cursus

Running north-west–south-east in the field immediately to the east of Newgrange, the cursus (C. O'Kelly 1978, 48) remains an enigmatic monument. Geophysical survey of this area (described in Smyth 2009, 23) shows the monument itself to be magnetically quiet, but placed within an area of very busy Late Neolithic archaeology associated with the Newgrange pit circle (Sweetman 1985). The cursus runs for *c.* 390 m north-west–south-east, ending in a hairpin

Figure 2. Newgrange cursus. LiDAR SkyView Factor image with inset showing post-defined area observed in July 2018 (photograph courtesy Anthony Murphy).

terminal to the south-east. The last *c.* 160 m to the south-east is defined by a ditch with no clear bank and runs to within 5 m of the Late Neolithic pit circle and associated features. These include the low mound listed by Claire O'Kelly (1978, 48) as the possible passage tomb of Site Z[1] (ME019-044003).

The north-west end is defined as heavily wooded relict field boundaries rather than as an upstanding earthwork monument. Cursus monuments in Ireland remain poorly understood and require further study (Condit 1995; Corlett 2014; Corlett and Kenny 2016; Kenny 2014; Leigh *et al.* 2018; 2019). Recent research appears to show a concentration of these monuments in the Dublin-Wicklow mountains (O'Driscoll 2024), an area where a series of Early to Middle Neolithic hilltop enclosures have also been identified (e.g. Hawkes 2019; O'Brien and O'Driscoll 2017), alongside the well-known concentration of passage tombs (e.g. Jackman 2018; Macalister 1932; Rynne 1963; Schulting *et al.* 2017; Walshe 1941). At Newgrange, aerial photography from 2018 shows a series of large, regularly-spaced postholes situated on the cursus bank, suggesting that this is a post-defined monument (Figure 2). Such post-defined cursus monuments are generally regarded as early in date (Thomas 2006), and its orientation is suggestive, running directly perpendicular to the direction of glacial striation, to the river and so to the general direction of monumentality in the Brú na Bóinne landscape.

South of the River Boyne at Donore Hill, large-scale geomagnetic survey (Davis *et al.* 2019) identified two probable Early Neolithic houses directly overlooking the Boyne and the floodplain at Dowth (Figure 3). Located 34 m apart at an elevation of *c.* 80 m OD, these are both oriented south-west–north-east (cf. Topping 1996, 161–3), with the western site measuring *c.* 15 × 7.7 m and the eastern *c.* 13 × 5.7 m, very much within the expected dimensions of such sites (Smyth 2014, 31; see also Grogan 2002, 519). A further 350 m to the south the western part of a large causewayed enclosure has been identified, surrounding a recorded prehistoric lithic scatter (ME020-077). The full extent of this is hard to define, but the geophysical signature — a double-ditched enclosure with multiple causeways — closely resembles that of Hughestown, Co. Wicklow, which was partially excavated by William O'Brien and James O'Driscoll (2017, fig. 5.4) and shown to be of Middle Neolithic date (*c.* 3600–3300 cal BC — O'Brien and O'Driscoll 2017, 325–6). Preliminary excavations in summer 2023 demonstrated the causewayed form as anticipated from geophysical survey, with very few finds other than crumbs of prehistoric pottery and a small number of struck pieces of flint, including at least one diagnostically Early to Middle Neolithic hollow scraper. This monument currently remains undated, but dateable material is available and post-excavation is currently in progress.

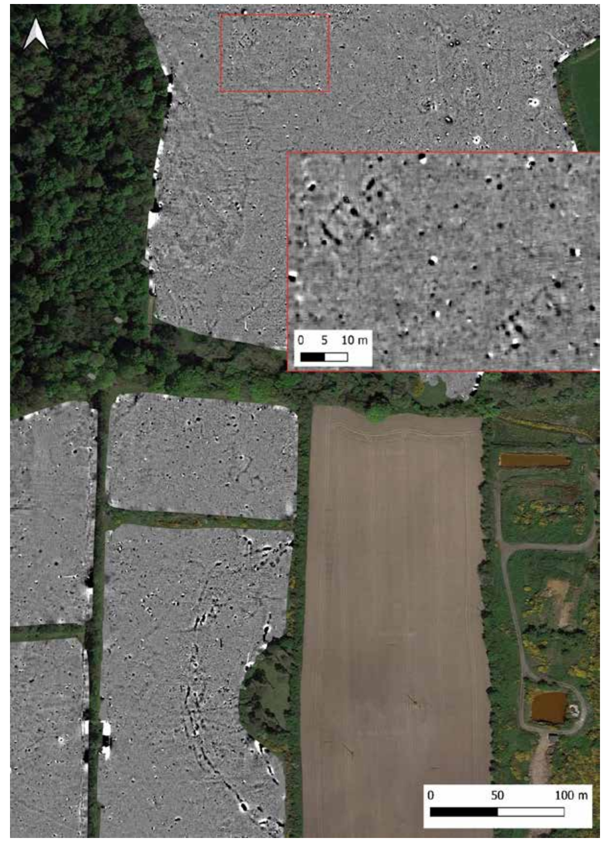

Figure 3. Donore area. Geomagnetic data over Google Earth (ramp ± 4nT), showing probable Early Neolithic house structures to the north and causewayed enclosure to the south.

Excavations at Townleyhall, Co. Louth

The greater part of the existing evidence for pre-passage tomb activity at Brú na Bóinne is through excavation, in particular the long-running and transformative programme of research undertaken by Eogan at Knowth over more than half a century (Eogan 1984; Eogan and Cleary 2017; Eogan and Roche 1997), and before that at Townley Hall, Co. Louth (Eogan 1961; 1963), where some of the first examples of pre-megalithic structures at Brú na Bóinne were excavated.

Early excavations by G. Liversage (1960) focused on what the author himself described as a rather uninteresting low mound. Early in his paper, he opines that if it had not been for the land reclamation scheme that exposed the site 'it is unlikely that the mound would ever have been excavated as the district teems with sites which [...] are much more attractive to the archaeologist' (Liversage 1960, 60). In fact, this does make a serious point about the history of excavation in Brú na Bóinne — it has tended to focus on the spectacular, and on passage tombs in general. Many other features within the Brú na Bóinne landscape remain very poorly understood and, especially, poorly dated.

Beneath Liversage's 'unimposing mound' (1960) lay what he described as an externally ditched and banked Neolithic settlement enclosure, into which two later cremations had been inserted. These mark what Liversage regarded as the transition of the site from 'domestic to spiritual ends' (1960, 49). Underneath the mound was a layer of subsoil mixed with charcoal belonging to a range of tree species, then a clay sealing layer marking another transition — from settlement to mound. The 'settlement' itself was difficult to define, but comprised a cluster of more than 90 stakeholes, perhaps representing an elongated tent-like structure (or at least this is how the author chose to reconstruct the site). While Liversage was of the opinion that these stakes were too narrow to support a heavy roof, it is likely that if they were woven into a basket-like construction they could have proved quite sturdy (see for example Early Medieval examples of similar construction — O'Sullivan *et al.* 2017). Finds from Liversage's excavation included 201 pieces of worked flint, 172 of these being flakes or partial flakes, and several sherds of prehistoric pottery with Carrowkeel-ware affinities. The excavation identified a probable flint-working area (a concentration of 63 flakes struck from two to three nodules within an area less than 30 cm square). This tight distribution suggests pressure flaking rather than percussion.

A second site at Townleyhall was excavated by Eogan in the early 1960s, focusing on a small passage tomb (Eogan 1961; 1963). Prior to excavation the site comprised a low, oval mound, measuring *c.* 18 × 12 m and *c.* 1 m in height. On excavation it became clear that the mound overlay an earlier occupation area, comprising a spread of habitation material covering an area of *c.* 15.75 × 11 m. Within this were recovered 314 sherds of pottery representing at least 24 vessels (largely Carrowkeel ware in character but with two sherds of 'Western' pottery, i.e. Carinated Bowl) and a large number of lithics (820 pieces of flint). Of these, 80 were considered to be tools, the assemblage dominated by hollow scrapers (46). As at Liversage's site, this spread again included a large number of stakeholes (142) averaging 5 cm in diameter by 15 cm deep, along with nine hearths, two of which were paved. Of the 124 pieces of charcoal recovered the majority derived from shrubby species, especially hazel (Eogan 1963, 39). Eogan suggests that this site might relate to a temporary camp by megalithic tomb builders or potentially a mobile 'family group' (Eogan 1963, 63), an idea he revisited at Knowth in relation to the so-called 'Decorated Pottery Complex'. A radiocarbon date from the sub-tomb habitation layer returned 3622–2701 cal BC (BM-170; 4460±150 BP), with a 96.4 % relative probability of being between 3531–2856 cal BC (Eogan 1991).

Pre-passage tomb Knowth

The majority of the Early Neolithic material at Knowth is discussed in the first two *Excavations at Knowth* volumes (Eogan 1984). Our understanding of pre-passage tomb activities at Knowth is hampered by the construction of the great mound itself, which occupies the spatially critical position between the earlier and later phases of activity. Eogan and Roche (1997) draw distinctions between the two phases based primarily on variations in material culture (pottery and lithic assemblages): specifically the earlier pottery and lithics are regarded as being of relatively poor quality, while the pottery within the later material is more developed in form with 'elaborated T-headed rims and exaggerated shoulders' (Eogan and Roche 1997, 5; see also Sheridan 1995; 2012).

The earlier phase, primarily located in Zones A and B (Figure 4) covered an area of approximately 75 × 25 m. Within this the foundation trenches for several buildings were identified, cut through the old land surface into natural subsoil. Of the three trenches identified in Zone A, two — Trenches 1 and 3 — are similar in form, incorporating substantial postholes of over 30 cm within the trench itself; however, these are arranged in such a way that they are difficult to reconcile into belonging to a single building. The third foundation trench — Trench 2 — appears to have been curved at each end and held much less substantial uprights, only 10 cm across. It also includes a possible doorway, a break of *c.* 90 cm 'outside' of which was a deposit of ash. Between Trenches 1 and 2 some pottery and evidence of flintworking was encountered. While Trenches 1 and 2 would appear to represent at least one rectangular post-built house, Trench 2 is perhaps part of a contemporary fence or land division. Two radiocarbon determinations from Trench 1 returned early dates of 5080±20 BP (GrN-20179), 3950–3800 cal BC, and 5040±15 BP (GrN-20180), 3946–3778 cal BC.

Immediately to the south of Zone A was Zone B, which contained four more shallow foundation trenches (Trenches 4–7), again most likely representing several buildings. Trenches 4 and 5 run directly parallel to one another, *c.* 5.5 m apart, likely representing wall trenches of a single house, while Trench 6 is spatially associated but on an entirely different orientation. In all cases, the features are fragmentary and truncated by later activity, perhaps providing some indication as to why more features of this kind have not been recorded at Brú na Bóinne. Trench 7, while of similar type and at the same stratigraphic level, was a further 15 m north of Trench 6 and likely represents the partial foundations of an entirely different building. A radiocarbon date from Trench 6 returned a very early date of 4318–4055 cal BC (5345±20 BP; GrN-20181). This is described as coming from a fill that consisted mainly of charcoal, implying either contamination from residual material or a very significant old wood impact.

To the west of Knowth, and covering a larger area, lay the later 'Western' Neolithic complex. Here the excavated remains are quite different in character and principally comprise a sub-rectangular structure of unusual design

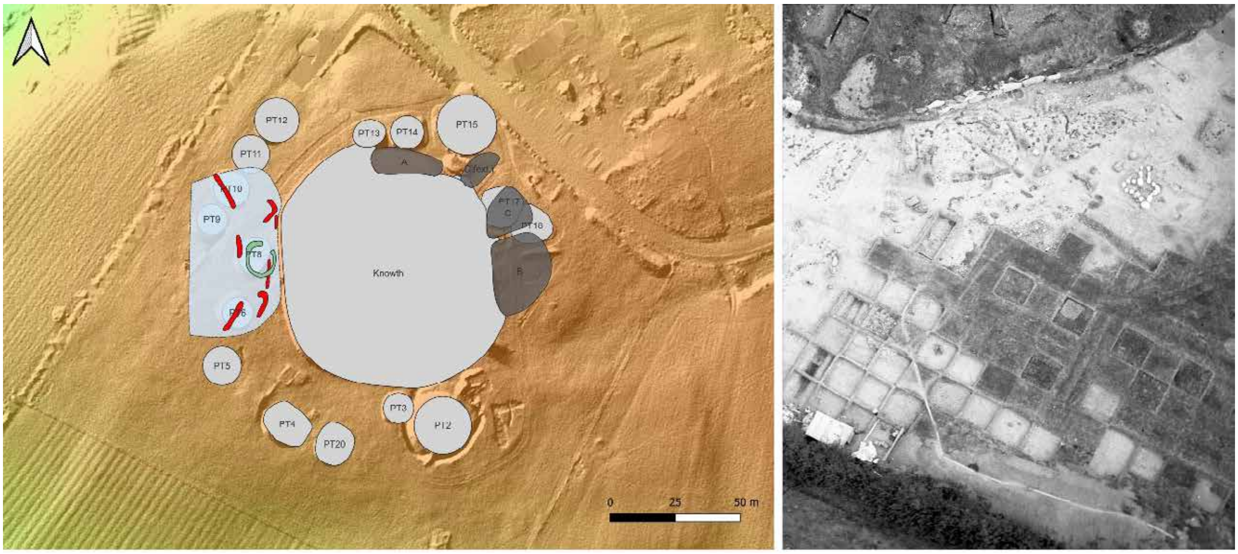

Figure 4. Left: Early Neolithic activity areas at Knowth. Areas A, B and C to the north-east mark the earlier ‘Western’ Neolithic settlement, with the later ‘Western’ settlement to the west. The ‘Decorated Pottery Complex’ of Zones D–H was located to the east, beneath Tomb 1, south of PT17 and PT18 and between PT15 and PT17 (cf. Eogan and Roche 1997, 51–3). Image redrawn from Eogan and Roche (1997) and overlain on LiDAR hillshade. Right: Aerial photograph from Leo Swan collection (LS_AS_67BWN_00070_06) showing the later ‘Western’ settlement under excavation.

and a double palisade. The sub-rectangular structure measured 12.3 × 10.1 m externally and appeared on three sides to be quite conventionally house-like, comprising narrow and moderately deep slot trenches (up to 40 cm). However, the fourth (western) side was different enough in character for Eogan to speculate that it was a later addition or modification, and the building lacks any obvious internal roof supports (not necessarily a unique situation; see examples in the catalogue in Smyth 2014, 28–30). Here, a much deeper trench (97 cm) held a row of 11 posts, on average *c.* 15 cm in diameter (Eogan 1984, 211). While Eogan (1984, 219) argues that this elaborated western side may have been for protection against prevailing winds, this seems quite a utilitarian explanation for such a substantial deviation in design. Within the building were a number of features including seven pits (although one of these, Pit 4, clearly pre-dates the building), a paved area and up to three areas of burning. All of the finds from here were interpreted by Eogan (1984, 215) as predating the rectangular structure. A single radiocarbon date from a pit within the structure returned 3792–3380 cal BC (BM-1076; 4852±71 BP) with 95.8 % relative probability of being between 3792–3505 cal BC, partially overlapping with some of the dates from the earlier material in Zones A and B, but with a substantial part of the range later.

Associated with and partially overcutting the ‘house’ were two palisades. These comprised two curving trenches, running not quite parallel to one another (they are 8 m apart at the southern end but 11 m at the northern end). These would have held narrow uprights, with an entrance causeway to the inner palisade defined by a 3.2 m break to the east. If these formed part of an enclosure then the inner palisade — the first phase — would have been *c.* 70 m in diameter, expanding to 100 m in the later phase (Eogan 1984, 240). However, Eogan (1984, 219) stresses that despite significant further excavation west of the palisades he was unable to locate any continuation of them, or any significant Early Neolithic material at all (two areas of pebbling with some lithics and a very few sherds of pottery were identified to the west), and that, similarly, there was no evidence that the trenches extended further at either end. Charcoal of oak and hazel, and grains of wheat were identified from a burned section of the eastern palisade trench (Eogan 1984, 223). Between the palisades there was a significant activity area, in fact almost all of the activity here was confined to the space between the palisades. This was interpreted as a possible living area, comprising a group of six pits of between 30–80 cm diameter and 5–20 cm deep, with two areas of pebbling. Numerous sherds of round-bottomed pottery were present especially around the southern of the two areas of pebbling and within Pit 12 (one of the largest). Also a broken stone axe and a scatter of 82 pieces of flint, including one leaf-shaped arrowhead and 11 rounded scrapers, was encountered.

Middle Neolithic I — the decorated pottery complex

To the east of Knowth, partially overlapping the earlier 'Western' Neolithic complex and covering an area of at least 50 × 25 m, lies what Eogan and Roche (1997) refer to as the 'Decorated Pottery Complex' of Zones D–H. Within this area a dense concentration of 590 stakeholes, 17 hearths and ten isolated pits was found. The stakeholes measured between 5–30 cm deep and 4–10 cm wide and were devoid of finds except for one flake of flint, some charcoal and hazelnut shells. As at Townleyhall, these are likely to represent the remains of stake-built houses, although they are difficult to define and likely relate to multiple overlapping structures. Among the stakeholes were a number of hearths and pits, with the authors using the hearths to attempt to define building outlines. Within the spreads of habitation material were a number of lithics (208) and 134 sherds of pottery of both Carrowkeel and broad-rimmed bowl type pottery. Two radiocarbon dates from within the Zone G habitation layer returned 4037–3345 cal BC and 3973–3028 cal BC (4875±150 BP; UB-318 and 4795±185 BP; UB-319 respectively). Given the overlap between the decorated pottery complex and the earlier 'Western' Neolithic, it is no surprise that some cross-contamination occurred within Zones G and H, where a number of sherds of Early Neolithic pottery were recovered.

Other excavations

At Newgrange there was very little obvious pre-tomb activity. The hut foundation excavated west of the tomb entrance (M. O'Kelly 1982, 76–7) is likely analogous to the stake-built structures seen in Middle Neolithic phases of both Townleyhall and Knowth, and Michael O'Kelly himself suggests it is likely contemporary with the tomb construction, but the dense concentrations of stakeholes at the other sites were not encountered. To the west of Newgrange, but occupying the same shale ridge, are two smaller satellite tombs — Sites K and L — that were fully excavated (M. O'Kelly *et al*. 1978). These are interesting in that despite the tombs being close enough to almost touch one another they appear to have quite different biographies: at one tomb (Site K) there was no apparent pre-tomb activity while at the other (Site L) this is not the case.

Site L, the more easterly of the two mounds, was already significantly disturbed by the time of excavation, but the central chamber retained an unusual form — a sort of inverted corbel stone-lined depression to a depth of 50 cm (M. O'Kelly *et al*. 1978, 252). The original mound had a diameter of 22–24 m, bulging slightly to the south-east but flattened to the west as it approached Site K, implying Site K was the earlier construction. Beyond the mound to the west was a double row of burned stakeholes, 30–40 cm deep. Unlike at Knowth or Townleyhall these do not appear to form potential buildings, but more closely follow the outer kerb of the tomb itself. If they do define a pre-tomb structure, its footprint would likely have quite closely matched the final tomb outline. Beneath the tomb lay a 'discontinuous habitation layer' (M. O'Kelly *et al*. 1978, 263), 5–10 cm thick and represented by no formal structures, but comprising six small pits and two depressions, one of which contained broken pottery belonging to an undecorated shouldered bowl. This is interpreted as having been gradually infilled and 'forsaken' by its inhabitants prior to the construction of the tomb. One hundred and three pieces of flint were recovered, of which ten were worked. No postholes were found, and only a single possible stakehole.

A third site was excavated at the same time — Site Z, located east of Newgrange. Once again there was some evidence of pre-tomb activity, although this was quite slight. The tomb itself was constructed on a thin turf layer *c*. 10 cm deep. Beneath this was a small, circular cobbled hearth and a number of substantial postholes, 35 cm across by 30 cm deep, perhaps forming a rough arc. Other postholes were also present but formed no clear pattern. No pottery was recovered from the pre-tomb levels, but the lithic assemblage included a fine but broken hollow-based arrowhead, which suggests that the whole construction might be quite late in date (cf. Woodman *et al.* 2006, 134).

Most recently, as part of a project to replant a tree avenue within the Dowth racecourse area, a small trench encountered several features including a large stone-packed posthole. This appears in the geophysical survey to be located within a possible small enclosure, bisected by the cut of the original carriage drive. This produced both Early Neolithic Carinated Bowl pottery and an Early Neolithic radiocarbon date of 3777–3648 cal BC (UBA-47341; 4943±29 BP — C. Ní Lionáin *pers. comm.*). As this was only a very small excavation area it is not really possible to speculate as to what this might belong to, although date-wise they fit within the 'house horizon' and in terms of the geophysical signature might bear some resemblance to Liversage's (1960) Townleyhall enclosure.

Conclusions

In conclusion, palaeoenvironmental evidence as well as an understanding of the landforms of Brú na Bóinne demonstrates that this almost certainly represented a very attractive location to early settlers, with areas of open water, marshland, scrubby woodland (likely rich in hazel) and perhaps some larger trees in places (e.g. Oldbridge). While it is likely that the shale ridge supported larger tree species, there is not as yet good evidence for this. Evidence does, however, suggest that these were cleared quite early — especially at Knowth — and that as a location these high points are likely to have been highly visible landmarks long before tombs were ever constructed there.

The earliest Neolithic evidence for habitation at Brú na Bóinne is at Knowth, where there appear to have been

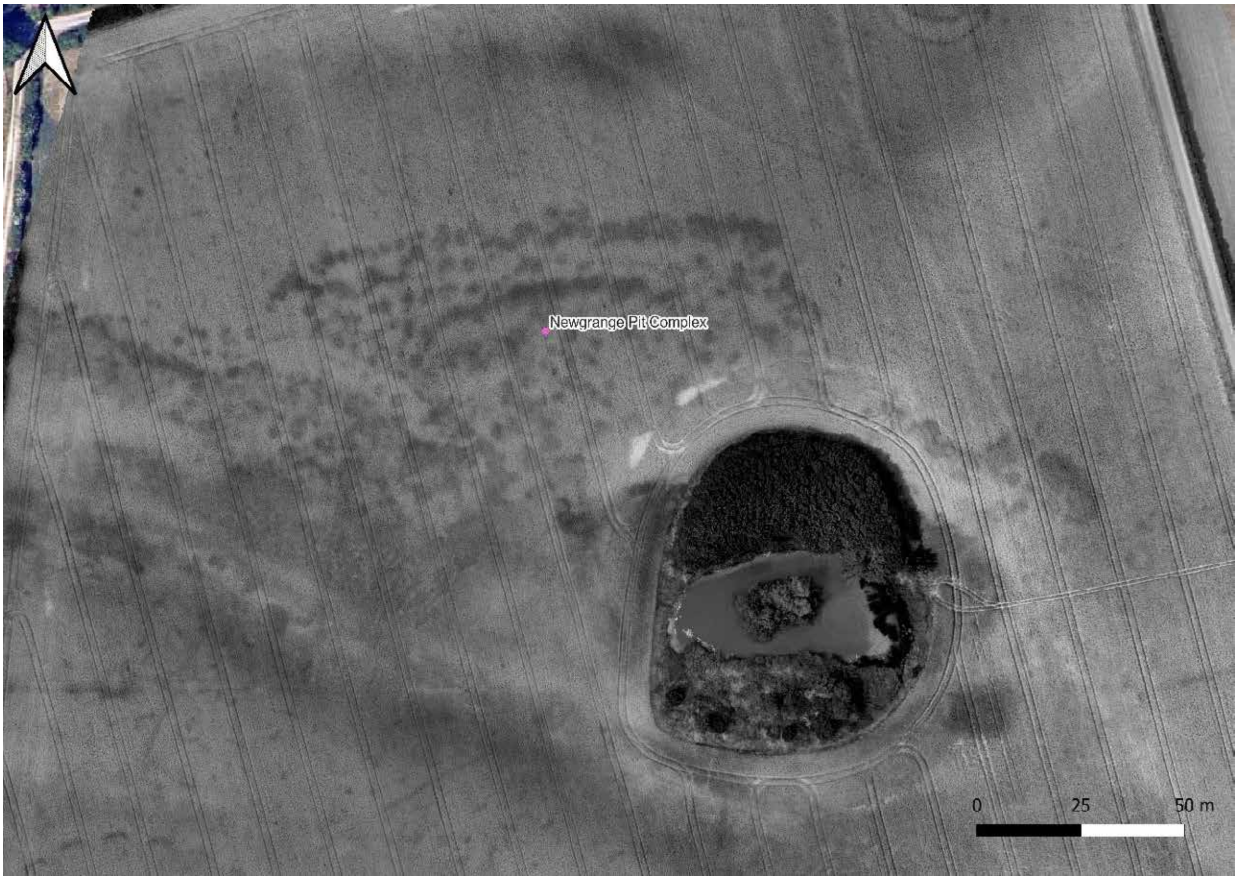

Figure 5. Pit complex at Newgrange, Co. Meath. Orthophotograph (red band only) courtesy Ken Williams.

several Early Neolithic rectangular houses, followed by the double palisade to the west. All of these comprise fragmentary slot trenches and postholes, but significant spreads of cultural material. The fragmentary nature of these remains suggests preservation across the wider landscape is likely to be a serious issue: if the slot trenches are ploughed out then these sites essentially become invisible to geophysical methods other than as a series of postholes/stakeholes, or as spreads of burned material. Recent survey at Brú na Bóinne using multichannel GPR (T. Axelsson *pers. comm.*) has also demonstrated the value of multiple methods in this landscape, especially in identifying features that do not include such burned deposits.

This highlights a further issue: even if early sites are preserved, they are likely to be difficult to spot short of excavation. An exception here seems to be the probable houses and causewayed enclosure south of the Boyne at Donore; however, the only other recent site identified through geophysical survey and tested through excavation is the small enclosure at Dowth that might very easily have been classified alongside Liversage's mound at Townleyhall as something of a 'second-rate' archaeological target. Across the *c.* 4 km^2 of geomagnetic data obtained so far at Brú na Bóinne there are a very large number of pit-like features identified that could be considered 'pit complexes' *sensu* Rowan McLaughlin and colleagues (2016). Indeed, one of the most startling crop marks to appear in the 2018 aerial photography was not the Late Neolithic henge monuments but the substantial pit complex south of Newgrange (Figure 5). The importance of pits and of pit digging has been previously highlighted by Smyth (2012; 2014, 112–8), who stresses the point that these remain an underexplored element within the Irish Neolithic. Of course, like many other structures those at Brú na Bóinne are not assignable to a specific period without excavation, but it is very likely that some represent traces of early activity. In terms of Mesolithic activity, to find this would likely require a dedicated research project, perhaps focusing on Mesolithic areas of standing water. So far, these remain almost entirely unexplored.

The dating of early activity here is also a major issue: while the dates are quite early, some of them are much earlier than one might expect, while others have such broad ranges to be quite unhelpful. This most likely implies the presence of residual charcoal, perhaps in significant quantities. For example, the slot at the later 'Western' settlement that Eogan chose to date was described as consisting of ‘wet and mushy charcoal’ (Eogan 1984, 223). This implies that the deposit was almost entirely charcoal, rather than containing a proportion of charcoal, and still returned a very early date. Is this evidence of pre-Neolithic activity at Knowth? It is impossible to say, and the absence of Late Mesolithic material culture might argue against this, although given the find of ‘Bann flakes’ at Newgrange such a presence cannot be discounted.

How much of a bearing did the first farmers at Brú na Bóinne have on the later placement of monuments, or indeed did pre-Neolithic activities have on the placement of those first farms? These are difficult questions to answer and at the very least need far better chronological control than currently exists. Location was clearly important — perhaps critical — for these early farmers (see for example Moore 2003b). It may be that developments at Knowth echo those at Ballyglass (Ó Nualláin 1972; Smyth 2020), where the construction of a court tomb partially sealed two Early Neolithic houses — not overbuilding these in their entirety, but partially overlying these ‘origin places’, perhaps as a means of commemoration (e.g. Kay *et al*. 2023, 884) and as a ‘continuous reinterpretation of place’ (Thomas 1996, 8).

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NOTES FROM THE ARCHIVES

Re-analysis of skeletal assemblages from three later fourth millennium BC Irish passage tombs

Jessica Smyth, Jonny Geber, Neil Carlin,
Muiris O'Sullivan and Seren Griffiths

Abstract

Passage tombs are one of the best-known aspects of the Irish Neolithic, with over 200 surviving examples recorded. A small fraction of these monuments have been excavated with any associated human remains rarely recorded to modern osteoarchaeological standards. This makes it challenging to make robust inferences on the nature of mortuary practice and social structure in the Irish Neolithic, but overcoming these challenges is not an impossible task. In this paper we outline recent and ongoing re-analysis of skeletal assemblages from three late fourth-millennium BC passage tombs — Knockroe, Co. Kilkenny, and Fourknocks and Newgrange, Co. Meath — all excavated between 1950 and 2010. The burial deposits from Knockroe and Fourknocks were fully sampled during excavation and represent a rare opportunity to fully analyse and assess what may come close to a complete sequence of prehistoric burial activity. The surviving archive from Newgrange, while incomplete, is nevertheless providing new insight on the nature of activity within the tomb. We highlight the value of approaching older excavation archives with new methods and fresh eyes, and underscore the importance of constructing robust, standardised baselines of archaeologically analysable populations.

Keywords: Neolithic Ireland; passage graves; mortuary practices; osteoarchaeology

Introduction

Passage tombs remain one of the most well-known aspects of the Irish Neolithic, with over 200 surviving examples recorded (Ó Nualláin 1989). A small fraction of these monuments have been excavated, but their construction and primary use seems to range from approximately 3700 to 3000 BC, with smaller 'simple' examples generally pre-dating the larger and more elaborate focal monuments at, for example, Brú na Bóinne (e.g. Cooney 2000; Hensey 2015). Many of these excavations were undertaken at a time when there was limited interest in human bone — especially cremated human bone — from archaeological contexts (O'Donnabhain and Murphy 2014), and it is unclear how much of the deposits encountered during those investigations was recovered (see Geber *et al.* 2017a; 2017b). Before the 1990s, it was common for anatomists to undertake skeletal analyses of archaeological bone assemblages in Ireland, but these studies are generally descriptive and brief. Despite that, they are still frequently referenced in archaeological literature, even though the reported results in those sources are often speculative and non-

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scientific to modern standards. Numerous reassessments of old ‘antiquarian’ collections previously analysed by anatomists have shown a clear disparity in results when assessed following osteoarchaeological methods and approaches (see Crozier 2016; Geber *et al.* 2017a; Laurence 2006). Where more modern recording methods have been undertaken, there is still considerable variation in approach. For example, standard recording methods (i.e. of bone fragmentation and taphonomy, as well as how exactly MNI was calculated) were not used during analysis of the human bone assemblages from Newgrange, Knowth and Mound of the Hostages passage tombs (Eogan and Cleary 2017; O’Kelly 1982; O’Sullivan 2005), making integrated analysis of data from these important passage tombs very difficult. In recent years, a quantitative reassessment of the surviving osteological material from the Carrowkeel passage tombs, excavated in 1911 (Hensey *et al.* 2014; Macalister *et al.* 1912), has demonstrated the informative potential of older passage tomb archives, even those where accompanying spatial and/or contextual information has been lost. At Carrowkeel, new work has revised the original minimum number of individuals (MNI), explored contextual patterns between tombs and material (unburnt and cremated) relating to sex and age-at-death, as well as providing new evidence for mortuary practice and processing of the dead (Geber *et al.* 2017a; 2017b; Kador *et al.* 2018). The following contribution details ongoing osteological reassessment of two substantial human bone archives from later fourth millennium BC passage tombs — Knockroe, Co. Kilkenny and Fourknocks, Co. Meath — following the same standardised methods undertaken at the Carrowkeel passage tomb complex (Geber *et al.* 2017a; 2017b). We also introduce new work on the surviving skeletal remains — human and animal — from the chamber of Newgrange passage tomb, also dating to the later fourth millennium BC.

Knockroe, Co. Kilkenny

Knockroe belongs to a small cluster of passage tombs associated with the Linguan river, a tributary of the Suir, in south-east Ireland; a large cairn on the summit of Slievenamon, about 10 km to the west of Knockroe, also appears to have been a prominent reference point for this group (Figure 1). Knockroe was noted in the Ordnance Survey memoranda of the 1840s, but did not appear on any subsequent O.S. maps. It was published for the first time in the early 1900s (Carrigan 1905, 324–5) but was not recognised as a passage tomb until the 1980s (Ó Nualláin and Cody 1987, 71–4). The monument comprises a cairn on a platform measuring approximately 20 m in diameter, with a megalithic kerb that encloses two orthostatic chambers, one entered from the south-east

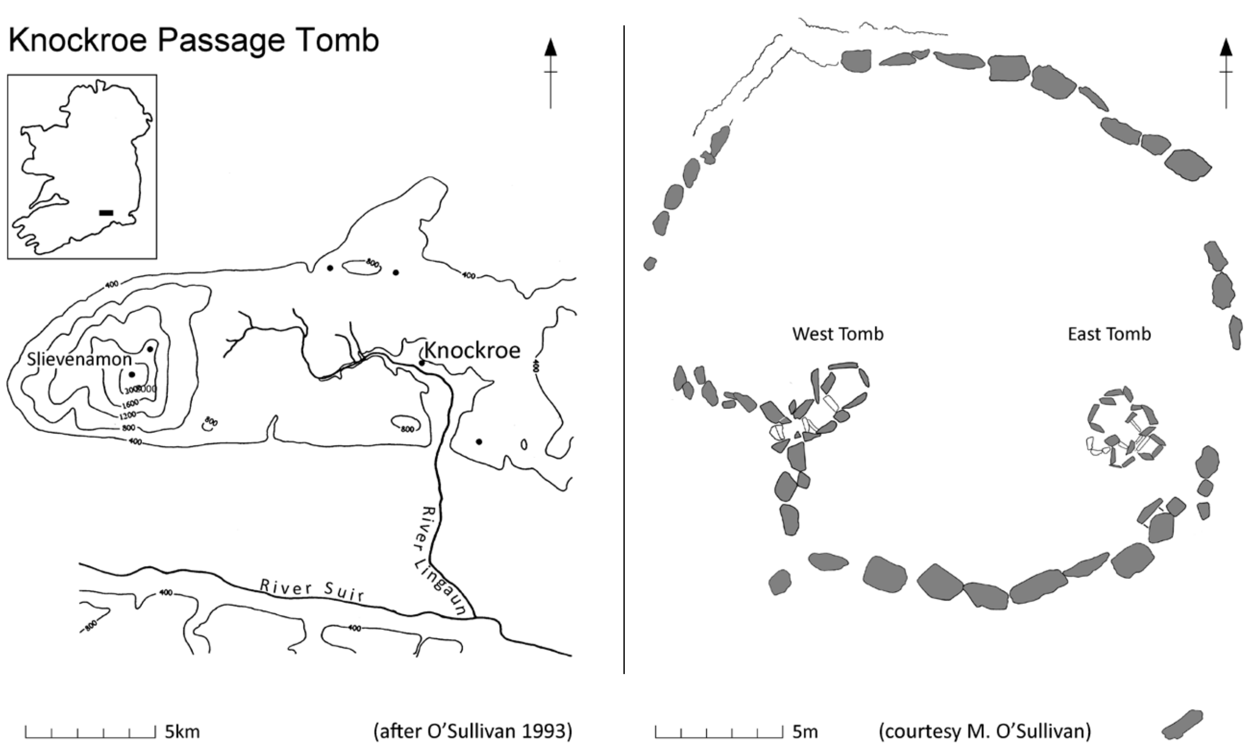

Figure 1. Left: distribution of passage tombs and cairns/mounds in the vicinity of Knockroe and the Lingaun river. Right: post-excavation plan of Knockroe passage tomb.

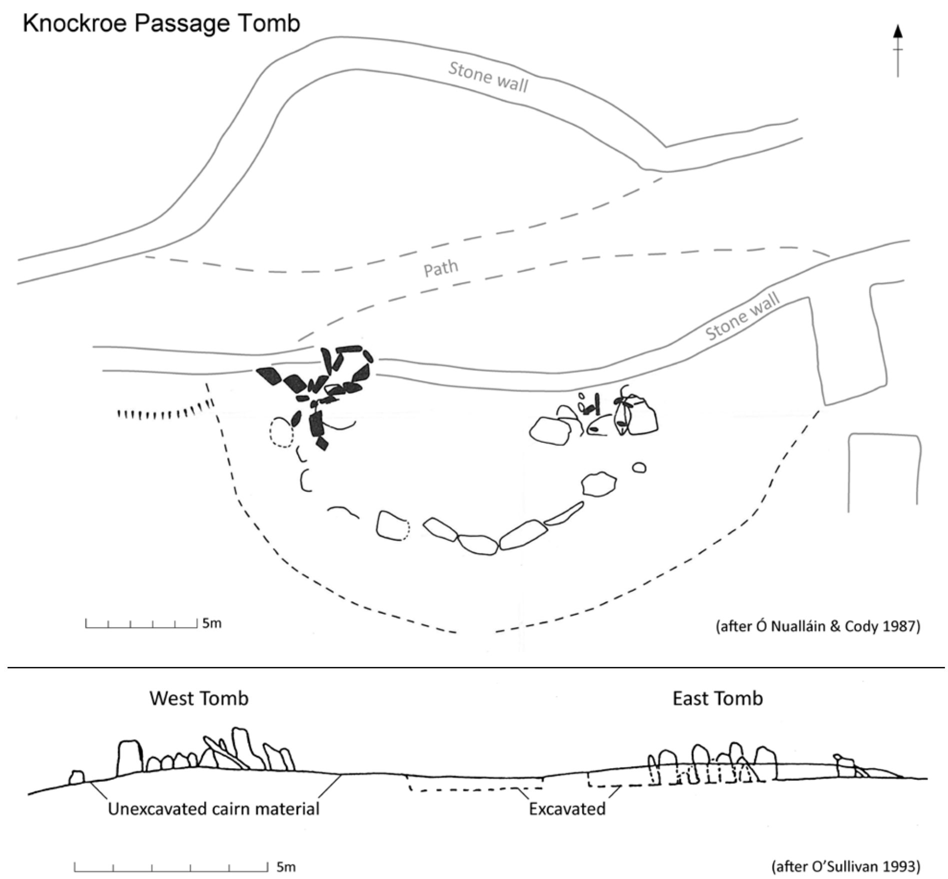

Figure 2. Top: 1980s field survey plan of Knockroe, showing modern agricultural disturbance. Bottom: profile of Knockroe, post-1990s excavation, showing relative height/exposure of tomb structures within the surviving cairn.

and the other from the south-west (labelled here the 'east tomb' and 'west tomb' for convenience; O'Sullivan 1993; 1995; 1996) (Figure 1). The east tomb is aligned to the rising sun at the mid-winter solstice and the west tomb is aligned to the setting sun on the same day, a unique double alignment. Approximately 35 decorated stones occur at the site, distributed mainly along the megalithic kerb and structural stones of the tombs (O'Sullivan 1987). Knockroe displays several points of close similarity with the much larger passage tombs at Knowth and Newgrange in the Boyne valley, not least the types of stones utilised in its construction, such as greywacke, quartz and sandstone (O'Sullivan 2004). However, at Knockroe these stones were available locally, a major point of divergence from the Boyne sites where many of the favoured stone types had to be sourced a considerable distance away (e.g. Eogan and Cleary 2017).

Significant structural damage and depletion was evident prior to the commencement of archaeological excavation. The west tomb stood proud of the cairn while the east tomb was mostly covered, with only the roof-stones and the tips of orthostats visible on the surface. This means that the west tomb was more accessible for an unknown period of time. The west tomb had a mature ash tree growing in the inner chamber, while a drystone field wall had been built over the east tomb, running across the top of its inner chamber (Figure 2). The site was initially excavated over four field seasons from 1991 to 1995, with a final season of excavation in 2010 associated with the reinstatement and conservation of the monument (O'Sullivan 1993; 1995; 1996; 2004). A large amount of cremated human bone and a small amount of unburnt bone was recovered from within the tombs, alongside sherds of Carrowkeel Ware and Grooved Ware pottery, worked flint, fragments of bone and antler pins, bone spacers, and stone beads and pendants. Many of these artefacts are typical of the material culture associated with Irish passage tombs (e.g. Herity 1974). The recovery of Food Vessel pottery sherds also indicates later use in the Early Bronze Age, a phenomenon commonly observed at passage tombs and other megalithic monuments (Mount 2013; Ó Riordáin 1968; Schulting *et al.* 2012); the Beaker pottery sherds from Knockroe are exceptional in a passage tomb context and have otherwise only been recorded at Knowth (Carlin 2018, 110).

Three radiocarbon dates obtained in the 1990s on charcoal from sealed ash layers in front of the tombs were modern in origin, likely related to recent scrub clearance on the site. More recently, two rounds of radiocarbon dating on 29 samples of cremated and unburnt human bone and animal bone, teeth and antler indicate that there has been considerable disturbance of the tomb deposits, with some younger dates returned from samples lower in the stratigraphic sequence and vice versa. Nevertheless, preliminary chronological modelling is teasing apart activity across the two tombs, with some emerging signs of sequence and tempo. In the west tomb, a complex series of burial rites is indicated by the available radiocarbon results. These rites may have included changes in burial practices between inhumation and cremation, and possible evidence of secondary burial prior to a main phase of cremation burial, most probably in either the thirty-third or thirty-first century cal BC (see discussion in O'Sullivan forthcoming). It is possible to infer a variety of practices that occurred in this monument, including the deposition of pins of animal bone and antler, but the nature of the burial practices in the west tomb appears to be of a subtly different character from those witnessed at the east tomb. In the east tomb, burial appears to have started a little later than in the west tomb, and the monument appears to have been the focus of much later activity, including in the twenty-ninth century and again in the late third millennium BC.

Notwithstanding the disturbance outlined above, Knockroe is one of the very few Irish passage tombs where we can be sure that the surviving burial deposits were fully sampled during excavation. It thus provides a unique opportunity to fully analyse and assess what may come close to a complete sequence of prehistoric burial activity. Osteological analysis took place over a 16-week period from July 2021 to May 2023 at the School of Archaeology, University College Dublin. The bone was mostly dry-sieved through a series of standard mesh sizes, with a small proportion of remains wet-sieved. The total bone assemblage amounted to 217.9 kg (>5.6 million fragments) and represents one of the largest assemblage of cremated human remains recorded from a megalithic monument. These remains were severely fragmented and posed a significant challenge in terms of analysis. Numerous fragments of artefacts (e.g. bone pins, beads etc.) were also recovered, as well as faunal remains, which are subject to separate investigation. This contribution summarises the results as they currently stand; the vast amount of data generated from the osteological analysis still need to be carefully assessed and evaluated through statistical analysis and various quantitative methods (e.g. taking size/sex/age-at-death, archaeological context and radiocarbon dates into account).

The vast majority of the human bone from Knockroe was cremated, representing 99.85 % of the assemblage by weight and 99.99 % by fragment count (NISP). Unburnt human bone was represented by 648 fragments (335.88 g), comprised primarily of very small fragments of smaller bones such as hand and finger bones and some cranial fragments and teeth. The high fragmentation of the Knockroe assemblage makes it difficult to conclude anything of significance relating to the demographic profile of the population interred in the tomb. Most of the identified fragments derive from adults, due to them being larger in size and generally better preserved. It is evident, however, that both adults and non-adults were deposited, with the latter category including individuals from neonates to older children. The total minimum number of individuals in the assemblage (preliminary), based on most frequently occurring anatomical landmark (generally the petrous part of the temporal bones), taking age group and side into consideration, is 92. Taking the considerable degree of fragmentation into account, the general anatomical distribution of identified elements suggests that depositions of complete cremated remains of individuals were placed within the tombs at Knockroe; selection of specific elements did not seem to be part of the burial rite. Only a small proportion of fragments could be used for sex estimations, which were conducted on a limited number of observable features. As the remains from Knockroe were commingled, it is impossible to grasp a sense of what are typically 'male' or 'female' features in the skeletal remains; most of the morphological traits display what are considered 'indeterminate' sex-dimorphic features.

Fourknocks I and II, Co. Meath

Fourknocks passage tomb is situated at the western end of a broad ridge running north-east–south-west, on high ground about 15 km south-east of Brú na Bóinne. Similar to Knockroe, Fourknocks was not identified as a passage tomb until the twentieth century. Indeed, prior to being brought to the notice of National Museum of Ireland (NMI) staff in 1949 by a local landowner, it had not been recorded as an archaeological monument. In total, three disturbed mounds were investigated by P.J. Hartnett from the NMI in 1949 and research excavations led by Hartnett commenced in September 1950, jointly funded by the Royal Irish Academy and the NMI. Three field seasons were completed, with Fourknocks I excavated from September to November 1950, and Fourknocks II and III from July to September 1951 and June to August 1952 (Hartnett 1957; 1971) (Figure 3). Fourknocks I, a grass-covered tumulus 20 m in diameter and 4 m high, was revealed to be a passage tomb and comprised an orthostatic passage leading into a large central area off which lay three chambers with lintelled roofs. The central area may have been at least partially covered by a corbelled roof, with the entire structure covered by a circular mound of turves delimited by a low drystone kerb. The nearby Fourknocks II, 50 m to the east, comprised an ovoid tumulus of 28 × 24 m and approximately 4 m in height. This tumulus, surrounded by a ditch, covered two separate monuments: a bell-shaped cairn and a megalithic passage with a trench placed transversely to it. The passage and trench were used for human burial and Fourknocks II was interpreted as a cremation site later made to resemble

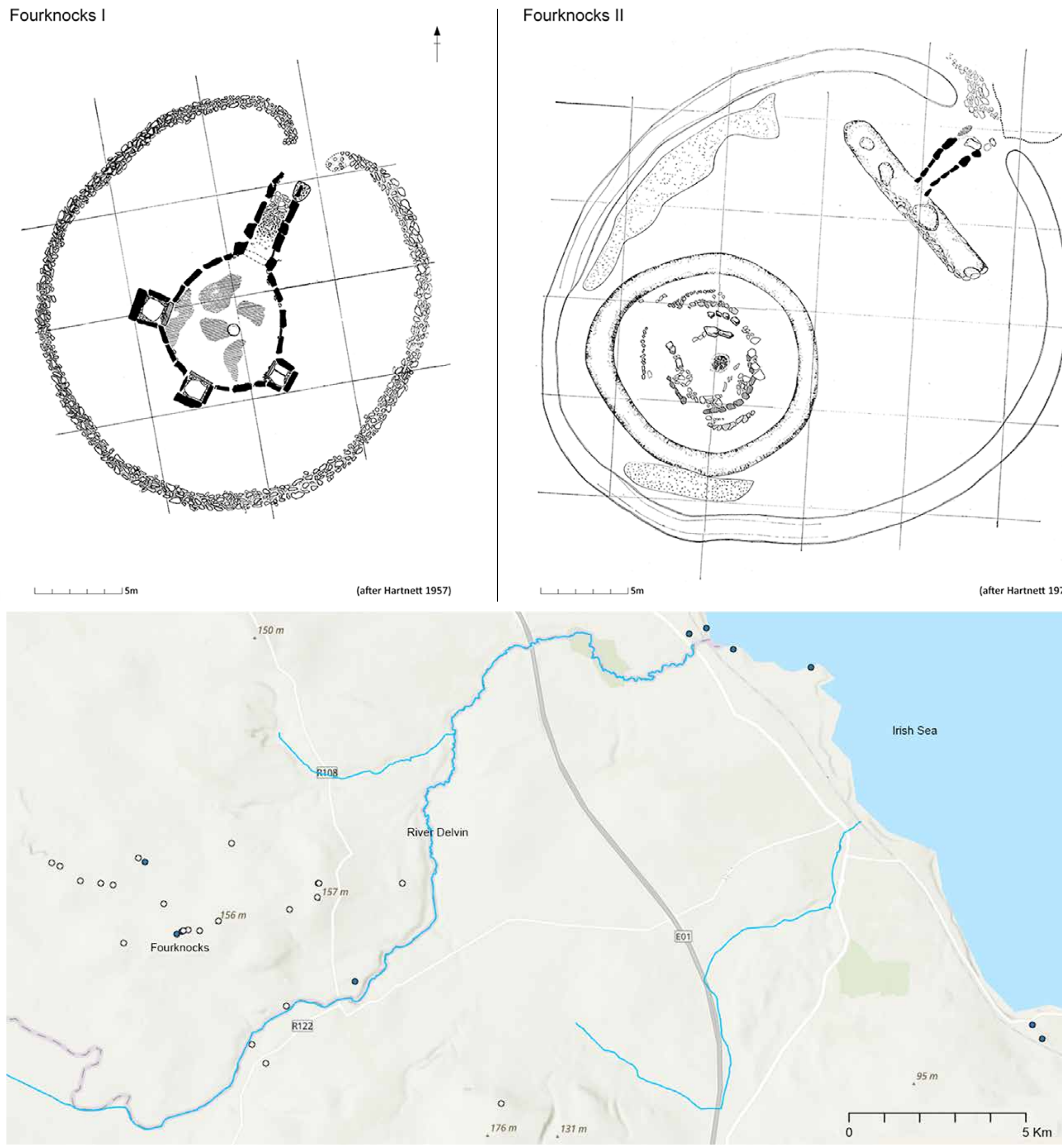

Figure 3. Top: post-excavation plans of Fourknocks I and II. Bottom: distribution of confirmed and likely passage tombs (blue circles) and confirmed and likely prehistoric monuments (white circles) in the vicinity of Fourknocks and the Delvin river.

a passage tomb with the addition of a covering mound and orthostatic passage (Cooney 2000, 106–12, fig. 4.6; 2023, 215; Hartnett 1971); Fourknocks III appeared to be an Early Bronze Age burial mound, with a small tumulus about 13 m in diameter and 2 m in height covering a central pit containing cremated human bone. Early Bronze Age burials were also inserted into the mounds of Fourknocks I, II and III.

There are no radiocarbon dates on primary (i.e. Neolithic) material from Fourknocks I or II, although samples of both unburnt and cremated bone from two secondary cist burials from Fourknocks II (Burials 2 and 4 in Hartnett 1971) recently returned dates ranging from 2450–1750 BC (Cleary 2016). We also know very little about the substantial quantity of human bone recovered from Fourknocks I and its associated cremation site Fourknocks II. These human remains were

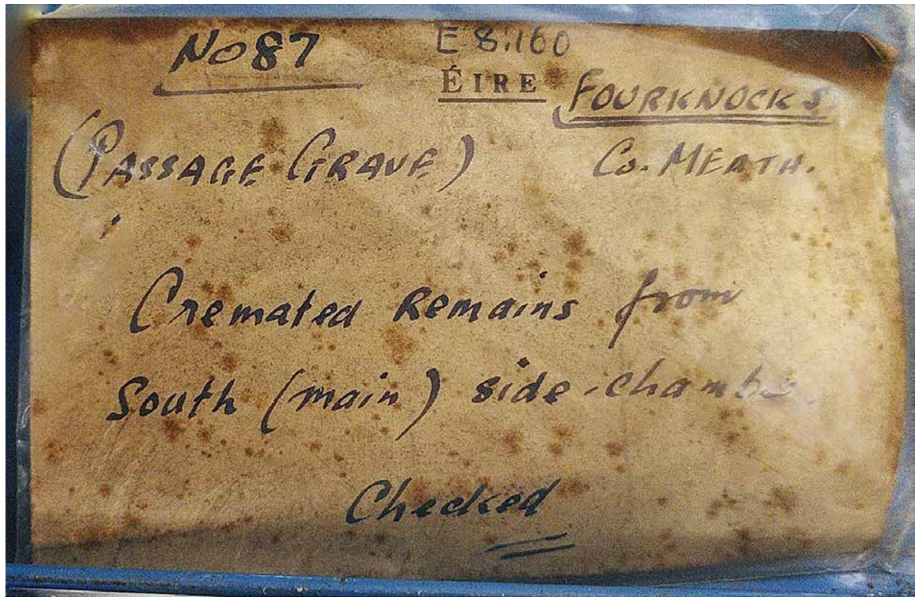

Figure 4. Example of original excavation label associated with the Fourknocks bone deposits in the National Museum of Ireland collections. 'No 87' refers to the finds/sample number assigned during excavation, while 'E8:160' refers to the museum registration number assigned post-excavation.

examined shortly after excavation by anatomist Prof. E. Keenan, but the original Fourknocks I human bone report runs to just two pages (Appendix B, Hartnett 1957), while the Fourknocks II publication contains a few paragraphs of information assembled posthumously from Keenan's notes (Hartnett 1971, 41–4). It appears that the Neolithic bone was deposited as a single commingled mass in each of the three recesses of Fourknocks I, with 'no suggestion of individual deposits' (Hartnett 1957, 216). A small admixture of unburnt bone material was observed during excavation, but it was estimated that over 80 % by bulk of the primary burials were cremated (Hartnett 1957, 249). In Fourknocks II, there appear to have been three separate burial deposits in the megalithic passage. The largest of these comprised a mass of cremated human bone with the unburnt remains of children scattered through it. In the transverse trench connected to the megalithic passage further small deposits of cremated bone were recovered, some associated with pits dug into the floor of the trench.

An initial assessment of the Fourknocks I and II human bone material, stored in the collections of the National Museum of Ireland, was undertaken in August 2022, with the first phase of osteological analysis taking place over eight weeks from June to August 2023. This work generated — for the first time — a precise quantification of the Neolithic osteological assemblage from Fourknocks I and II (*c.* 100 kg) with approximately half of the assemblage (51 kg) now fully recorded to modern osteoarchaeological standards. Phase 2 of the analysis commenced in January 2024 and was completed in April 2024. To date, workflow has followed that of the Knockroe human bone assemblage, with cremated material sieved through a series of standardised mesh sizes, quantified and described. Unlike Knockroe, the Fourknocks assemblage also contains a more sizeable amount (4.86 % by fragment count and 8.70 % by weight) of unburnt bone and this is being washed prior to analysis to aid identification of any pathological changes or trauma. Animal bone and worked bone/antler have also been separated out for identification by specialists. The presence of extremely small rodent bones in the assemblage indicate that the Fourknocks deposits were 100 % sampled at the time of excavation.

While the Fourknocks mounds were comprehensively published not long after excavation, and the human bone deposits given museum registration numbers, a site archive or sample inventory which could link these museum numbers to their excavated contexts is missing. Spatial and, hopefully, stratigraphic relationships are thus being re-assembled from old excavation labels still associated with the bone deposits (Figure 4), with any descriptive text cross-referenced with the Fourknocks publications. We are optimistic that this will provide enough information for a targeted programme of radiocarbon dating and chronological modelling, similar to that undertaken for Knockroe and other passage tombs in recent years (e.g. Bayliss and O'Sullivan 2013; Lynch *et al.* 2014; Schulting *et al.* in Eogan and Cleary 2017). This is turn will provide us with vital background information for planned isotope analyses and aDNA analysis on the unburnt portion of the assemblage.

Newgrange, Co. Meath

In parallel with the above work, another new project (Carlin *et al.* in prep) is aiming to clarify the sequence of activity within the interior of Newgrange passage tomb, which is very poorly dated. Remarkably, the only sample of human or animal bone to have been radiocarbon dated from the tomb interior is a petrous fragment of the temporal bone from a male (NG10), included in a recent programme of aDNA analysis of Irish Neolithic humans (Cassidy *et al.* 2020). NG10 was dated to 3340–3020 cal BC (OxA-36079: 4473±29 BP, 95.4 % probability) and revealed to be the offspring of either full siblings or parent and child (Cassidy *et al.* 2020). These results, together with the recorded findspot of the petrous fragment — close to or inside the right-hand recess of the tomb (O'Kelly 1982, 106–7, fig. 21) — has led to the framing of NG10 as an elite ruler, possibly the 'god king' responsible for the construction of Newgrange (Cassidy 2020, 40; 2023, 161; Cassidy *et al.* 2020, 384–5). However, the context of recovery of this petrous fragment may not have been the original context of its deposition: given the existing evidence for fragmented and commingled deposits in other passage tombs (such as that outlined above and e.g. Cooney 2000; 2017; Geber *et al.* 2017a; Kador *et al.* 2018; Kuijt and Quinn 2013; O'Sullivan 2005), and the small number of whole and/or articulated burials recorded for the Irish Neolithic overall (e.g. Beckett 2011; Jones 2019; Ó Floinn 2011), the likelihood of NG10 representing the remains of an individual interred as a focal burial in the east recess at Newgrange seems low (Smyth *et al.* in press). However, it is a scenario difficult to properly scrutinise, as the long history of antiquarian interest in the tomb, together with the current lack of radiocarbon dates for the interior, prevents a deeper understanding of the taphonomy of the deposits.

By the late nineteenth century Newgrange was already viewed as a 'despoiled tumulus', with little in the tomb thought to remain intact (Coffey 1892, 15). Michael O'Kelly himself provides extensive details on this disturbance, based on his own observations during excavation and on a thorough review of earlier antiquarian accounts (O'Kelly 1982, 39, 102, 105, 192). The rediscovery of Newgrange in 1699, recorded and popularised by antiquarian Edward Lhwyd, who visited shortly after the chamber was opened, is well known. Perhaps less well appreciated is that over the course of the eighteenth and nineteenth centuries the interior of Newgrange was visited by at least 28 antiquarians, their activities ranging from relatively low-impact survey work to digging through the terminal recess in search of treasure and smashing the floor-stone (Coffey 1892; O'Kelly 1982, 38, 102). When Newgrange was taken into state care in the 1880s, restoration work undertaken by the Office of Public Works also created significant disturbance in the interior. This included the addition of an iron entrance gate, the shoring up of orthostats and lintels with wooden beams and concrete, and the removal of material from the tomb floor (O'Kelly 1982, 39, 102). These OPW interventions extended

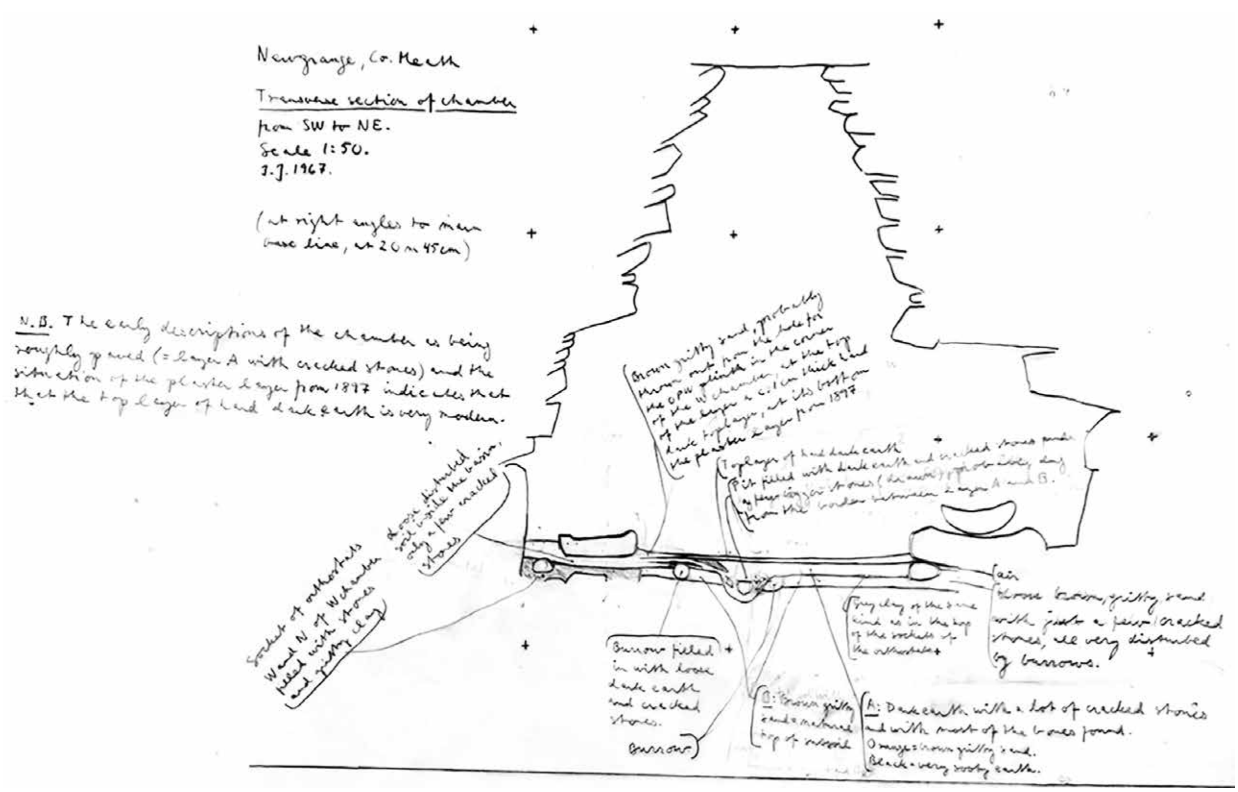

Figure 5. Photograph of part of Drawing 36, O'Kelly archive, showing transverse section of Newgrange chamber, from SW to NE, with animal burrows and other disturbance to the chamber floor labelled (© Photographic Archive, National Monuments Service, Government of Ireland).

into all of the recesses, with O'Kelly encountering spreads of concrete on the recess floors as well as concrete plinths used to support timber struts. In the west recess, a rebate had even been cut into one of the decorated side stones in order to accommodate one such support (O'Kelly 1982, 102). The basin stones from both the east and west recesses had been disturbed at least once, the former moved to the centre of the tomb chamber in the eighteenth century and not returned to the east recess until 1959 (Lucas *et al.* 1961; Stout and Stout 2008). The final major disturbance of the tomb interior — prior to modern excavation — took place in 1901, when holes were dug along the front of the orthostats in the passage and chamber to facilitate the taking of plaster casts of the megalithic art (O'Kelly 1982, 102). O'Kelly's excavation of the tomb interior also revealed considerable evidence for bioturbation; he describes an old soil surface 'much disturbed by animal burrows' (O'Kelly 1982, 105), features clearly visible in section drawings in the Newgrange excavation archive (Figure 5). Above this surface is the layer containing the bone deposits — described as loose brown earth containing small broken stones, with the bone encountered as 18 concentrations or 'lots' of commingled human and animal remains, most of which were adjacent either to the east or west recess (O'Kelly 1982; fig. 21). According to the anatomists' reports (Fraher 1982; O'Sullivan 1982), the human remains from the chamber represented at least five individuals: the unburnt portion derived from at least two adults, while the burnt material included remains from three or more skeletons, with all fragments widely scattered and intermingled in the tomb interior (O'Kelly 1982, 107).

Despite the above, O'Kelly appears drawn to the idea that the unburnt adult remains were deposited as two complete skeletons, arguing that the tomb chamber was effectively sealed after the Neolithic and that the recorded disturbance occurred after 1699, when Newgrange was reopened (O'Kelly 1982, 24–6). He was struck by similarities between details in the anatomy report — at least two individuals, one more heavily built than the other and likely male (Fraher 1982, 198, 200) — and the account of antiquarian Thomas Molyneux, who claims he was told by the landowner who re-opened Newgrange that 'the bones of two dead bodies entire, not burnt, were found upon the floor, in likelyhood the reliques of a husband and his wife' (Molyneux 1726, 204). However, Molyneux is alone in this assertion, and the veracity of his supposed 'eye witness' account has been challenged (Coffey 1892, 15; Herity 1967, 130–1). Edward Lhwyd, recounting his own visit in a letter to a friend in December 1699, does not detail any burial deposits in the tomb, only mentioning that '[t]hey found several bones in the cave […] and some other things, which I omit, because the labourers differ'd in their account' (Lhwyd 1710, 504). The weight given to Molyneux's 'pair of skeletons' (O'Kelly 1982, 107) is thus surprising. O'Kelly was certainly aware of the large quantity of commingled bone recovered from Fourknocks I, published just a decade prior, and from Seán Ó Ríordáin's then unpublished excavations at Mound of the Hostages passage tomb at Tara. At both of these sites, there is no issue accepting that 'people were put in at one moment of time in a single collective burial and that the tomb was then closed' (O'Kelly 1982, 126). Unfortunately, O'Kelly never elaborates on whether the Newgrange 'pair of skeletons' should be seen in this light, i.e. a lucky survival from a much larger collective burial deposit, or if — as two fleshed bodies placed (alone?) in the chamber — they were exceptional (O'Kelly 1982, 27).

One way to achieve greater clarity on the above was to seek further radiocarbon dates on bone from the tomb interior. The published human anatomy and faunal reports (Fraher 1982; O'Sullivan 1982; Van Wijngaarden-Bakker 1982) indicated the possibility of additional human and animal bone to investigate in the Newgrange archive; fortuitously this coincided with National Museum of Ireland work to reassemble the surviving skeletal assemblage from specialists' archives in University College Cork, Cork Public Museum and the University of Amsterdam. Since summer 2023, work on this NMI Newgrange archive has been ongoing and emerging results are summarised here. Our first target has been the partial skeletons of three dogs, each recovered from just outside or close to each of the three tomb recesses. These skeletons were interpreted as being of recent origin because the bone was very well preserved and they had very large shoulder heights of *c.* 64 cm, closer in size to medieval dogs than prehistoric dogs (Van Wijngaarden-Bakker 1982, 215). Although considered to be 'stray dogs that were unable to get out of the tomb' (Van Wijngaarden-Bakker 1982, 218), their occurrence in or near the three recesses suggests that they may represent deliberate burial deposits, even though they are considered to post-date the Neolithic. A key objective was thus to locate the surviving faunal remains, re-identifying and radiocarbon dating each of the three dog skeletons. This would provide further information on the sequence and nature of activity within Newgrange, and test O'Kelly's claim that the interior of the tomb was closed off near the end of the fourth millennium BC until its 1699 rediscovery (1982, 24–6).

In total, five samples were selected from the surviving faunal archive in the NMI collections — a complete left humerus and distal fragments of two left humeri from three dogs/canids, an unburnt cattle humerus fragment and a pig tooth. The complete dog humerus, labelled Newg. 1A, came from bone lot 1 close to the terminal recess, while the two dog humerus fragments were labelled as Newg. 5E and Newg. 19C, and came from bone lots 5 and 19, just outside the east and west recesses, respectively (Figure 5). All five samples produced radiocarbon measurements: the pig tooth dates to 2900–2700 BC, while the other samples range from 3300–3000 BC (Carlin *et al.* in prep). This reveals that the three Newgrange canids are neither modern nor medieval in date, but instead were deposited at an early stage in the use of the passage tomb, broadly contemporary with the petrous fragment NG10. So far, radiocarbon dates support O'Kelly's assertion that the tomb interior was sealed in early prehistory, though perhaps directly after the primary, Neolithic phase of deposition. While analysis and interpretation is ongoing, these results also raise exciting new possibilities about the role and status of animals in society in the fourth millennium BC in Ireland, potentially as non-human kin. Based on their exceptional size, it is possible that these canids may well be wolves.

Discussion

The above studies hopefully highlight the value of approaching older excavation archives with new methods and fresh eyes, and underscore the importance of constructing robust, standardised baselines of our archaeologically analysable populations (e.g. Frieman 2023, 59–60). Only then can we begin to build detailed narratives around mortuary practice — and perhaps even social structure — in the Irish Neolithic, something undoubtedly hampered by the prevalence of cremation as a mortuary rite. Certainly, the study of cremated remains is not without obstacles; many of the methods developed for estimating age-at-death or sex and identifying pathological conditions cannot be applied due to fragmentation and distortion of bones because of the fire and the chemical reaction involved when the organic components of the bones evaporated during the process (Gejvall 1948; Iregren and Jonsson 1973; Lisowski 1968; McKinley 1989; Thurman and Willmore 1981). Nevertheless, the bones can still allow an elucidation of funerary rites and processing of remains, that allow us to gain better understanding of how the remains of the newly dead (both human and non-human) were integrated with those of the ancestors (both human and non-human) within the monuments (McKinley 2006). Looking at the surviving burial deposits from Carrowkeel, Knockroe and Fourknocks passage tombs, some initial observations can be made. Compared with the cremated human bone assemblages recovered from Carrowkeel and Fourknocks, it is evident that the degree of fragmentation at Knockroe is substantial (Table 1). However, this may reflect sampling strategies undertaken during the excavations, as well as taphonomic factors, and these processes are still being scrutinised. At Carrowkeel, excavated in 1911, the high proportion of large fragments (and the relatively small amount of bone) suggest that only a selected sub-sample was collected for analysis. The Fourknocks I and II assemblage, excavated in the 1950s, is likely to contain the total amount of bone encountered during the excavation, but the bones in these monuments may have been better protected against taphonomic factors and bioturbation compared to Knockroe, the most recently excavated passage tomb. Further analysis of the pattern of fragmentation in Neolithic cremation burials in Ireland is required to tease out what influenced the emerging patterns observed in these deposits (see Geber 2009): whether it is possible to determine what factors caused this fragmentation, and whether deliberate fragmentation of the remains was part of the funerary rite.

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Site	Unburnt	Cremated				
	Weight (kg)	Weight (kg)	≥10 mm	5–9 mm	2–4 mm	<2 mm
Carrowkeel, Co. Sligo	9.7	5.7	94.23	5.44	0.33	0.00
Knockroe, Co. Kilkenny	0.3	217.6	8.02	27.19	48.78	16.01
Fourknocks I and II, Co. Meath	8.1	84.8	60.28	35.58	4.12	0.02

Table 1. Summary table of quantity and relative fragmentation (by %weight) of human bone assemblages from Carrowkeel, Knockroe and Fourknocks I and II.

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POTS, STONES, BONES AND A GRAIN

The recipe for a more nuanced view of Neolithisation in Britain, Jutland and Switzerland

Martin Hinz

Abstract

This study delves into the complex process of Neolithisation in northern Europe, focusing on Jutland, Britain and Switzerland. By challenging oversimplifying interpretations of recent ancient DNA (aDNA) results and employing a comparative approach, the research underscores the diversity of regional Neolithic transitions shaped by migration, environmental factors and interactions with indigenous populations. Neolithisation was far from uniform. In Britain, the process was marked by a rapid, migration-driven adoption of practices with minimal Mesolithic influence. Conversely, Jutland experienced a more gradual integration, significantly influenced by Mesolithic contributions. In Switzerland, the Neolithic transition, characterised by substantial Western Hunter-Gatherer admixture, resulted in a stable and selective adoption of agricultural practices. This nuanced perspective highlights the crucial role of local conditions and the interplay between migrating Neolithic populations and resident Mesolithic groups, offering a more complex understanding of cultural integration and economic development during the Neolithic transition.

Keywords: Neolithisation; ancient DNA (aDNA); migration; Mesolithic contributions; cultural integration

Introduction

In this article I would like to invite you to immerse yourself in the complexity of the Neolithic transition in northern Europe (Ammerman 2003; Bogucki 1988; Colledge and Conolly 2007; Cummings 2009; Fischer and Kristiansen 2002; Gkiasta *et al.* 2003; Gron and Sørensen 2018; Johansen 2006; Klassen 2004; Price 2000; Rowley-Conwy 2011; Sheridan 2010; Whittle and Cummings 2007; Whittle *et al.* 2011; Zvelebil 1986), with a specific focus on Jutland, Britain and Switzerland, to shed light on the diverse pathways through which Neolithisation unfolded. Despite a hiatus from direct engagement with this field over the past five years, in this study I try to leverage my expertise in data aggregation and pattern identification to contribute to the discussion about the Neolithic transformations across these regions. Focusing on a comparative approach, this research contrasts recent publications based on ancient DNA (aDNA) to illustrate the diversity of agricultural transitions and to challenge the notion of a monolithic process of Neolithisation (Allentoft *et al.* 2024a). This is not to say that I question the driving force of migration in the establishment of a farming economy *per se*. However, I think that a more nuanced view is needed of how this was established in the individual regions, what role the indigenous hunter-gatherer population played, and what cultural adoption processes were linked to the adoption of the new economy in each case. Migration is a multifaceted

In D. Hofmann, V. Cummings, M. Bjørnevad-Ahlqvist and R. Iversen (eds) 2025, *The early Neolithic of Northern Europe. New approaches to migration, movement and social connection*, 159–170. Leiden: Sidestone Press.

phenomenon (Cummings *et al.* 2022). While the initial spark for cultural change can be instigated by migratory movements, the resulting manifestations are heavily influenced by specific circumstances and the dynamic interactions between local populations and newcomers. This interplay invariably involves mutual influences. Additionally, migration is not a singular event that concludes upon the arrival of new settlers. Instead, it sets off subsequent movements of groups, resulting in a diverse array of outcomes shaped by historical contexts.

The 'Neolithic expansion', originally perceived as a rather homogeneous north-westward spread (Ammerman and Cavalli-Sforza 1971; Pinhasi *et al.* 2005), is now understood to have occurred in waves (Bocquet-Appel *et al.* 2012; Brami and Zanotti 2015; Hervella *et al.* 2012; Shennan 2009; Silva and Vander Linden 2017), with the Atlantic façade and Switzerland among the later recipients. This study questions the apparent homogeneity suggested by archaeological maps (e.g. Gronenborn and Horejs 2023), revealing the underlying complexities of the Neolithic spread as influenced by migration, environmental factors and the integration of existing lifestyles, conditions and populations.

Different empirical analyses and theoretical considerations reveal distinct trajectories of Neolithisation, for example Bettina Schulz Paulsson's (2017; 2019) mapping of the spread of the megalithic phenomenon and Martin Furholt's (2020) theoretical model of archaeological communities of practice. Based on these ideas, in the following I will distinguish between the individual components of the so-called 'Neolithic package' (cereals and food production, pottery, megaliths and population). Through case studies from Britain, Denmark (Jutland) and Switzerland, this article identifies varying patterns of adoption and adaptation to 'Neolithic' lifestyles. It discusses the implications of these findings for understanding the interactions between migrating Neolithic populations and resident Mesolithic groups, offering a more complex picture of Neolithisation that incorporates elements of both migration and cultural integration.

This study ultimately argues for a differentiated understanding of the Neolithic transition, where localised conditions, interactions between different communities and the selective adoption of practices played crucial roles. The paper demonstrates that the process of Neolithisation was not uniform, but varied significantly across different regions, influenced by both internal dynamics and external migrations.

General background

The diffusion of the Neolithic across Europe was a complex and heterogeneous process, characterised by its propagation in waves rather than a uniform north-westerly spread. This is particularly evident along the Atlantic façade, the primary region for the spread of megalithic phenomena, which represents the fourth wave of Neolithic expansion. Switzerland, encapsulated by regions with an already established Neolithic economy, witnessed the emergence of a distinct culture with the advent of lakeside settlements around 4400 BC. Contrary to the apparent homogeneity suggested by archaeological maps, this spread encompassed a variety of practices, including agriculture, although it was closely associated with the slow migration of farming populations from west Asia and the advent of pottery use. The phenomenon of megalithic burials, as detailed in Schulz Paulsson's (2017; 2019) comprehensive mapping project, suggests a potential reverse trend in movement, with temporal discrepancies observed between the spread of megalithic burials and Neolithisation across Britain, southern Scandinavia and Switzerland.

In the third millennium BCE, the dissemination of beaker-using cultures presents a notable parallel in the evolution of Neolithic societies, prompting an examination through the lens of Furholt's (2020) theoretical framework. This model elucidates the distinctions and commonalities within the cultural practices associated with the adoption of individualised burial customs. Furholt's approach, grounded in the concept of communities of practice, delineates burial rituals, settlement patterns and ceramic production as distinct spheres of cultural activity. These spheres allow for the participation of individuals across various contexts, thereby facilitating engagement in diverse networks and cultural phenomena (Furholt 2020, 5). This analytical perspective enables the disaggregation of the Neolithic cultural package into discrete components, specifically cereals and food production, pottery, megaliths and population structure (Figure 1). Such differentiation reveals the varying degrees of involvement by different actors within these domains. By applying Furholt's model, this analysis bridges the gap between local agency and the cultural changes engendered by migration. Consequently, it affords a nuanced understanding of the contributions of the local Mesolithic population to the Neolithic transition, facilitating a probabilistic assessment of their involvement in these transformative processes.

The nuanced perspective on the transition to Neolithic ways of living, particularly in southern Scandinavia, aligns with earlier scholarly discussions. Marek Zvelebil and Peter Rowley-Conwy's (1984) proposition of a phased transition, emphasising the active engagement of local populations, contrasts with Rowley-Conwy's (2004) subsequent shift towards acknowledging the significant role of migration in cultural and economic transformations. This latter viewpoint gradually superseded the theory of indigenous adoption marked by gradual economic evolution, which had prevailed in the 1990s (compare e.g. Hofmann 2015, 455; Terberger *et al.* 2018, 66). Advancements in ancient DNA (aDNA) analysis have increasingly established migration as a pivotal explanatory model (Bramanti *et al.* 2009; Haak *et al.* 2005; 2010), seemingly diminishing the contribution of Mesolithic populations to this transition (Gron *et al.* 2020). However, divergent perspectives

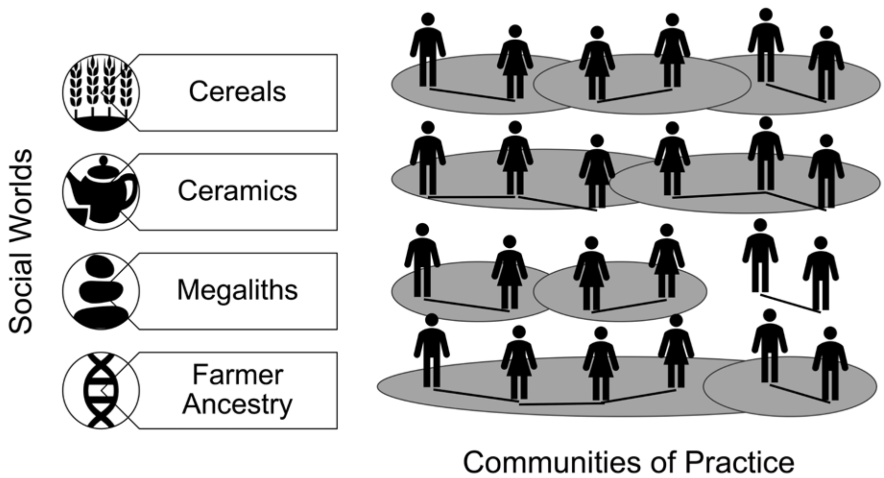

Figure 1. Selected communities of practice involved in the transition to a Neolithic lifestyle, conceptualised after Furholt (2020).

persist, evidenced by discussions on an experimental phase in the shift towards agriculture, described by David Graeber and David Wengrow (2021, 266–73) as 'play farming'. The dating of this experimental phase relative to the transition depends on the interpretative lens and specific contextual factors. Neolithisation, understood not as a singular event but as a multifaceted process, is subject to variable manifestations contingent upon distinct circumstances. Accordingly, the interrelated components of the 'Neolithic cultural package' suggest a propensity for mutual reinforcement of factors rather than obligatory co-dependence, thereby allowing for varied developmental pathways.

Methods

To gain a comprehensive and nuanced understanding of processes in the individual study regions, the study dissected the components of the Neolithic package — cereals and food production, pottery, megaliths and population growth — and examined each independently. The selection of these proxies was driven not only by their relevance to the Neolithic package, but also by the extensive availability of robust datasets that facilitate in-depth analysis. The literature, as detailed in the individual sections, provided the chronology for the advent of pottery and megalithic structures. The focus was exclusively on the timing of their initial appearance, without delving into their subsequent development. The investigation of food production involved analysing indicators of land cultivation and finds of cereal remains, alongside a general population development analysis through the sum calibration of radiocarbon dates. Recognising that each of these indicators in itself is subject to error and is influenced by different distorting factors, each individual result must be viewed critically, and only the correlation between individual indicators can be taken as an indication of the development under investigation. Deviations between individual indicators require special consideration and explanation.

The assessment of land cultivation was based on the analysis of herb versus tree and shrub pollen ratios, utilising data from the Neotoma database (Williams *et al.* 2018). This process involved downloading data sets for specific geographic areas using the *neotoma2* R package (Dominguez and Goring 2023) (only pollen data, only the pollen groups upland herbs ('UPHE') and trees/shrubs ('TRSH'), only data with a chronology). The ratio of 'UPHE' to 'TRSH' was then calculated for each individual sample within the respective profiles. This was then averaged using a rolling window with a width of 100 years, and the proportion of 'UPHE' was plotted in the diagram.

Using radiocarbon data to estimate prehistoric population development presents several challenges and potential biases, such as calibration issues, sampling bias from uneven archaeological exploration, and preservation conditions affecting datable materials. Additionally, interpreting increased numbers of radiocarbon dates as direct indicators of population growth can be misleading, as this may stem from heightened research activity or cultural and environmental factors. Despite these limitations, radiocarbon data remain invaluable for their ability to provide quantifiable and widespread evidence of human activity, enabling cross-regional comparisons and helping to identify broader patterns and trends in prehistoric populations.

For the analysis of radiocarbon dates, both general and cereal-specific data were sourced from the open data infrastructure and database for chronometric data XRONOS (https://xronos.ch), using its dedicated R package. After filtering and deduplication, the *rcarbon* R package (Crema and Bevan 2021) was employed for analysis, adhering to its default settings. This involved site-level binning and smoothing the data with a 100-year rolling window. While the analysis tested theoretical growth models using default settings, these aspects were not central to the interpretation of the results. Each dataset was complemented with an interpretive framework (Panel IV), and the synthesised data for each region were then graphically presented.

Britain

In the examination of Neolithisation across Britain, Alasdair Whittle and colleagues' (2011) application of sequential calibration has meticulously delineated the timing and trajectory of this process, proposing a model consistent with rapid, migration-driven expansion. I have not sought to amend this analysis but rather to complement it through the evaluation of alternative indicators (Figure 2), utilising aggregated pollen and radiocarbon date collections. This broad analysis inevitably sacrifices the detailed focus on individual regional developments. Consequently, while such an analysis cannot replace an in-depth regional study, it serves to provide a broader perspective on general trends. Specifically for Britain, with its distinct cultural and environmental gradients, it is evident that diverse manifestations of Neolithisation, such as those observed in Scotland versus southern England (Bunting *et al.* 2018), cannot be fully captured here.

For this, I synthesised pollen data from 136 individual profiles, focusing on the tree/shrub to herb pollen ratio. This

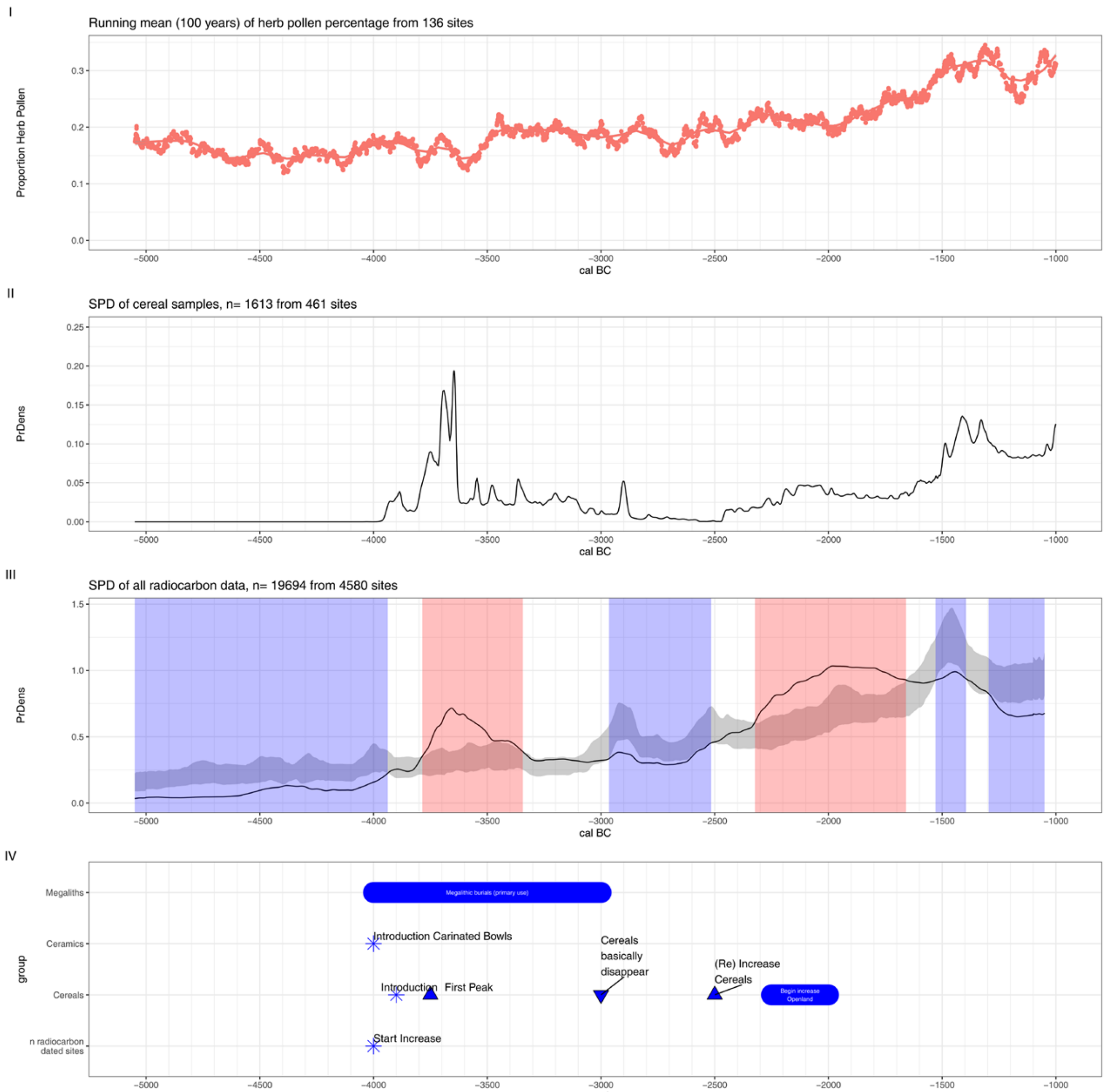

Figure 2. Data analysis of the evidence from the UK. I) Running mean (100 years) of herb pollen percentage from 136 pollen profiles; II) sum calibration (SPD) of radiocarbon samples from cereals (n = 1613 from 461 sites); III) sum calibration (SPD) of all radiocarbon dates, binned by site (n=19,694 from 4580 sites); IV) interpretation and cultural developments.

condensed analysis reveals that the transition to agricultural practices, marked by landscape clearing, becomes significantly evident only from the Bronze Age, suggesting minimal agricultural impact during the initial Neolithisation phase (Farrell *et al.* 2020; Woodbridge *et al.* 2014, 222). Whilst the radiocarbon dates for cereals start to appear from around 3900 BC, with a pronounced peak from 3700 BC, there is little effect on the open land indicators in the form of herb pollen. A regionalised analysis with a stronger focus on the southern part of the United Kingdom could probably show a more visible shift in the curve, but is outside the scope of this paper. After this first peak, the intensity of the cereal signal drops significantly and remains at a very low level, almost disappearing completely from 3000 BC onwards. It is not until 2500 BC that the evidence of cereals in the radiocarbon record begins to increase again and to be steady, and it is not until 1500 BC that significantly higher values than in the Neolithic are reached (taking into account the blurring effects caused by summing radiocarbon dates). However, from 3500 BC onwards there is a noticeable opening of the land (albeit to a limited extent). The discrepancy between increased pollen values for herbs and decreasing amounts of cereal dates indicates that the land opening could not be primarily due to cereal production, but to other land use (perhaps pastoral).

This is in line with earlier analyses of summed radiocarbon dates of cereal finds and their interpretation. Chris Stevens and Dorian Fuller (2012) asked whether 'Neolithic farming [did] fail', highlighting a pronounced boom and bust pattern and attributing the actual agricultural revolution to the Bronze Age. This fluctuation, here corroborated by an expanded dataset from the XRONOS database, reflects broader trends in archaeological site prevalence, indicating economic volatility associated with newly introduced agricultural practices. Despite criticisms of their study's methodology and questions regarding its validity for Scotland (Bishop 2015, Bishop *et al.* 2022), the general trend they identify for the Neolithisation in Britain is likely not entirely incorrect. Stevens and Fuller (2012) attributed this reduction of agricultural activity to climate deterioration, but I wonder if the decline observed primarily in the second half of the fourth millennium may imply the unsustainability of an 'imported' economy, introduced by migrants. A recent paper by Morten Allentoft and colleagues (2024a) indicates a substantial proportion of Near Eastern genetic ancestry within Britain, akin to levels found in France, suggesting minimal influence from the local Mesolithic population on both genetic makeup and lifestyle. The contemporaneity of Carinated Bowl pottery with other Neolithic indicators further underscores the synchronicity of these cultural transitions. Whittle and colleagues' (2011) comprehensive data compilation reveals a consistent south–north gradient in the spread of Neolithic practices across Britain, with little deviation in timing, suggesting a predominantly migration-driven process.

The summation of all radiocarbon dates combined shows that there is a significant increase in the number of radiocarbon-dated sites from around 4000 BC, with a markedly accelerated development from 3800 BC (again, considering the smearing effects of radiocarbon summation). This is followed by a decline, a well-known boom-and-bust pattern already documented elsewhere (Shennan *et al.* 2013), whereby the detectability and archaeological prominence of sites from this period (megalithic architecture) is also likely to play a role. At the same time as the increase in dated cereal finds, there is a general increase in radiocarbon-dated sites, which continues from around 2500 BC into the Bronze Age.

Megaliths appear to have been an integral part of the package that was taking root in Britain (Schulz Paulsson 2019). The dating of the first megaliths is only slightly offset from the first other signs of the new economy, way of life and perhaps ideology. This provides further evidence that people following an already established and self-contained, integrated new way of life sought to settle in Britain, with little room for adaptation to local conditions, possibly contributing to the problems they encountered later.

In sum, the rapid dissemination of a fully-fledged Neolithic package, characterised by a pronounced economic boom-and-bust pattern and a relatively low (~10 %) admixture rate, indicates limited interaction with, and influence from, the Mesolithic population post-4000 BC. Evidence suggests a phase of contact and experimentation prior to 4000 BC (e.g. Lawrence *et al.* 2022), yet this appears to have had minimal impact on subsequent developments, leading to the likely displacement or assimilation of the Mesolithic remnant population. This narrative underscores the critical role of migration in shaping the Neolithic landscape of Britain, with minimal room for the Mesolithic population in the post-4000 BC era.

Jutland

In examining the transition to Neolithic cultural and economic practices within Jutland and Denmark, recent aDNA evidence has necessitated a re-evaluation of the hunter-gatherer population's role, with narratives shifting dramatically to suggest population replacement (Allentoft *et al.* 2024b). This stark re-interpretation highlights the complexities of integrating new genetic data into existing archaeological narratives. It can be anticipated that the results of recent excavations and findings will shed further light on this dynamic and perhaps lead to a slightly different perspective. The sites found near Syltholm (Gron *et al.* 2024; Groß and Rothstein 2023) in particular are likely to contribute to a greater focus on the processual nature of Neolithisation in southern Scandinavia and the possible long-term parallelism of different lifestyles and economic strategies.

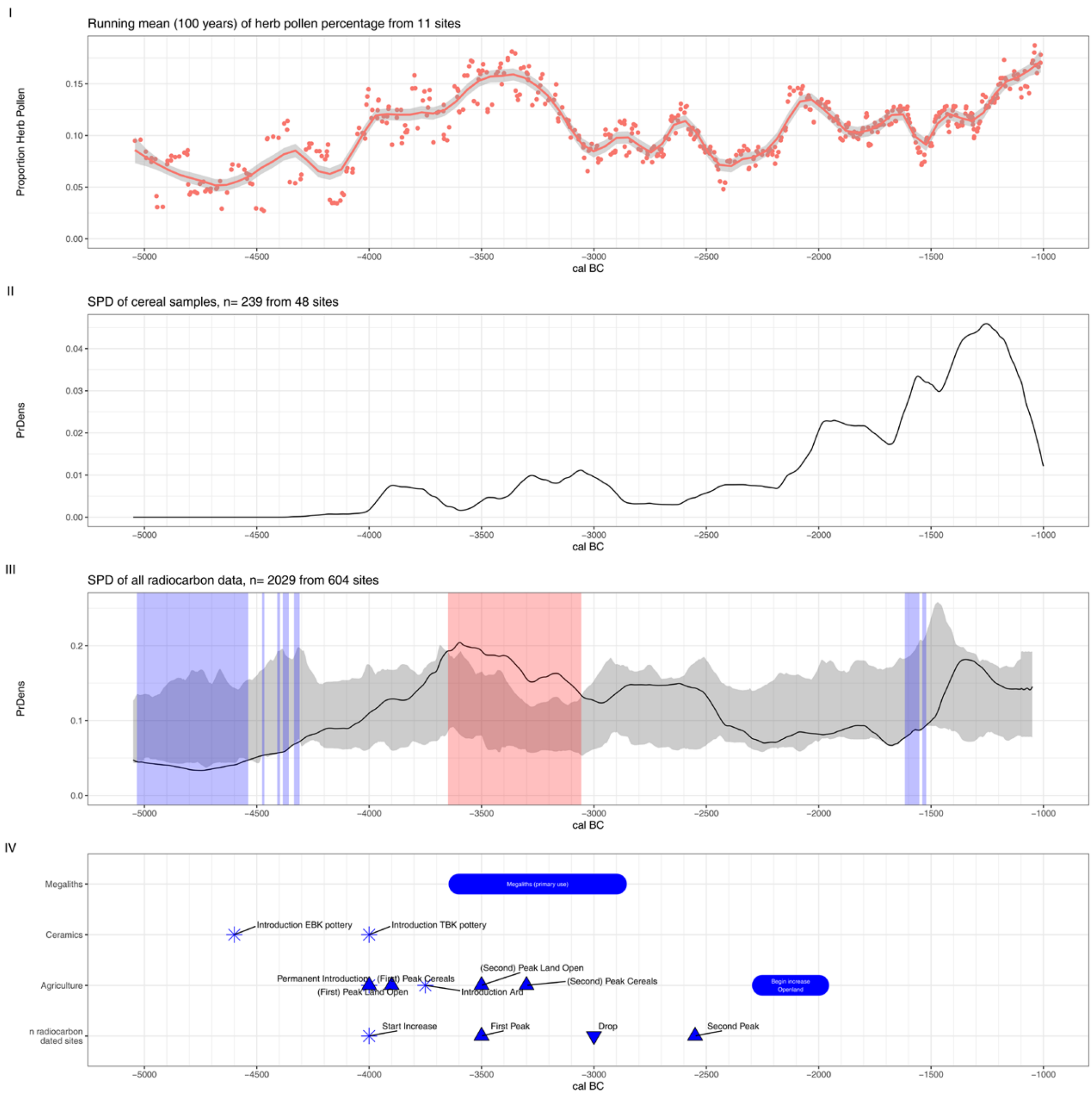

Figure 3. Data analysis of the evidence from Jutland. For the explanation of the individual plots, refer to Figure 2.

The aggregated pollen data (Figure 3), sourced from the Neotoma database, offer a glimpse into the development of open land in Neolithic Jutland, albeit with a reliance on north German profiles due to the scarcity of Danish records in that database. These data suggest a slightly earlier and more sustainable appearance of agricultural practices compared to Britain, with a definitive transition visible only by the Late Bronze Age. A notable increase in herb pollen starts at (or shortly before) 4000 BC, indicating initial agricultural activities. There is a second pronounced increase after 3700 BC, followed by reforestation and significant landscape opening in the Late Bronze Age.

The cereal dates are consistent with this timeline and show fluctuations in agricultural productivity, with a notable increase towards the Late Bronze Age that is not entirely dissimilar to the patterns observed in Britain. Here, too, we can see a boom-and-bust pattern, although the decline in the dated cereals is not as pronounced as in Britain and this signal never fully disappears. It is perhaps not entirely unreasonable to assume that the early peak in dated cereals is also at least partly due to the focused search for the earliest possible dates. However, the curve recovers, only to fall again from around 3000 BC and remain at a low level until around 2200 BC. This is the time of the Corded

Ware culture, for which a pastoral-oriented economy can be made credible, but in any case the archaeological visibility of settlement sites declines significantly.

The archaeological site distribution does not exhibit the same boom-and-bust pattern seen in Britain throughout the Neolithic, suggesting a different trajectory of settlement and economic development, despite a high proportion of Near Eastern genetic ancestry indicating significant migration. The highest peak of radiocarbon-dated sites is at 3600 BC, certainly influenced by dates on megalithic graves. As might be expected, the number of dates decreases towards and during the Corded Ware period and only increases again significantly from the Middle Bronze Age onwards.

Ceramics in Denmark predate Neolithisation by approximately 600–800 years, indicating an early familiarity with this key technology among local populations, contrasting sharply with the British context. The comprehensive chronology of innovations compiled by Kurt Gron and Lasse Sørensen (2018) details the difficulties with the narrative of a sudden and sharp cultural change, showing that many hallmark Neolithic changes predate or follow the conventional threshold of 4000 BC. This suggests a more gradual and stable integration of Neolithic practices, without the pronounced economic setbacks characteristic of Britain. The arrival of the Neolithic in the north was certainly dramatic, but clearly the agents of the innovation were better prepared for the local conditions, and the overall integration of the lifestyle more sustainable and less disruptive.

Megalithic burial practice began with a clear delay to the first establishment of the Neolithic way of life (Schulz Paulsson 2019). Intermediate steps via earthen long barrows towards a monumental, collective mode of burial, which ultimately demonstrated the impact of an ideology also found across large parts of Europe, show that Jutland did not see the arrival of a complete, self-contained package of innovations, but a selective introduction — or adoption.

The evidence points to a more active role and greater cultural compatibility of the Mesolithic populations with 'Neolithic' newcomers in peninsular Denmark, as indicated by a higher degree of admixture (~20 %) and a less tumultuous transition to agriculture. This scenario posits a likely retreat of Mesolithic communities into refugia, as seen in sites like Syltholm and Ostorf (Fernandes *et al.* 2015; Lübke *et al.* 2009), where aspects of their lifestyle and genetic signatures persist. In summary, the Jutlandic case study presents a model of Neolithisation marked by gradual integration, stable development and significant interaction between Mesolithic and Neolithic groups, challenging the notion of a unilateral driver of the transition.

Switzerland

In Switzerland, the establishment of the Neolithic, particularly evident in lakeshore settlements (Hafner and Suter 2003), diverges significantly from the patterns established in Jutland or Britain. Notably, the Neolithic transition is marked by sparse signals at the scale of vegetation changes (Figure 4), with significant alterations occurring primarily in the Early Bronze Age. Early indications of cereal cultivation between 6500 and 4500 BC suggest a period of agricultural experimentation (Nielsen 2003; Tinner *et al.* 2007), albeit at a minimal level. A recent study on the direct dating of cereal remains from presumed Mesolithic contexts (Jacomet and Vandorpe 2022) came to the conclusion that all direct evidence of such agricultural activities dates later, i.e. that all dated cereal grains were dated to after 4500 BCE.

The Bronze Age heralds more definitive shifts in agricultural practices, as seen in herb pollen concentrations, yet the overall magnitude of change remains comparatively lower than in Jutland or Britain. Radiocarbon dating of cereals, constrained by the preference for dendrochronology in lakeshore settlement studies, supports the onset of cereal use around 4400 BC, with no substantial evidence for earlier cultivation. Unfortunately, the data in XRONOS that can be directly linked to the dating of cereals are still insufficient, and the picture will certainly become much clearer over the next few years.

The evaluation of the sum calibration of all data from Swiss contexts aligns with known developments. The number of dated settlements increases rapidly after 4500 BC, congruent with the establishment of the lakeshore Neolithic. A clear decline after 3700 BC can be linked to the general decline in settlement activity at the transition to the Horgen phase, which has been discussed elsewhere (Heitz *et al.* 2021a; 2021b). However, the evaluation of radiocarbon dates must be carried out with caution, especially in Switzerland: due to the dominance and accuracy of dendrochronological dating, which is available on lakeshore settlements, the validity of a summed calibration for this area is rather questionable.

To overcome the dating challenges, a multiproxy method based on a Bayesian hierarchical model was developed (Hinz *et al.* 2024) which integrates different data streams to produce a more robust chronology of settlement and agricultural development to compensate for these weaknesses. The integration of radiocarbon and dendrochronological dates with aoristics (an aoristic sum calculates the expected number of events occurring within uncertain time intervals) and land opening data (Figure 5) shows a marked upward swing in the curves in the middle of the fifth millennium, then a plateau during the fourth millennium, and finally a maximum at the turn to the Corded Ware style. Overall, population expansion seems to have taken place at a low but stable level. The genetic data here are not published and resolved in the same way as in the other study regions, especially for the earlier parts of the Neolithic, due to the lack of burials and therefore human remains. But in sites before the influx of Steppe

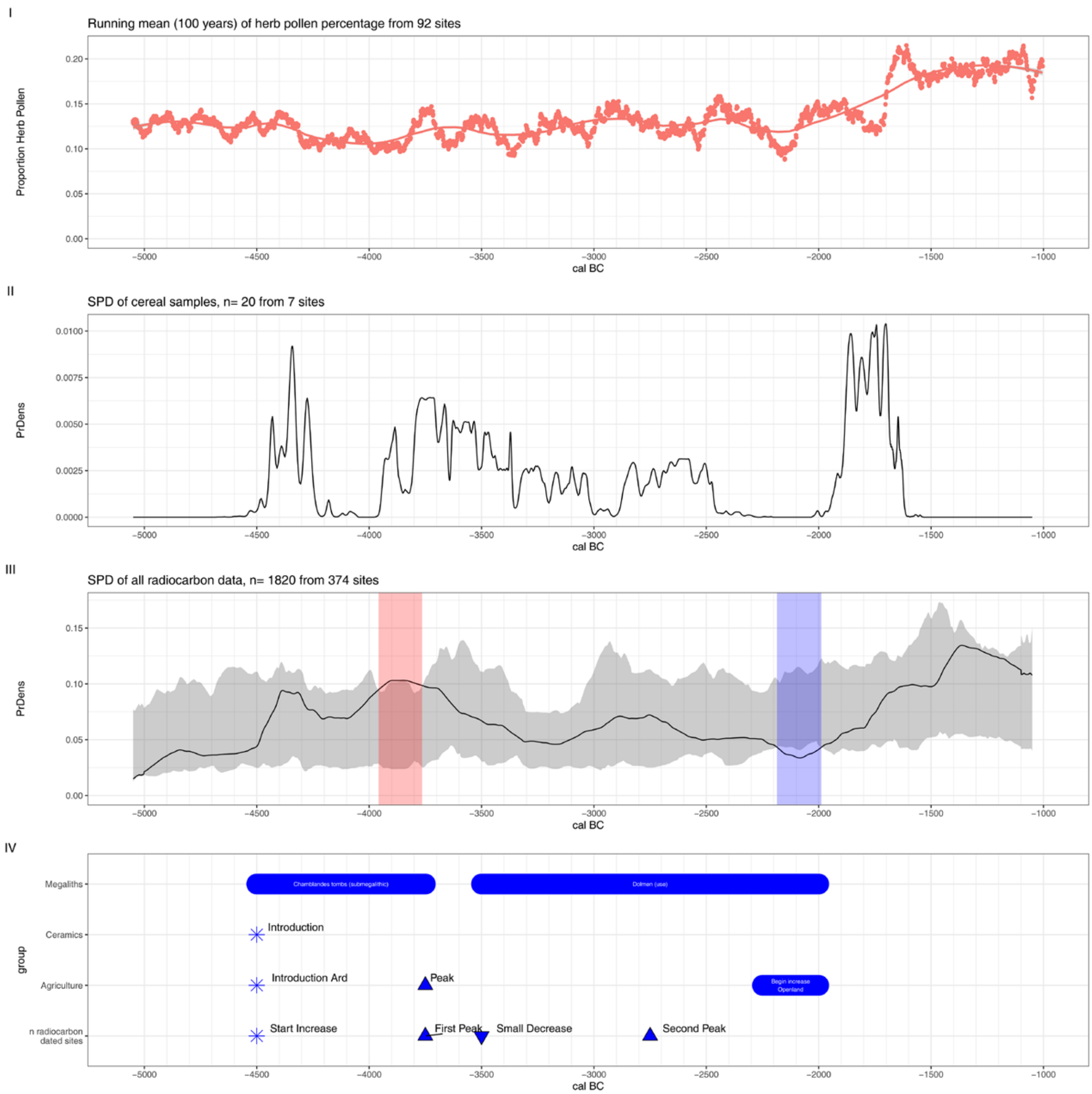

Figure 4. Data analysis of the evidence from Switzerland. For the explanation of the individual plots, refer to Figure 2.

ancestry, the admixture is significantly greater than in Britain and Jutland, up to 30 % on average across the sites (Furtwängler *et al.* 2020). The bearers of so-called Western Hunter-Gatherer DNA thus play a much greater role in the population of Neolithic Switzerland.

Pottery, while present in the periphery, only becomes prevalent with the advent of lakeshore Neolithic settlement from 4400 BC (Ebersbach *et al.* 2012), suggesting a delayed but comprehensive adoption of Neolithic cultural practices. In contrast, megalithic burial practices were never established in Switzerland in the same way as in the other regions analysed. The cists of the so-called Chamblandes graves were assumed to contain the burials of the lakeshore Neolithic. However, more recent extensive dating (Steuri *et al.* 2023) shows that these burials are earlier than the settlement of the lake shore. In addition, they are geographically limited to a southern area and were not adopted throughout the Swiss Plateau. Other, later megalithic burials do exist in Switzerland, but are very rare compared to Britain and Jutland (Ramstein *et al.* 2022). The use of dolmens and other comparable monuments takes place here over long periods of time, but at an extremely low frequency. If we take the archaeological record seriously as it is, then we could speak of a 'play burial' in reference to Graeber and Wengrow's

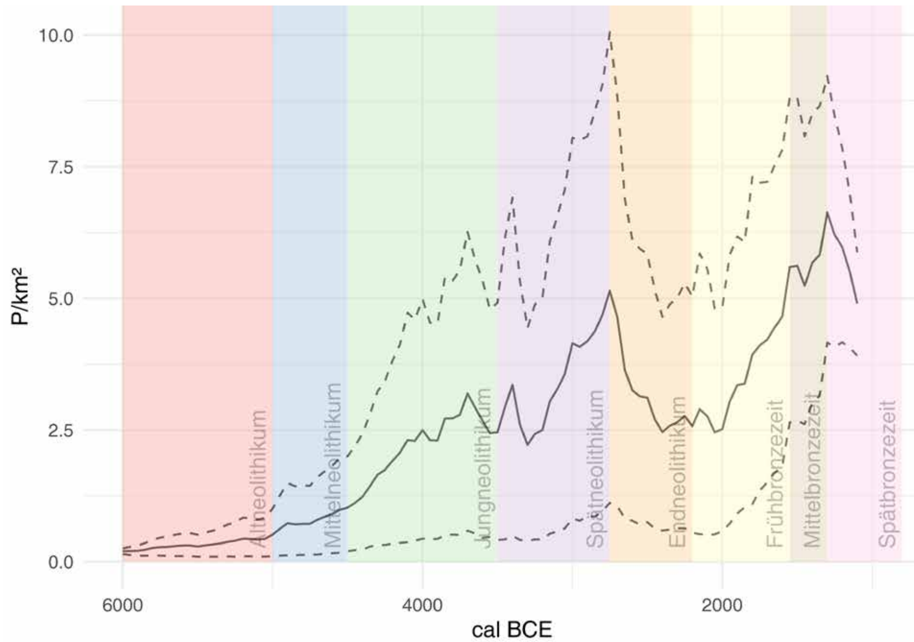

Figure 5. Population estimate for the Swiss Plateau using a Bayesian hierarchical model. From left to right: Early, Middle, Younger, Late and Final Neolithic, and Early, Middle and Late Bronze Age.

(2021, 266–73) 'play farming'. Apart from that, this burial custom, and therefore the ideology behind it, obviously played no role in the Neolithic of Switzerland. This is also supported by the clearly different settlement pattern, as far as the archaeological record currently indicates, and the fact that this settlement pattern (and possibly also the economic pattern associated with it) is not clearly influenced by the transition to the Corded Ware period, as is the case in other parts of Europe.

All this implies a gradual, selective shift. The switch to a new lifestyle took place suddenly in historical terms. But only ceramics and new economic practices found their way into the Swiss Neolithic, and there is a lack of pronounced boom-and-bust cycles similar to those observed elsewhere. The integration of Mesolithic populations into the new 'Neolithic' environment, indicated by the higher genetic admixture, might have played a role here.

Comparatively, the Swiss situation shares similarities with southern Scandinavia, as arable farming techniques are available in the periphery of both regions, yet diverges from the British scenario by avoiding extreme economic fluctuations and by demonstrating a higher degree of genetic diversity. This unique blend of factors suggests a localised and highly adapted approach to Neolithisation in Switzerland, distinct from its European counterparts, making a significant Mesolithic influence and a nuanced, stable transition to agricultural societies possible.

Summary

The process of Neolithisation across Europe exhibits diverse trajectories, characterised by variations in pace, scale and the elements involved in the transition to agricultural lifestyles. In Britain, this process closely resembles a significant population shift, suggesting that migration was the primary, if not exclusive, mechanism driving Neolithisation. Conversely, on the Jutland Peninsula such a drastic exchange appears far less probable. Here, the presence of prosperous coastal Mesolithic communities, already well-acquainted with key items of a 'Neolithic' lifestyle, such as pottery, points towards a smoother integration of these novelties, highlighting a higher degree of compatibility between the two ways of life. The Neolithic was finally established after a longer transitional period of over 700 years with parallel lifeworlds, in which the hunter-gatherer lifestyle retreated more and more into refugia, before life was transformed once more by the arrival of Corded Ware-associated things and practices.

Switzerland presents a unique case where the inception of Neolithic practices is indeed tied to migration, but only after a considerable delay and with a significant contribution from individuals of Western Hunter-Gatherer genetic heritage. This interaction fostered a distinct and stable Neolithic culture that seamlessly transitioned into the Bronze Age with only minor modifications in settlement patterns. This scenario suggests a more deliberate and involved role for hunter-gatherer communities in the adoption of Neolithic cultural and economic practices, despite potential gaps in the archaeological record. In all cases, new arrivals with new genetic signatures were instrumental in re-organising the way of life. In some cases, they brought with them a complete package of innovations. In others, these innovations were already known (e.g. ceramics), or were accessible in the periphery without gaining a foothold. Here, the newcomers played the role of the ultimate triggers that helped the innovations to break through. In yet other cases, certain elements of the new way of life were not adopted at all, whether as an adaptation to local conditions or due to the fact that the original inhabitants of these regions played a greater role. These different aspects linked different communities of practice in different ways, connecting them on one level but making a difference in other aspects. Collectively, these variations underscore the complexity of the Neolithisation process, revealing a spectrum of human responses to the challenges and opportunities of early agricultural life across different European landscapes.

Acknowledgments

Data were obtained from the Neotoma Paleoecology Database (http://www.neotomadb.org) and its constituent databases. The work of data contributors, data stewards, and the Neotoma community is gratefully acknowledged.

Availability of data and code

All data were obtained from freely accessible and open access sources. The manuscript and the code to create the figures can be found in the following GitHub repository: https://github.com/MartinHinz/pots_stones_bones_grain_2024. A version-controlled long-term storage version can be found on Zenodo with the following DOI: https://zenodo.org/doi/10.5281/zenodo.10680503.

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A COMPARISON BETWEEN THE NEOLITHIC MONUMENTS IN THE SARUP ENVIRONS, THE BRITISH ISLES AND IRELAND

Niels H. Andersen

Abstract

Through excavations of various Neolithic monuments belonging to the Funnel Beaker culture in the Sarup area of south-west Funen, Denmark, several details were observed in these monuments which were also found in contemporary monuments in the British Isles and Ireland. The excavation of two ´long barrows´ at Frydenlund exposed a wooden coffin placed over the postholes of a former house plot. This finding demonstrates that interpreting tall and distinctive posts at the gable ends of coffins must be reevaluated. The excavation of the causewayed enclosures in Sarup shows that the system ditches, just as in some of the British sites, can only have been open for a very short time, perhaps only a few hours, an important observation when trying to interpret the purpose of the causewayed enclosures. Passage grave A1 at Damsbo proved to have many features in common with the Scottish and Irish passage graves. Finally, attention is drawn to the fact that in large parts of northern Europe, there has been a preference for dolmens to have distinctive capstones and that these should preferably have the shape of a flat cap.

Keywords: Funnel Beaker culture; Sarup sites; Frydenlund; unchambered long barrows; plank coffins; causewayed enclosures; system ditches; megalithic features; dolmens; passage graves; stone circles; capstones

Introduction: the Sarup project

For more than 50 years, since 1971, archaeological investigations have been conducted around the village of Sarup in the south-western part of Funen, Denmark. During the first 13 years, efforts were concentrated on uncovering the first Neolithic causewayed enclosures in the Danish area. On a sandy promontory partly surrounded by wetlands, people built two causewayed enclosures at the time of the Funnel Beaker culture around 3400 BC and again around 3200 BC. These two sites correspond in form and content to similar sites in Britain, Germany and France (Andersen 1997; 2018; 2019b; 2022).

Interpreting the purpose of building and using large and monumental causewayed enclosures has always been associated with uncertainty. A prerequisite for us to approach an interpretation is that careful excavations of the sites are carried out, thorough analyses of structures, soil layers and finds, but one also looks at the simultaneous activities that took place in areas close to the sites. As pointed out by Alasdair Whittle (2014, 5),

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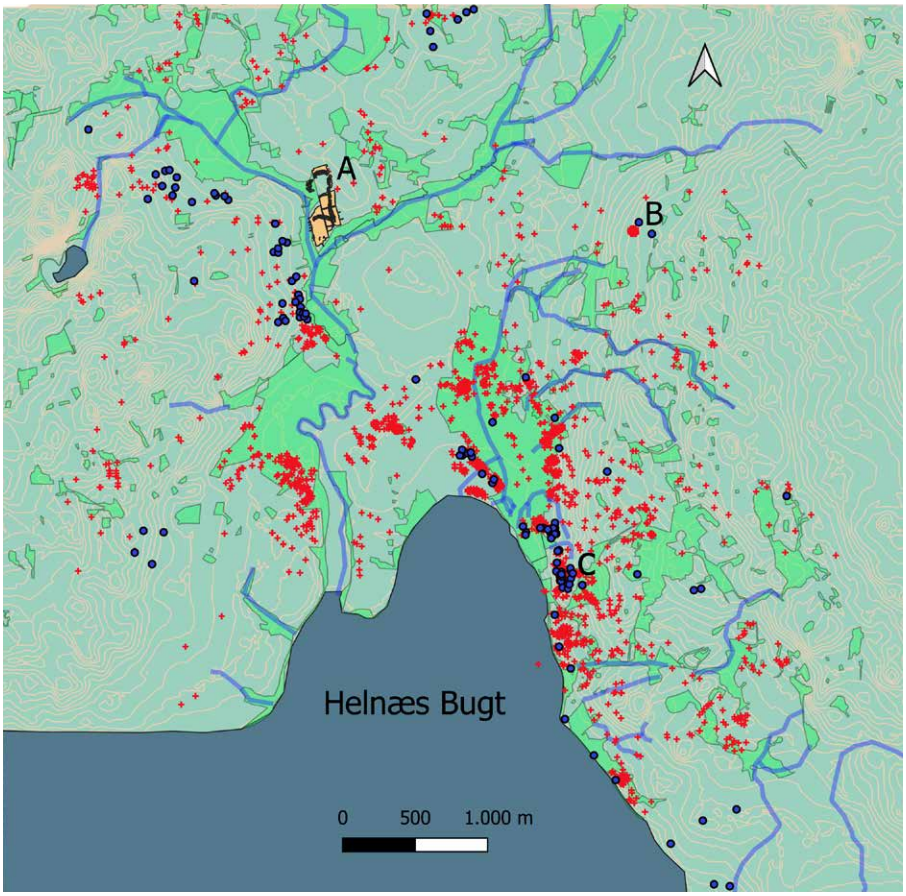

Figure 1. Sarup Project study area in south-west Funen, Denmark. This area is located next to Helnaes Bay. The red crosses show the locations of finds dated to the Neolithic (4000–2000 BC); blue circles show the location of approximately 125 megalithic sites, of which only two have preserved megalithic stones. The letters refer to the locations of Sarup (A), Frydenlund (B) and Damsbo (C) mentioned in the text. Drawing: author.

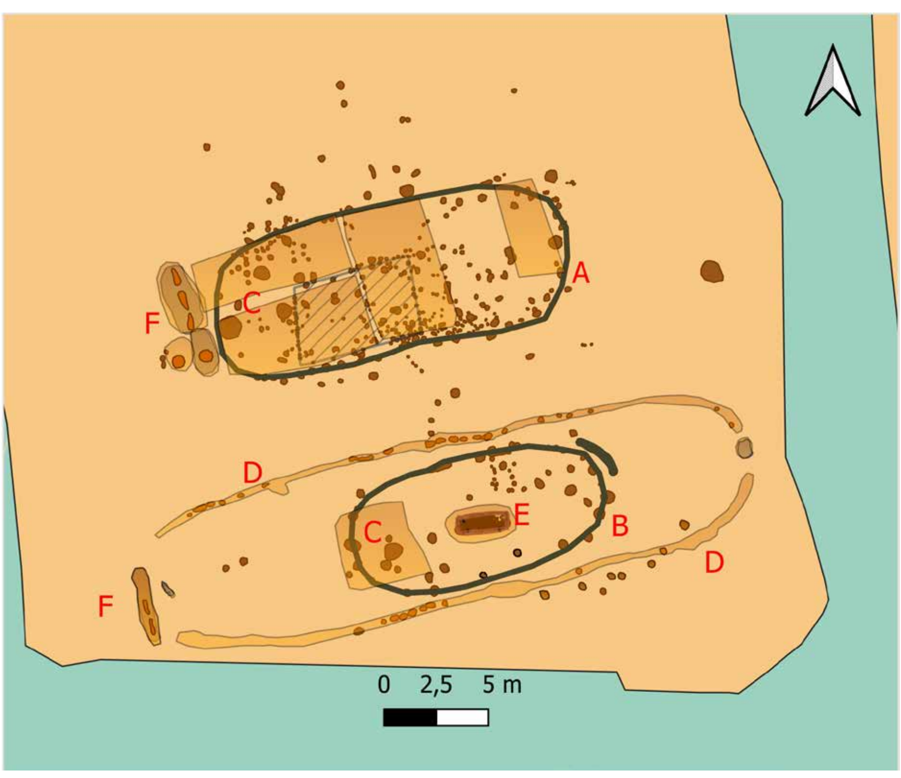

Figure 2. The locality of Frydenlund dates to the Early Neolithic period, after 3635 BC. Traces of house plots (A and B), flat stone paving (C), post-built enclosures (D), plank coffin (E), and two facade trenches (F). Drawing: author.

one should, among other things, acquire knowledge of population density, the distribution of settlements and the prevailing economy. It is probably no coincidence that the two enclosures at Sarup were built when dolmens and passage graves were being constructed (Andersen 2019b).

After the end of the excavation activities at Sarup in 1984, we began a study of the Neolithic settlement in an approximately 12 km^2 area around Sarup (Andersen 2009). One of the primary aims of this study was to locate and excavate some of the area's megalithic structures, such as dolmens and passage graves, but also to find long barrows, settlements, houses and sacrificial sites that could have been in use at the same time as the Sarup enclosures, and thus tell about the activities that occurred at that time. In addition, there was a desire to collect material to study the area's vegetation and how the landscape was utilised.

Our study began with museum archives. At that time, four sites with megalithic structures were known: two protected megaliths and two that had been destroyed a long time ago. In addition, a few sites with flint debitage were located, possibly settlements from Mesolithic or Neolithic times. Subsequently, we visited all farmers in the area, who often kept the many artefacts found during agricultural activities. We recorded these artefacts, mostly the flint axes, and mapped where they had been found. However, the greatest effort required a survey of all available fields. At approximately five-metre intervals, the fields were carefully traversed, and the artefacts and structures were measured and described.

Through our efforts, material from all prehistoric periods was found, but particularly noteworthy was the location of approximately 125 demolished megalithic structures and approximately 80 Stone Age settlements. Half of the Stone Age settlements had artefacts that could be dated to the same time as Sarup I or Sarup II. These settlements and megalithic structures provided interesting material for understanding the period to which the two Sarup enclosures belong (Figure 1).

In addition to non-destructive efforts, 16 excavation campaigns were conducted in the area around Sarup between 1985 and 2012. Places where the survey had located traces of megalithic structures, preferably several structures, were chosen so that it was possible to see a connection between the monuments. The largest excavated area was at Damsbo, where 1.5 ha were exposed and excavated. In this area, reconnaissance showed traces of four megalithic structures, but excavation showed that there had been nine structures here, that is, a doubling of what we had noticed on the field surface (Andersen 2019a, 127, fig. 5; 2019b, 238, fig. 8).

During many campaigns, traces of four unchambered ´long barrows´, 29 megalithic sites, a further causewayed enclosure and parts of the four settlements were uncovered. Traces of five houses were found in two settlements. In addition, a 15-metre-long drill core was taken in Sarup Lake, two kilometres west of Sarup, with material for further analysis of pollen, charcoal dust, diatoms and algal pigments (Rasmussen *et al.* 2002). At all locations, large amounts of soil were collected for flotation, which yielded rich material, especially macrofossils and charcoal (Kirleis 2019).

The excavations and subsequent analyses showed that some of what was found can also be observed in some of the exciting material published from the British Isles and Ireland. Let us examine some examples in chronological order.

Frydenlund — Neolithic settlement covered by two long mounds from the thirty-seventh century BC

The oldest site excavated in the area was Frydenlund, which dates to the late part of the first phase of the Early Neolithic period in Denmark, beginning after 3635 BC. On a horizontal plateau located approximately 2 km east of Sarup, traces of a settlement with two longhouses and many artefacts were exposed. Subsequently, the two houses were covered with two unchambered barrows. During the Late Bronze Age, this was covered by a burial mound with a transverse extent of 28 m (Figure 2). The soil of the burial mound has protected the Neolithic constructions (Andersen 2015; 2019a; 2019b, 233–6; Eriksen and Andersen 2016, 101–4).

The first activity on the site, called the settlement phase, was the construction of two houses, A and B, which were placed parallel 4.2 m apart (Andersen 2019a, 124, fig. 2). The houses were two-aisled houses with lengths of approximately 17 m and 12 m and widths of approximately 6 m. Almost 12,000 artefacts were found in and around the houses, showing a varied range of Neolithic flint tools and pottery, as well as extensive macrofossil material (Kirleis 2019).

Directly on top of the houses, two unchambered ´long barrows´ were built in the subsequent phase, known as the monument phase. The northern house (house A) was carefully covered with a horizontal stone paving, defined as a delimited horizontal area of one to two layers of stones. The dimensions of the paved area were 17 × 6.6 m, while the area of the southern house (house B) was framed by a palisade enclosing an area with dimensions of 30.4 × 8.2 m. Neither of the two ´long barrows´ were covered by a mound. At the west end of both constructions, façade ditches, both with three wooden planks, each 85 cm wide, were located. In one of the trenches, planks were dug down to a depth of 2.5 m. This tells us that the planks probably protruded 5–8 m; that is, the planks were probably originally approximately 10 m long. Therefore, these are significant constructions (Andersen 2019b, 235, fig. 5). In Denmark, there are no monumental stones in moraine soils that can be used to construct large megalithic structures. Neolithic people often had to express themselves in wooden buildings.

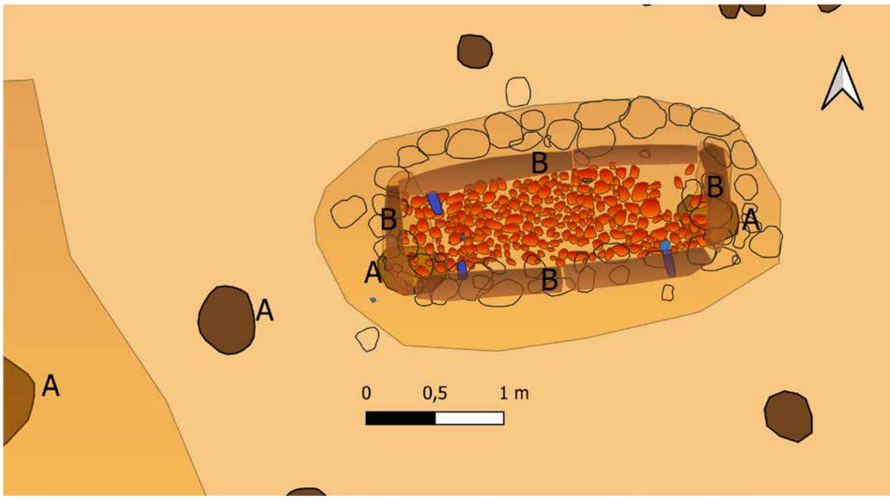

Figure 3. Plank coffin A18 with traces of postholes (A) reminiscent of the removed house (Figure 2, B). The coffin was placed between two sets of postholes; the posts were removed shortly before building the coffin. The coffin was constructed from six planks (B) and the bottom paving. Three flint axes, two transverse arrowheads, an hourglass-shaped amber bead and a collared flask were found in the coffin. Drawing: author.

In the northern barrow, there were no traces of regular burial; however, between the stones in the horizontal stone paving, a whole flint axe, parts of a funnel beaker and a handful of amber beads were placed. Here, we are probably seeing a special form of grave good deposition. Similar finds were recovered in a ´long barrow´ excavated in Rustrup (Fischer 1976).

A stone setting supporting a wooden plank coffin was found in the southern monument. The burial chamber of the coffin was 2.2 × 0.7 m and had two planks on each long side and one plank on each gable end. The burial ground consisted of a fine paving made of round stones approximately 5 cm in size (Figure 3). In the grave, three complete flint axes were found: two in the west end and one in the south. There were also three transverse arrowheads in the west end, an hourglass-shaped, 5.7 cm large amber bead in the middle of the north side of the grave and a collared flask in the south end by one of the flint axes. The grave is one of the richest among the wooden coffins of the Funnel Beaker culture.

During excavation, it became clear that the two ends of the coffin had sunk by approximately 10 cm; that is, the gable planks were set in an area of loose soil. After the stone layers from the grave were removed and the surface was cleaned, it was clear that the gable planks were placed on top of the fill of the two larger postholes. These posts were included in a series that had been middle posts in the southern house during the settlement phase (Figure 2). The wooden posts of the house were pulled up from the holes, and the holes were refilled with loose soil. Subsequently, the two gable planks of the coffin were pounded into the loose soil filling the posthole. Because it takes at least a year for the soil to be compressed, which had not occurred here, we must conclude that the planks from the gables were placed quickly after the house's posts were removed, that is, within the same year.

In excavations with similar features, traces of large postholes were also found at the gable ends of the coffins. It has been considered that the tombs had a tent-like form where the posts carried a beam (Madsen 1979, 309; Mischka 2022, 604, fig. 6.2). However, this interpretation has been doubted; among other things, you can see that the two posts did not stand in the middle of the gable of the coffin but were off-set (Noble 2006, 88). By excavating large surfaces and avoiding the emptying of features such as postholes at Frydenlund, we obtained information that provides a different view of this type of plank coffin. The gable planks were placed on top of the traces of the middle-post pairs in a two-aisled longhouse that had been dismantled shortly before. Previously, it has also been assumed that the solid posts could have been set here to carry a superstructure where corpses were laid for skeletonising before being placed in the closed part of the coffin (Noble 2006, 75–8).

It is recommended that in future excavations of plank coffins, one should uncover a larger area under the coffin. Here, one should check whether the coffin is located on top of house remains. Likewise, one should not empty or cut the postholes until information regarding the relationship between them and other features is obtained.

Analyses of 50 ^{14}C dates from Frydenlund´s two phases, namely the first settlement with two houses and then two monuments of a type similar to unchambered ´long barrows´, show no temporal difference. This location was used from around 3635 BC onwards (Andersen 2019b, 126, fig. 4).

Sarup — two causewayed enclosures from the second half of the fourth millennium BC

It was mentioned earlier that the first archaeological excavations in the area took place in 1971 with the discovery of the enclosures at Sarup. Two enclosures were located and partly excavated, dating from *c.* 3400 and 3200 BC, respectively (Andersen 1997; 1999). The rather intensive and comprehensive excavations at the site resulted in many interesting findings, and the sandy soil of the site provided very good conditions for carefully studying deposits in the system ditches and pits. In addition, the Danish Funnel Beaker culture is blessed with richly decorated and varied ceramics, which is beneficial for dating features and soil layers. This material, as well as the good soil, is important for understanding the activities at the site.

During excavations at Sarup, it soon became clear that we found traces of activities that had also occurred in similar places examined in western Europe (Andersen 1997, chapter 5). Here, I will focus on some elements that also occur in British enclosures.

Whittle has drawn attention to the fact that the British enclosures were placed on sites that had no traces of activity before they were used as enclosures (Whittle 2014, 5). The same is true for Sarup; here, we have no signs of prior activity. The 9 ha promontory bounded by streams should have been quite suitable for activities in the periods before the construction of Sarup I around 3400 BC. From these earlier centuries, we found traces of settlements and burial features similar to those at Frydenlund. Therefore, the areas around Sarup were inhabited at that time, but the promontory at Sarup was avoided.

For some reason, the sites on which causewayed enclosures were constructed must for generations before have been a 'prohibited' area. Were these later enclosure sites already chosen as special earlier on? In addition, it is striking that we only located a few traces of tree throws on the 6 ha that were uncovered at Sarup, a total of 41 (one per 1463 m^2), which can, however, date to many different periods. In contrast, on Frydenlund's approximately 0.133 ha, we found traces of eight tree throws (one per 166 m^2). Was Sarup an almost open space?

The Sarup II site was placed in an area where there had previously been activities, namely a few hundred years earlier, in connection with Sarup I. However, it is noteworthy that there was no activity at Sarup between the two enclosure phases. Pottery decorated in the typical Troldebjerg style, dated to the time between Sarup I and II, does not occur at the site at all. From the time Sarup II was built, however, we see that re-cuttings took place in a few system ditches belonging to Sarup I. Therefore, after a few hundred years, people still had the memory of exactly where the former and long-since backfilled system ditches were located.

Causewayed enclosures are characterised by rows of system ditches that are laid out like elongated beads on a string in a row, arc, or big circuit. Originally, the ditches had approximately the same horizontal shape; however, their depth varied significantly. Two ditches that were aligned with each other at Sarup I have depths of 0.20 m and 2 m respectively (Andersen 2019b, 240, fig. 10). This indicates that the ditches were not dug to provide earth for the earthen rampart. We find a similar variation in the depth of system ditches for example at the Stepleton site in Dorset, particularly evident in segments 3 to 10 (Mercer and Healy 2008, 213–23, figs 3.85, 3.88). The 1.500 m^3 of soil excavated from the ditches at Sarup I would, if the soil was placed on one side of the ditches, only provide material for a 1.3 m high rampart (Andersen 2018, 41). Therefore, the construction of earthen embankments is not part of the activities at Sarup.

In the north-eastern part of Sarup, there are a couple of system ditches where areas of untouched subsoil have been left in their northern part; that is, the system ditches have framed blocks of subsoil (Figure 4). This also confirms

Figure 4. Traces of the system ditch A3063 in the north-eastern part of the Sarup I enclosure. An area of subsoil, like a ridge, remained when the ditch was dug. The picture was taken from the north. Photo: Moesgaard Museum.

the interpretation that the ditches were not dug to supply soil for earthen ramparts. There were no finds on or near the blocks of subsoil that could tell us about their purpose. However, in ditch I at the Haddenham site, Cambridgeshire, a system ditch was found with a larger block of subsoil left in the middle of the ditch. A flint axe was found on the surface of this block, and several fragments of human skulls were found at the base of the block (Evans and Hodder 2006, 253, 255).

In 80 system ditches at Sarup I and II, cross-sections were cut to obtain profiles. These profiles provided knowledge about how the ditches had been dug, their appearance, activities at their base and higher up in the infilling layers, and how the ditches were backfilled, recut and so on. The fine sandy soil at Sarup provided optimal conditions for studying traces of activity in individual ditches. It was thus very surprising that in only one of the 80 cross-sections did we find traces of silt deposited in the corner between the base of the ditch and the side walls (Andersen 2018, 43). When excavating on sandy soil, you will always find that silt layers are quickly deposited in a hole. This occurs when fine sand from the side walls rolls down the sides and deposits at the bottom of the hole, especially if the side walls are exposed to rain, wind or drying out, that is, under almost every weather condition. Such deposits can form within a short period. This is something that archaeologists have experienced when cleaning a fine-grained excavation surface. When returning from picking up the camera, silt has already been deposited. However, in 79 out of 80 cross-sections in ditches at Sarup, we did not see traces of silt deposited on their bases, which is worth noting.

The absence of silt deposited at or on the bases of the ditches indicates that they were not open for a very long time and were probably emptied in connection with the deposit of something on their bottom, after which the ditches were immediately refilled. This is similar to the action we observe when a seed is sown in a furrow (Geschwide and Raetzel-Fabian 2009, 245). This is something that the Stone Age farmers had just become familiar with.

In 1971, Isobel Smith noted that the Windmill Hill culture system ditches in Britain must have been quickly refilled. At the bottoms of the ditches in several locations, she learned that larger limestone blocks had been found which had no traces of exposure to wind, rain, or frost (Smith 1971, 98). Traces of various weather effects can be easily observed on the surfaces of limestone blocks, but this was not the case in this study. The limestone blocks excavated from the ditches were quickly replaced and covered. Smith believed that the ditches were open for only a very short time.

Only a few objects were found at the bases of the ditches at Sarup, with an average of one object per excavated metre. What was often found was fragmented, worn and weathered material rather than whole and unused objects or whole human and animal skeletons. Among the materials is a mandible of an adult (Andersen 1997, 54, fig. 59). Before deposition at the bottom of the ditch, the mandible passed through several stages. After defleshing, it was removed from the rest of the skeleton and left to dry for a long period. During this process, it weathered. This process took at least a few years. Finally, the mandible was deposited at the base of the ditch on the day the ditch was opened. Deposition of old human bones has also been observed at Windmill Hill, Wiltshire (Whittle *et al.* 1999, 362).

At the bases of the system ditches at Sarup are fire-cracked and fragmented flint axes, parts of stone clubs, animal skulls and ceramics. We have an interesting find from Sarup II, where sherds from the same finely decorated bowl were found at the bases of three ditch segments as well as in four pits that lay on the inner side of the barrier (Andersen 1999, 285, fig. 6.8; 2018, 45, fig. 11). Interestingly, the bowl was broken into pieces of approximately the same size. This can only occur through conscious action. In addition, all sherds (bar two) are weathered and worn. Thus, most sherds were unprotected and exposed for a long time, probably for a few years. Similar evidence is available for weathered sherds from Windmill Hill (Whittle *et al.* 1999, 352, 358). Furthermore, matching parts of clay vessels can be found in different system ditches, for example at Windmill Hill, Hembury (Dorset), and Etton in Cambridgeshire (Pryor *et al.* 1985, 297; Smith 1965, 14; 1971, 96). In Staines (Surrey), parts of the same human skeleton were recovered 94 m apart (Robertson-Mackay 1987, 36).

The fact that sherds from the same vessel were found at the bases of several ditches indicates that the ditches were probably open at the same time and that there was an intention that sherds from these vessels should be deposited here. Activities involving the fragmentation of an object into roughly equal-sized fragments must be understood as social relationships that are transferred to objects.

After deliberate and rapid backfilling of the system ditches, a series of recuts took place in the following century. These recuts remained within the outline of the primary ditches and respected the depth of the previous excavations. Neolithic people had hundreds of years of knowledge of the location and shape of the system ditches at this site and continued to deposit special material in the ditches. However, rich cultural layers were deposited in the uppermost and youngest recuts. These layers could contain up to three times more finds per m^3 than the settlement layers excavated in the Sarup area. Therefore, waste material must have been deliberately collected at some of the settlements around Sarup and subsequently carefully deposited in the enclosure ditches.

Megalithic site in the Sarup area

Traces of approximately 125 megalithic structures were found within an area of 12 km^2 (Figure 1). In connection with this project, 29 sites were excavated. Excavations have only been carried out at megalithic sites that have been demolished during cultivation and have been under cultivation for at least 100 years. Some of the sites were badly damaged, and it was the last resort to obtain knowledge about them through archaeological investigation. However, other sites were better preserved, and for many it was the case that the actual chamber in the dolmen or passage grave had a floor layer that was placed 10–20 cm into the subsoil. In several cases, it was possible to find undisturbed layers, as the sites were destroyed before the nineteenth century, when great interest in ancient times arose, which in turn led to the looting of the preserved megalithic tombs. Thus, with good preservation conditions, information and objects can be found in demolished megaliths which are almost impossible to find in preserved structures. Some excavation projects have been mentioned in different publications, but let us examine Damsbo (Eriksen and Andersen 2016, chapter 20).

From 2003 to 2008, an area of approximately 1.5 ha was uncovered at Damsbo. Field surveys and aerial photography have shown traces of four megalithic structures in the field. However, the excavation yielded traces of nine megaliths, that is, a doubling of what we had previously recorded. When uncovered, it was observed that the megalithic features were laid out in a pattern (Andersen 2019b, 238, fig. 8; Eriksen and Andersen 2016, 264, fig. 20.11). A long dolmen, two single free-standing dolmen chambers and a small passage grave were located at the southernmost point of the area. A similar pattern was observed in the middle of the site. At the northernmost point of the site we found the southern half of a long dolmen. The combination of a long dolmen, two single dolmens and a passage grave showed chronological development in the Sarup area from approximately 3400 to 3200 BC. Within the same short period, we also found the same pattern at other sites in the area, for example at Sarup Gamle Skole XII and Strandby Skovgrave (Eriksen and Andersen 2016, 256, fig. 20.5, 259, fig. 20.7, 263, fig. 20.10). Neolithic farmers must have returned to each area approximately every 50 years. There must have been a reason for this return to a special place, as there was otherwise plenty of space in the area and the same pattern of returning to a special place also happened with the ditches at Sarup.

Although the megaliths were demolished, it was possible to determine that they, especially the passage graves, were built using different materials, but also that they were re-used at different times. Even within smaller areas, there are variations in megalithic construction and use.

Three of the megaliths in Damsbo were built in places where houses had previously stood, as we saw at Frydenlund (Eriksen and Andersen 2016, 264, fig. 20.11 – features A2, A1 and A121). These houses can be dated to the Fuchsberg phase, approximately 3400 BC, that is from the time Sarup I was built. In two cases, the dolmen chambers were placed between the traces of central roof-bearing posts in the middle of the houses (Eriksen and Andersen 2016, 264, fig. 20.11 – features A2 and A121). This corresponds to what we also experienced at Frydenlund, where the plank coffin was placed between the traces of the roof-bearing posts of the demolished house B (Figure 3). The dolmen chambers at Damsbo were probably built soon after the houses were abandoned. On the other hand, the third house was located to the west of a passage grave chamber, but the plot of the house was carefully framed by kerbstones surrounding the tomb (Eriksen and Andersen 2016, 264, fig. 20.11 – feature A1). The passage grave was a few hundred years younger than the house; therefore, there must have been a memory of the house's location during this time interval.

The passage grave above and east of the house plot consisted of a pear-shaped chamber with a corridor to the east (feature A1). A spiral stone row of head-sized stones was placed around the chamber. We also found similar rows of stones around the chambers on a series of Irish megalithic features, for example, at Townleyhall and from the passage graves at Knowth (Eogan 1986, 21, fig. 8). These rows of stones around the chambers framed them at an early stage in their history. In five places in the spiral row at Damsbo A1, there were also piles of sherds from parts of finely decorated vessels (Andersen 2013, 521, fig. 5). Some of the sherds were weathered, i.e. old, and had been used when placed. The sherds were carefully placed, and in three cases the handles of the vessels were placed at the top of the piles. These actions took place before a mound of earth was built to secure and cover the stone chamber.

At the same time as the construction of the inner mound, the whole feature was framed by a series of closely-set kerbstones without an opening into the chamber and the inner area (Andersen 2013, 520, fig. 4). Between these kerbstones and the inner burial mound that covered the chamber, there must have been an open space for a while. Therefore, the kerb is set to frame the features and not form an edge to hold the earth of the mound. Kerbstones only achieved this stabilising function at a later stage of development. A similar open space between the kerb and the inner mound is also found at some of the Irish passage graves, for example at Loughcrew site L (Eogan 1986, fig. 39).

A series of monoliths was placed outside the closed chain of kerbstones at Damsbo A1. Originally there must have been 12 monoliths; however, ploughing on the westward-sloping surface removed some traces. Rows of monoliths set in circles around the mound can, for example, be found at the site of Balmuran of Clava in northern Scotland (Bradley 2007, 173).

Finally, a mound extends above the passage grave and reaches the kerbstones. Inside the chamber of the passage grave, a 5 cm thick layer of white *Cardium* shells was found on the floor, where human bones were preserved. Because of ^{14}C dating and the recovery of a wrist guard, the chamber is thought to have been reused by people related to the Bell Beaker culture in the second half of the third millennium BC.

The Damsbo excavation has shown that by carefully excavating even demolished megalithic features, new knowledge can be obtained, which can otherwise be difficult to gain from preserved and protected monuments.

The dolmen capstones

Dolmens are freestanding monuments in which a stone chamber is constructed of at least four supporting stones and covered with a single covering stone: the capstone. Several types of dolmens exist, ranging from small, low stone coffins to larger monumental structures with short passages. However, for the site to be classified as a dolmen this passage must not have a capstone. If there are capstones above the passage, the feature must have been covered by a mound of earth, and it is then defined as a passage grave. Some colleagues call round stone chambers with a covered passage a 'large dolmen' (*stordysse*), which is confusing because the whole construction corresponds to what we see from passage graves, for example well-built chambers, passages that reach the edge of the mound, passages with capstones and a covering mound. In contrast, a dolmen is an open monument meant to be seen (Ebbesen 2011, 45–6; Eriksen *et al*. 2023, 36–7; Hansen 2016, 54–8).

Dolmens can stand alone but can also be framed by kerbstones set in a round or rectangular shape. The supporting stones in the dolmen chamber can be laid horizontally, whereby a low chamber is achieved, or the stones can stand upright as orthostats. With orthostats, a significantly higher and more monumental chamber was achieved. Covering the high chamber, a capstone, a distinctive stone that is much larger and more massive than necessary, was chosen. They were chosen on the basis that the dolmen should stand out in the landscape and be seen.

When studying the capstones of monumental dolmens, we observed that they may have been chosen based on their special shape. Capstones often have the shape of a large drop, perhaps closer to the shape of a flat cap or hat (Figure 5). These flat-cap capstones always have a thin part, that is, the brim of the cap, placed over the entrance to the dolmen's chamber. When studying dolmens in Mols, Denmark, many were shown to have capstones shaped like flat caps. We also find the same form of capstone on many other dolmens in Denmark, Sweden, Germany, Ireland and Britain, for example at Arthur's Stone in Wales (Cummings and Richards 2021, 100, fig. 4.6). In this large area, there was a common idea of choosing capstones with a special shape.

Long dolmen at Ellested, located 10 km south-west of Nyborg, Funen, Denmark. The long dolmen framed four dolmen chambers with pronounced capstones and one chamber missing its capstone. The capstones have a distinct shape similar to a flat cap. Photo: author.

At the Carrowmore site in north-western Ireland, there is a very fine group of approximately 30 preserved dolmens. In form and expression, these dolmens are very similar to contemporary dolmens in the Nordic area. At Carrowmore, dolmens also have distinctive capstones, some shaped like flat caps. Furthermore, the chambers can also be surrounded by kerbstones placed in a circular construction (Burenhult 1984, plate IIA and IIIB).

Concluding remarks

The above summarises some observations on Neolithic monuments in Denmark, especially in the area around the excavated causewayed enclosure in Sarup, as well as on other contemporary monuments in the British Isles and Ireland. Here, it is presented how earthen graves in so-called ´long mounds´ in several cases must be interpreted in such a way that the graves were placed on top of the traces of house plots which previously stood in the same place. Thus, there is no argument for imagining graves with tent-shaped superstructures. Causewayed enclosures show many similarities, especially in the selection of areas for their placement and the way the system ditches were dug, used and refilled. Likewise, megalithic tombs show similarities in the way they were built and used, just as dolmens in both areas often seem to have been covered by big stones in the shape of a flat cap.

The examples provided are probably only a small part of what can be found through more in-depth studies. It is difficult to interpret why we found traces of uniform activity in areas that are far apart. Possibly, it has something to do with contact between the areas, or the two outlying areas had a common origin for their monuments in one or more areas further south. The conference in Copenhagen in May 2023 has shown that there is an exciting topic, which I hope will be the subject of further study in the coming years.

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UNDERSTANDING THE ROLE OF FLINT ARTEFACTS AT NEOLITHIC CAUSEWAYED ENCLOSURES IN BRITAIN AND SOUTHERN SCANDINAVIA

Peter Bye-Jensen

Abstract

The causewayed enclosures of Europe have been and continue to be one of the main focal points of research in the Neolithic. This research has mostly been focused on the spatial and architectural analysis of these enigmatic structures and typological descriptions of the artefact assemblages. However, a better understanding of the deposited material culture found in the ditches of the enclosures enables insights into the nature of the activities performed at the monuments. These artefacts are sometimes arranged in so-called structured deposits, which furthers the inference of the activities on the sites and alludes to the purpose of enclosures in general. The research presented here focuses on the flint artefacts deposited in ditches at various causewayed enclosures from Britain and Denmark, with further examples from other Neolithic settlements and mortuary contexts used to contextualise the findings from the enclosures. The investigation is grounded in use-wear analysis in combination with the further development of this method to create a more comprehensive biography of the artefacts. Therefore, this approach offers a rare insight into the selection of flint artefacts for deposition that constitute one of the key and recurring activities at the enclosures found around the edges of the North Sea.

Keywords: Neolithic; use-wear analysis; flint; artefact biography

Introduction

The Neolithic in Europe represents a pivotal point in human history, marked by transformative shifts in societal structures, technologies and cultural practices. Among the monuments of this period, causewayed enclosures have stood as enduring subjects of scholarly inquiry, occupying a central position in archaeological research of the Early Neolithic. Investigations have historically centred around spatial configurations and architectural attributes, seeking to unveil the purpose and function of these structures that dot the European landscape (Oswald *et al.* 2001; Whittle *et al.* 2011, 878). Historically, the inferred purpose of these monuments has varied, from defensive structures to settlements and gathering places. However, the one feature that is the same for all the monuments are the ditches, which sometimes enclose several hectares of land (Oswald *et al.* 2001). The

In D. Hofmann, V. Cummings, M. Bjørnevad-Ahlqvist and R. Iversen (eds) 2025, *The early Neolithic of Northern Europe. New approaches to migration, movement and social connection*, 181–192. Leiden: Sidestone Press.

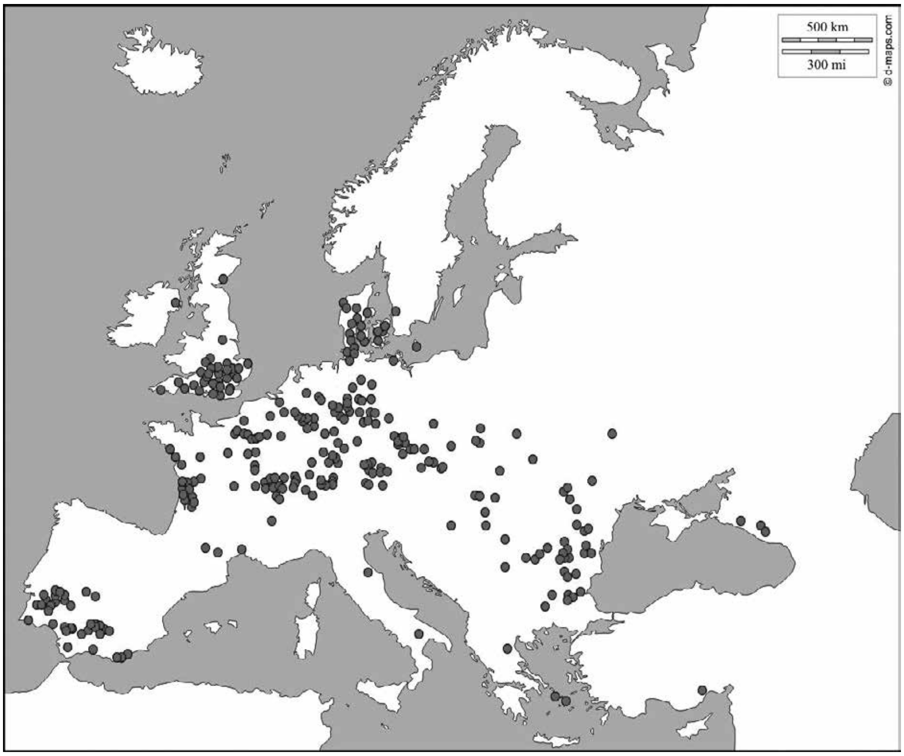

Figure 1. Distribution of Neolithic enclosures from about 4200 to 2800 cal BC. The location of sites is approximate (redrawn from Andersen 1997, fig. 178, with addition of the south Iberian enclosures from Márquez-Romero and Jiménez-Jáimez 2013, 447–60).

ditches are what make the enclosures and encircle *spaces of meaning* as a monumental statement in the landscape. These ditches would be dug, covered up and later recut. The recutting of ditches at causewayed enclosures reflects a complex sequence of activities that suggest both continuity and change in the use of these sites. The episodic recutting and deposition of artefacts within the ditches were often highly formalised processes, with care taken to avoid disturbing previous layers (Smith 1966). This suggests that each recut event was a significant communal activity, likely imbued with social or ritual importance, linking the community to their past actions and the site itself. For instance, at Etton, the eastern arc of the enclosure features up to eight recuts, indicating repeated and structured re-engagement with the site over time (Pryor 1998).

However, a remarkable facet often overlooked is the material culture carefully deposited within the ditches encircling the monuments (Pollard 2001). These assemblages, encompassing a selected range of artefacts, present a unique opportunity to gain deeper insights into the activities carried out at these sites (Saville 2002). In certain instances, these artefacts are meticulously arranged in structured deposits, which provide valuable clues into the activities conducted there at the time of deposition and the overarching purpose that propelled the creation of these enclosures (Andersen 2014a; Pollard 2001).

The present research is focused on a specific category of these artefacts — the flint tools — deliberately selected and deposited in the ditches of the causewayed enclosures. A comprehensive investigation of material from selected sites has been conducted, employing a novel analytical approach merging use-wear analysis and the nuanced development of a methodological framework aimed at unravelling the complex biographies of these artefacts, extending beyond their functional uses. This study endeavours to transcend the traditional confines of artefact analysis, offering a rare glimpse into the deliberate choices behind the selection of flint tools for deposition at causewayed enclosures. Thus, one might perceive the used flint tools as fossilised memories of remembered activities in the Neolithic, and this study highlights their transformation from flint tool to artefact. Ultimately, this approach strives to decipher recurring patterns across the North Sea, portraying a set of choices made in the Neolithic practices, traditions and activities that the flint artefacts represent.

The primary objectives of this study are to:

- Analyse the function of flint artefacts from causewayed enclosures: focus on assemblages from ditch contexts to determine their roles in site construction and/or primary depositional practices
- Understand the taphonomy of flint artefacts: examine the preservation processes of flint artefacts in causewayed enclosure ditches
- Improve interpretation of causewayed enclosures: investigate their functions as defensive structures, ritual places and/or gathering sites

- Showcase the integration of use-wear analysis: highlight the importance of use-wear analysis from excavation to post-excavation research
- Enhance use-wear analysis methods: develop and integrate use-wear analysis with other interdisciplinary science-based methods

Methodology, selection and results

Method

Use-wear analysis of prehistoric flint tools is a method that has been practised for almost half a century (Jensen 1988; Stemp *et al.* 2013). The approach employed in this study, distinct from prior investigations on use-wear (Marreiros *et al.* 2015; Van Gijn 2014), resides in the analytic integration of taphonomic factors, specifically focusing on surface modifications of flint artefacts, as an integral narrative element in the construction of biographical accounts for flint artefacts originating from causewayed enclosures and other integrated archaeological sites. Furthermore, the analysis was carried out using a metallographic microscope (Olympus BHM and Nikon LVT Eclipse 120) and a high-end USB microscope (Dinolite Edge-series) at magnifications of 20x, 100x and 200x. Samples were prepared by scanning the artefacts at 20x magnification, then cleaning them with warm water and pH-neutral detergent. Surveying and sampling flint assemblages with the USB microscope technology enables mobility that eases scanning the flint assemblages. Furthermore, the area which one observes in a USB microscope is much larger than in a conventional microscope. This means that more surface area is visible, and artefacts can be analysed faster (Figure 2).

The techniques employed in this study build upon the foundational principles of use-wear analysis but also incorporate advanced digital microscopy and image processing. This approach offers significant advantages over traditional microscopic investigations, allowing for the analysis of larger areas when identifying use-wear patterns. Recent studies (e.g. Boström and Lundin 2021; Calandra *et al.* 2019; Zhang *et al.* 2024) have demonstrated the potential and pitfalls of 3D imaging software and machine learning (Artificial Intelligence/AI) to revolutionise use-wear analysis, making it more precise and reproducible. However, this is not a practical or logistical approach when travelling to assemblages due to time constraints and the need for relatively light equipment. Therefore, this study represents a more standardised approach in the sense that it utilises conventional direct-light microscopy. Furthermore, most analyses happened between 2014 and 2019, which timewise was on the cusp of the next development in use-wear analysis.

Typology and use-wear

Within the realm of archaeological discourse, the classification and typology of artefacts represent fundamental tools for methodically describing material culture. Particularly, when examining archaeological flint artefacts, the establishment of typologies for flint assemblages emerges as a foundational framework for comprehending and categorising their functional roles and

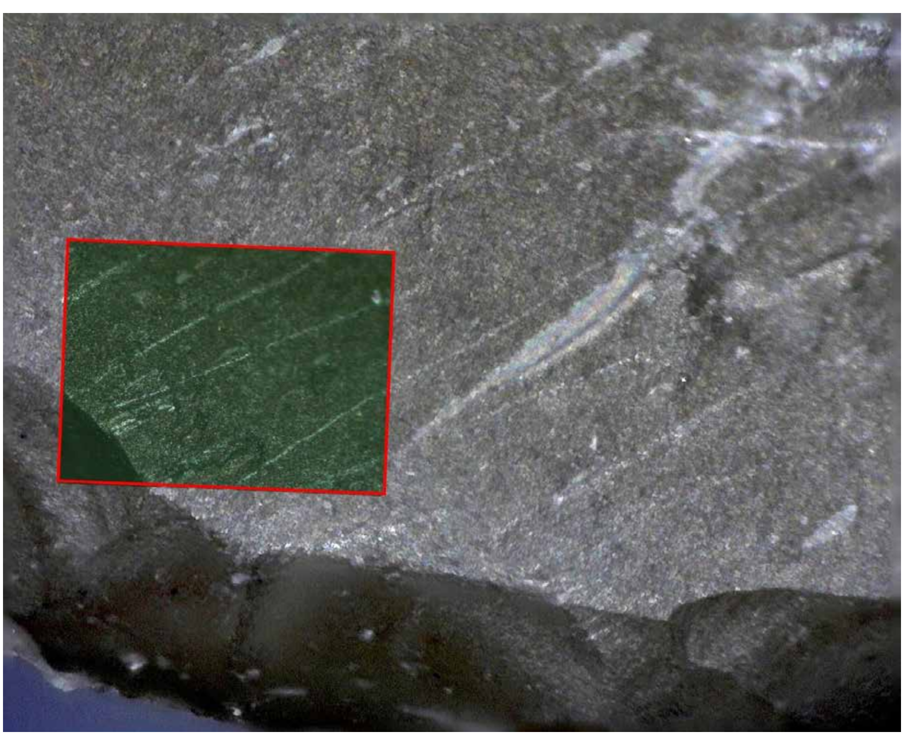

Figure 2. The greyish edge of a flint arrowhead. The red box shows the area observed in a conventional microscope at the same level of magnification.

economic significance within broader tool assemblages. It is imperative to acknowledge that, at times, the terminology, semantics and classification of flint tools may exhibit inherent biases concerning their intended usage and interaction with various materials. An illustrative example can be drawn from the category of scrapers — a class of tools conventionally presumed to be designed for scraping activities, albeit subject to uncertainties that can only be resolved through use-wear analysis. Similarly, and more importantly, the supposition of specific contact materials associated with scrapers requires a more nuanced evaluation, as traditional perspectives have often leaned towards the belief that most scrapers were primarily engaged in hide processing. Nevertheless, archaeological research has shed light on the versatility of scrapers, encompassing activities such as woodworking to hide-processing, as elucidated by the research of Jens Jeppesen (1984).

Selection

The flint assemblages from causewayed enclosures are characterised by an abundance of material (Andersen 2014b; Saville 2002). Therefore, to make sure that data for the interpretation of the analysed material was as informed as possible, the following criteria were used:

- Fully excavated ditches
- Analysis of complete flint assemblages within ditches
- Priority of primary layers of the ditches
- Special focus on understanding what serrated-edge flakes were used for

The following sites have been studied for this analysis (Figure 3): Windmill Hill, Crickley Hill, Staines, Hambledon Hill, Etton and Sarup. These are well-researched and published causewayed enclosures. Caerau is a relatively newly excavated causewayed enclosure in Wales (Davis and Sharples 2017). It has been incorporated to gain access to new and freshly excavated material in contrast to the material from the other enclosures, some of which has been curated for close to a decade. However, to gain further comparative insight and compose a diachronic study, Skaghorn and Ascott-under-Wychwood have also been included. Skaghorn features as a contemporary settlement located near Sarup I and Ascott-under-Wychwood is used as a counterpoint, as the material stems from a Neolithic long barrow with traces of pre-barrow settlement activity (Bye-Jensen 2019; Meadows *et al.* 2007).

Results of the use-wear analysis

The results below are a summary of some of the overall results of the author's ongoing research in the use and treatment of flint tools in the Early Neolithic of northern Europe. However, a more in-depth account of the individual sites is available (Bye-Jensen 2019). The primary objective behind the utilisation of use-wear data in this research has never been to provide quantitative results, given the substantial quantity of artefacts within the causewayed enclosures. Instead, the goal has been to delineate the activities represented by these flint artefacts by thoroughly analysing each piece.

Roughly, the number of artefacts selected for analysis from causewayed enclosures totalled over 500 flint artefacts, almost 100 from a long barrow and just over 200 from settlements. A key finding in this study is that most of the flint artefacts recovered from the causewayed enclosures exhibit evidence of use, as detailed in Figure 4. Interestingly, this trend holds for most of the artefacts

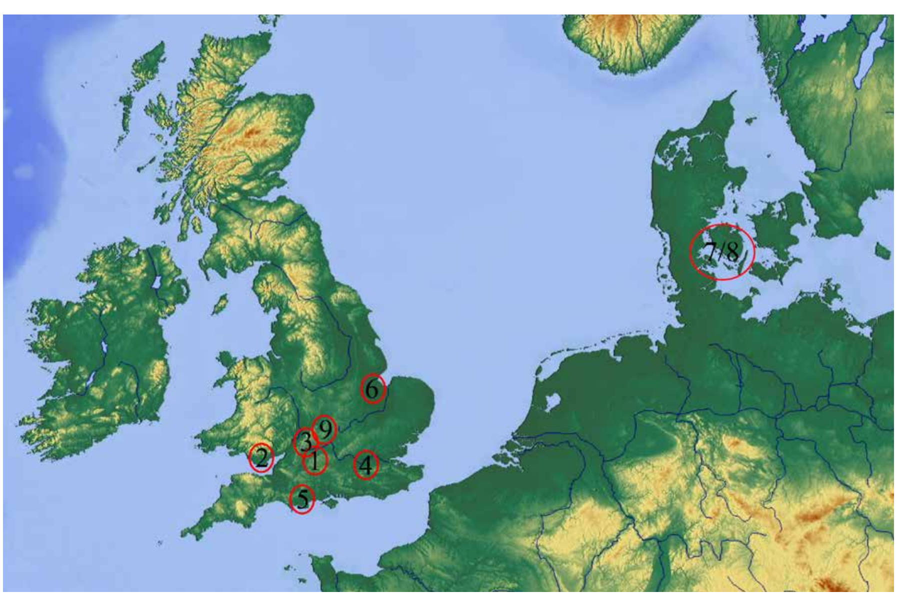

Figure 3. Location of sites mentioned in the text. 1. Windmill Hill; 2. Caerau; 3. Crickley Hill; 4. Staines; 5. Hambledon Hill; 6. Etton; 7. Sarup I; 8. Skaghorn (settlement); 9. Ascott-under-Wychwood (settlement and long barrow).

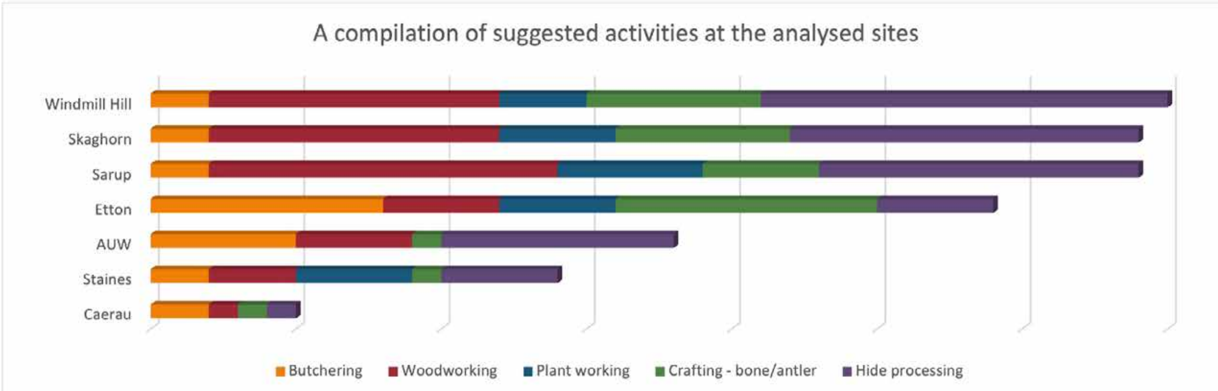

Figure 4. This figure shows the trend in activities found through qualitative use-wear analysis at the mentioned sites. AUW = Ascott-under-Wychwood.

selected for analysis in this research. Conversely, the flint artefacts likely originating from settlements, such as the midden layer at Ascott-under-Wychwood and Skaghorn in Denmark, display fewer indications of use (Andersen 2000; Benson and Whittle 2007). This difference suggests a more varied pattern of both used and unused flint artefacts in the settlement context compared to causewayed enclosures. It also highlights the fact that it was used flint tools that became the artefacts selected for structured deposition.

Furthermore, in the use-wear analysis of the selected sites represented in Figure 3, one sees that the flint tools deposited in the ditches of the causewayed enclosures were involved in butchering, woodworking, plant working, crafting in bone or antler and processing hide (fresh and dry). The representation is not intended to be statistical but opens up a wider discussion about how the flint artefacts were related to the construction of the monuments or activities at them, or if indeed at all related to activities at them. The role of the flint artefacts in enclosure ditches will be discussed later, as this may be different to the activity that the flint tool carried out. These results exclude the analysis of the flint assemblage from Crickley Hill, which was originally a part of the enclosures selected for analysis. This is because the analysis of this site specifically assessed the alleged battle events put forward in previous site interpretations (Dixon 1994). Later in this paper, a brief consideration of the use-wear analysis of the material from Crickley Hill will be presented. However, a special focus has been directed to a specific kind of flint tool, the serrated-edge flakes. This is because they are a particularly common type of flint artefact found in the ditches of causewayed enclosures (Saville 2002).

Serrated-edge flakes

Serrated-edge flakes are a typical phenomenon in Early Neolithic Europe, and they often appear in the causewayed enclosure assemblages and disappear in the Middle Neolithic. One might even see it as a cultural marker related to the Early Neolithic cultures in northern Europe and perhaps a tool relating to a tradition in processing a specific material in a certain way. Most of the serrated-edge flakes, as well as the occasional non-serrated-edged flake, displayed use relating to plant processing (Bye-Jensen 2019; Jensen 1994; Van Gijn 2010). The use-wear seen on prehistoric serrated-edge flakes is not easily replicated. However, through experiments with many different kinds of plants, the use-wear traces on modern replicas of serrated-edge flakes that come closest to the traces observed on archaeological examples are those of stinging nettles (*Urtica dioica*). One of the other discoveries in this research lies within the kinematics of the use of the tool. By holding the tool as seen in Figure 5, one can drag the fibres through the serration and pull them out of fresh stinging nettle. This is a variation on other experiments that have sought to replicate the observed use-wear traces. Thus, the experiments performed by the author provide an analogue in both kinematics and use of serrated-edge flakes. How fine the end product was is dependent on the time spent pulling the fibres. Experimentally, everything from fine yarn to rope could be achieved. This inference enables a better understanding of the possibilities of fibre technology in the Neolithic of northern Europe.

Case study: Crickley Hill — the battle that never happened

One of the classic interpretations of causewayed enclosures is that they served as defensive structures (Andersen 2014a; Grimes 1960). At certain locations, such as Crickley Hill, the substantial quantity of arrowheads discovered has been proposed as evidence supporting this interpretation (Bye-Jensen 2019; Dixon 1994). Consequently, a portion of the author's research project focused on re-assessing whether any warfare-like activity could be identified at this enclosure. As mentioned above, the analysis of the flint artefacts

Figure 5. Plant processing with a serrated-edge flake to replicate its use.

from the Crickley Hill assemblage was not included in the comparative study of similar enclosures. This omission is due to the specific research focus on understanding the role of the many leaf-shaped arrowheads found within the context of this atypical enclosure (Dixon 1994).

Upon examining 21 arrowheads sampled across the site, only two displayed fractures consistent with those typically associated with fired arrowheads, namely bending fractures and hinge fractures (as outlined by Fischer *et al*. 1984). It is noteworthy that such fractures can also occur through alternative means, such as walking on the arrowheads. Notably, none of the arrowheads exhibit linear polish, a microscopic trace indicative of an arrowhead having been fired (Bye-Jensen 2011; Lammers-Keijsers *et al*. 2014; Rots and Plisson 2014). The prevailing impression is that most of the arrowheads remain unused, with some potentially intentionally broken and destroyed. The observed damage primarily resulted from trampling or intentional breakage unrelated to firing or burning. Additionally, the number of arrowheads showing any possible traces of use is notably small, suggesting that the deposited arrowheads were not used for their conventional purpose of hunting or warfare.

Nevertheless, one arrowhead bears a distinctive trace potentially indicative of axial hafting. This trace extends from the base of the arrowhead to approximately 5 mm before the fractured tip, with a patina width measuring about 4–6 mm, corresponding to conceivable arrow shaft dimensions (Figure 6). The presence of a white patina as a hafting trace

Figure 6. Stitched image from the microscopic examination of a leaf-shaped arrowhead from Crickley Hill. Observe the pale white patina indicating the area where the arrow shaft was attached.

appears unprecedented in the existing literature. This patina might have developed through a chemical reaction involving a mastic securing the arrowhead within the arrow shaft. Furthermore, this particular arrowhead exhibits a step-terminating bending fracture, conceivably resulting from its use as a projectile (Bye-Jensen 2011; Fischer *et al.* 1984). It is pertinent to mention that this arrowhead shows no discernible indications of handling, such as transportation, curation or placement and subsequent exposure to weathering. Contrary to prevailing perspectives, my analysis posits that the numerous arrowheads discovered at Crickley Hill do not support the notion of an offensive against the continuous ditch enclosure. It is plausible that certain arrowheads were deliberately crafted not for practical use as functional projectiles but rather as symbolic or token artefacts.

The rationale underlying the deposition of token arrowheads remains speculative; however, a plausible conjecture is that the substantial quantity of arrowheads accumulated over an extended temporal span as offerings or sacrificial objects. It is conceivable that the causewayed enclosure, along with its succeeding iterations, served as a consecrated space for pursuits related to symbolic and ritualised hunting or feuds, but importantly not actual warfare.

The life, death and afterlife of a flint artefact

The methodological approach used in this research aims to unravel the life biography of a flint artefact, akin to constructing a narrative storyline for such an object (Wentink 2006). The primary objective of this study is to systematically analyse the selected artefacts, employing an objective lens to discern traces of use and treatment that connect the artefacts to actions and activities in which these flint artefacts have participated. Annelou Van Gijn has previously employed a similar methodology in her examination of Neolithic and Bronze Age flint tools from the Netherlands (Van Gijn 2010).

However, the novelty in the present methodological approach is the coupling of use-wear analysis with taphonomic observations of surface modification of the flint artefacts (Bye-Jensen 2019). This approach is grounded in an insight into Michael Schiffer's sequence of activities (Schiffer 1972). The method begins with a taphonomic division of contexts, distinguishing between the life and death of a flint tool — where we find it as archaeologists (archaeological context) and the broader context we theorise about (systemic context). Schiffer breaks down the systemic context into procurement, manufacture, use, discard and subsequent refuse or transport, eventually leading to secondary discard. All elements of the systemic context can involve refuse (Schiffer 1972). The developed *taphonomic-wear analysis* approach devised for this research reveals that the patina or surface modifications of flint artefacts can be read as a life biography and indicate their exposure to sunlight, temperature and local environment before deposition. This insight enables us to infer the 'life' of these artefacts just before entering their archaeological context. Over time, the surface of flint tools can change due to specific contexts, acquiring patina or incrustations from their surroundings (Burroni *et al.* 2002; Stapert 1976). This observation is valuable for addressing questions about how long flint artefacts were in use before being deposited in the system ditches or pits of causewayed enclosures.

The taphonomic processes affecting the examined flint assemblages differ due to the varied soil and sediment compositions at the selected sites. Factors like soil chemistry, movement, water table fluctuations, site erosion and modern intrusions (e.g. ploughing) must be considered in archaeological contexts. The sites are situated on different subsoils, such as gravel/sand (Etton), gravel, clay, sand (Staines), chalk (Windmill Hill) and clay (Caerau). Consequently, the potential for altering the original surface of flint artefacts varies between assemblages. For instance, the chalk at Hambledon Hill has significantly modified many of the flint artefacts, making high-powered use-wear analysis challenging due to the patina obscuring use-wear traces.

The analysed flint artefacts from the causewayed enclosures exhibit a structured and intricate deposition cycle, evident in the physical arrangement of clusters and varied linear and sometimes seemingly random placements within ditches and pits (Garrow 2012; Pollard 2001). Initially, one might have speculated that these artefacts were linked to activities surrounding the construction and maintenance of the monuments. However, the use-wear analysis results indicate that few, if any, deposited flint artefacts directly related to the construction of their corresponding causewayed enclosures. Instead, these artefacts likely played a representative role within complex cycles of curation, transformation and deposition alongside other artefact types.

This interpretation is supported by observed differences in surface modification and subsequent natural alterations of the flint artefacts found in the analysed assemblages from the selected enclosures. These differences in surface modification contribute to suggestions regarding the temporality of deposition. The curated flint artefacts were exposed to weather conditions, such as rain, sunlight and snow/ice, potentially alongside decomposing organic material, forming part of cycles studied by Chris Fowler (2003, 45–63), whose theories align with this study's results. Notably, none of the analysed flint artefacts exhibited signs of frost damage, suggesting a limitation on the time they spent in environments susceptible to frost. Experimental data indicate that frost damage typically manifests after approximately 300–600 freezing-thawing cycles, equivalent to five to ten years, with a potential two-month induction in a frost/thaw environment such as December to February. Consequently, data from experiments with frost damage on replicas of flint artefacts suggest that the flint artefacts were curated for a maximum of ten years (Bye-Jensen 2019). Weathering experiments connected to this research suggest that the observed surface modifications would develop on prehistoric flint artefacts within one to five years. Therefore, it is reasonable to argue for a deposition cycle of approximately one to five years for weathered artefacts, though the immediate deposition following this treatment remains uncertain. This is because the level of weathering suggests that although some of the artefacts look freshly made, they display microscopic surface modifications that are analogous to an exposed deposition for a short number of years. The weathering or environmental abrasion results from exposure to UV from the sun and so-called wind-polishing caused by dirt and dust particles. This is evident in most artefacts, with one side showing more surface modification than the other. Therefore, the present author proposes the following scenarios:

Off-site curation: In this scenario, flint artefacts chosen for deposition undergo an extended curation process involving the collection of various items like fragmented pottery, human and animal bones, and potentially decomposed organic artefacts. Following curation, these artefacts travel from settlements and midden sites to the causewayed enclosures for deposition.

On-site curation: In the second scenario, curated artefacts are initially used at the causewayed enclosures for activities suggested by use-wear analysis. Subsequently, these artefacts are retained and become part of on-site curation, possibly within a midden-like structure, serving as reminders of prior events.

The research suggests that depositions occurred relatively rapidly, within a timeframe shorter than the estimated five years. Consequently, the evidence indicates a possible combination of both scenarios, where some artefacts may have been selected and brought from near and distant locations to be mixed with material curated on-site before deposition. This supports the idea of causewayed enclosures being gathering places for various ceremonial purposes. Additionally, the analysis presented here includes Sarup I in Denmark, which displays comparable results to the principal selection of material from chosen enclosures in both use-wear and taphonomic analysis. This hints at a pattern, practice or perhaps tradition in artefact treatment at causewayed enclosures around the North Sea.

It has been argued that in the Early Neolithic mind, the concepts of ritual and memory formed a complex, cyclical pattern of repetitive activities (Fowler 2003, 45–63). While this notion is acknowledged (Whittle *et al.* 2011), the temporal aspect of activities involving the deposition of flint artefacts in the ditches of causewayed enclosures and associated pits remained unclear before this research. The overall impression of flint assemblages persists, encompassing various types of flint tools and debitage deposited at causewayed enclosures throughout monument use phases. What distinguishes these seemingly

Figure 7. Flint artefacts from Ascott-under-Wychwood. One artefact was found in the cist and the other in the midden, but the dark residue imprinted on each item suggests both were originally deposited in the midden. This supports the hypothesis that the material in the cist was selected from midden deposits (scale 1:1).

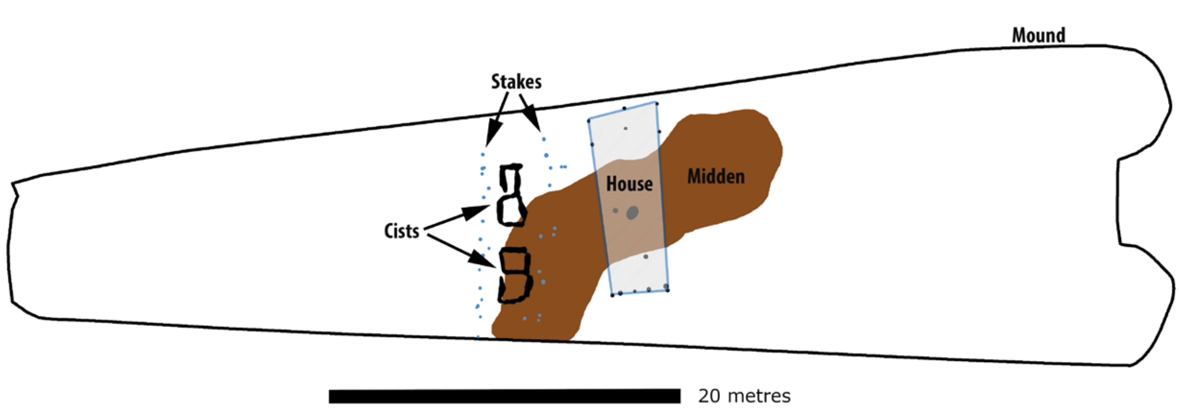

Figure 8. The four phases at Ascott-under-Wychwood are a house, a midden, cists and a mound.

ordinary tools is how they are treated, i.e. not as tools but as artefacts. Use-wear analysis consistently indicates that most flint tools deposited at causewayed enclosures were already relics or artefacts when placed there. Surface modification and general weathering make the tools appear relatively fresh, yet microscopic examination reveals the early stages of a white patina and degrees of weathering.

Furthermore, the flint artefacts analysed in this study almost all bear traces of use. This suggests that the people who deposited the flint artefacts intended to use a selection of flint tools they knew had been used. Therefore, the flint artefacts would serve as a *pars par toto*, souvenirs of memories. They could represent an event, a group or a family member, or relate to the life lived on a settlement.

This insight raises questions about the broader implications for other artefact types like pottery, bones and miscellaneous materials. Could these materials generally be preserved refuse with an intrinsic value, collected for final deposition when the time was deemed appropriate? This contemplation aligns with Schiffer's notion that 'refuse labels the post-discard condition of an element — the condition of no longer participating in a behavioral system' (Schiffer 1972, 159), suggesting a final stage in the rite of passage for these artefacts.

Further to this discussion, the use-wear analysis and general work with the material from the excavation of the midden and long barrow at Ascott-under-Wychwood reveals that the treatment of artefacts as mementos might build on slightly older practices and traditions in curating material for deposition (Bye-Jensen 2019; Meadows *et al.* 2007, 342). This is apparent in the refittable flint artefacts in Figure 7. One piece of flint was found in the midden layer of the pre-barrow soil, while the other was among a very few selected artefacts in the cist of the long barrow. The midden is inferred to be the result of occupation on the site and up to two houses (Figures 7 and 8).

Museum wear and modern curation

Apart from prehistoric wear traces and surface modifications, the analysis of flint artefacts continuously reveals additional insights during numerous visits to museum storage facilities housing these artefacts. Beyond their archaeological context, these artefacts have embarked on a continued life journey, entering a new phase in their biography in the preservation of current heritage. Consequently, they engage in another cycle of treatment influenced by present-day human activities. Surface modifications can occur due to handling, cleaning and storage practices in museums. For example, edge damage from artefacts stored in the same finds bag or scratches from cleaning tools can significantly affect the artefacts, introducing wear patterns that are not related to their original use but to their modern curation environment (Figure 9).

Figure 9. A flake from the Staines causewayed enclosure demonstrates the fight for surface space to write on.

The recently excavated enclosure at Caerau, Wales, offers a unique opportunity to differentiate modern museum-wear from prehistoric surface modification and general wear (Davis and Sharples 2017; Davis *et al.* 2016). Since the flint artefacts from Caerau are freshly recovered and have minimal modern contamination, they provide a clearer baseline for identifying genuine prehistoric use-wear traces and prehistoric surface modification. Comparing these observations to older collections, such as those from Windmill Hill, highlights the extent to which museum practices can alter artefacts. This differentiation is crucial for accurately interpreting the biographies of flint artefacts and understanding their true historical context.

Conclusion

In conclusion, this research has endeavoured to shed light on the hitherto understudied dimension of flint artefacts deposited in the ditches of Neolithic causewayed enclosures in Britain and Scandinavia. By employing a methodological approach that combines use-wear analysis and the nuanced development of a biographical framework, this study has sought to unravel the activities and choices encapsulated in these artefacts. The findings presented here contribute significantly to our understanding of the Neolithic landscape, going beyond traditional analyses of spatial and architectural aspects of causewayed enclosures.

The investigation into flint artefacts has unveiled not only their varied functional roles, including butchering, woodworking, plant working, crafting in bone or antler and hide processing, but also their potential cultural significance. The focused study of serrated-edge flakes has offered insights into specific traditions and practices related to fibre technology in the Neolithic of northern Europe. The meticulous use-wear analysis has demonstrated that a majority of the flint artefacts recovered from causewayed enclosures exhibit evidence of use, contrasting with the lower indications of use in flint artefacts from settlements. This divergence in usage patterns suggests a more complex and varied role of flint artefacts in the context of causewayed enclosures.

The research has also presented a detailed analysis of a specific site, Crickley Hill, challenging prevailing interpretations of Neolithic warfare. The study of leaf-shaped arrowheads at Crickley Hill suggests that these artefacts were not primarily intended for offensive purposes, but rather held symbolic or token significance. The absence of clear evidence for battle-related damage on the arrowheads raises questions about the role of these artefacts in the broader ritual and symbolic practices associated with causewayed enclosures.

Furthermore, the novel approach of constructing the life biography of flint artefacts, considering taphonomic factors and surface modifications, has provided valuable insights into the deposition cycles and temporal aspects of these artefacts. The structured and intricate deposition patterns observed in the causewayed enclosures, along with the absence of signs of frost damage, indicate a relatively rapid deposition cycle. The proposed scenarios of off-site and on-site curation offer plausible explanations for the diverse origins of flint artefacts and their subsequent deposition within the enclosures.

In summary, this research contributes not only to the specific understanding of flint artefacts but also opens avenues for reinterpreting the broader narratives of causewayed enclosures. The deliberate choices behind the selection and deposition of flint artefacts reflect a complex interplay of cultural, symbolic and utilitarian aspects in Neolithic communities. As we unravel the 'life and death' of these artefacts, we gain a deeper appreciation of the cyclical and ritualised nature of Neolithic practices, challenging conventional notions and paving the way for future explorations into the multifaceted aspects of prehistoric material culture.

Through this paper, the author has striven to gain a more nuanced insight into the role of flint artefacts in a selection of Neolithic causewayed enclosures. The *Gathering Time* project (Whittle *et al*. 2011) changed our understanding of *when* events at selected causewayed enclosures happened, such as construction, primary use and subsequent use phases. This paper has contributed to answering questions about what role the flint artefacts played there. With this research and this paper, the groundwork has been laid for further investigation on the nature of structured depositions via taphonomic-wear studies. More research and experiments are needed to gain a more detailed understanding of the taphonomic processes observed, however; this is ongoing and will inform future research projects. One might propose to combine taphonomic and use-related questions to the material culture of all categories, i.e. pottery, bone and other artefacts from the ditches of the causewayed enclosures. Studies mentioned above of the pottery at Sarup I clearly show potential. This may provide insights into how various categories of artefacts are treated, highlighting similarities and differences. The structured depositions hold a fossilised record of activities and the way Neolithic people treated their material culture, which potentially can be decoded and impact the understanding of Neolithic Europe. This research, therefore, stands as a cornerstone, guiding future explorations into the heart of Neolithic Europe's past.

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THE PARADOX OF THE BABEL FISH

Culture, geology and society in Neolithic Europe

Anne Teather and Lasse Vilien Sørensen

Abstract

This article considers the breadth of antecedent knowledge required by people to mine for flint in primary chalk deposits in the Early Neolithic of northern Europe (***c.*** 4100–3700 cal BC). Chronologically contemporaneous flint mining by the shaft and gallery method is evidenced in the archaeological record throughout the appropriate chalk bearing areas in northern Europe, without prior examples of failed prospection in areas of unsuitable geology. This demonstrates a degree of existing geological knowledge held by migrants at the beginning of the spread of the Neolithic in these areas. We therefore examine this question through two case studies of migration in different geographical areas at different times, to illustrate how prior knowledge of new settlement areas can be archaeologically evidenced through a process of landscape learning. We also consider how population diversity may be masked by one dominant cultural group.

Keywords: flint mining; chalk; migration; axes; settlement; diversity

Introduction

This paper discusses the theoretical considerations that underlie our interpretation of Early Neolithic migration and/or social contact in Europe, and the relationship to the Early Neolithic innovative practice of flint mining in chalk deposits. It is increasingly common for the novel aspects of the Early Neolithic, such as monumentality or the adoption of pastoralism, to be viewed within models of social transformation, whereby material changes in the archaeological record are attributed to a shift in social or cultural behaviours. Some of the main actors in this change were immigrants, as the first farmers in northern Europe show an Anatolian genetic ancestry. The level of admixture between local foragers and incoming farmers seems to be very low in both the British Isles and south Scandinavia, reflecting a population replacement (Allentoft *et al.* 2024; Brace *et al.* 2019). This could be an effect of either low population densities of local foragers or a deliberate avoidance of mixing between the two groups. In such a transitional development, containing a population duality, there could be many interrelated and socially entangled processes, enacted at different scales between the indigenous hunter-gatherers and their encounters with the incoming farmers. Consequently, investigations of the extent and speed of migration and cultural change have generated a compelling body of scientific and theoretical work that seeks to explain the rapid change and varied reproduction of material culture in the record, through modelling the speed and extent of population movement and cultural assimilation (e.g. Furholt 2016; 2021; Högberg *et al.* 2023; Robb 2013).

In D. Hofmann, V. Cummings, M. Bjørnevad-Ahlqvist and R. Iversen (eds) 2025, *The early Neolithic of Northern Europe. New approaches to migration, movement and social connection*, 193–204. Leiden: Sidestone Press.

To summarise these models, there is an anthropologically-based and archaeological premise that the further one is from a defined 'core' of 'correct' cultural expression that has a defined origin, the more diffuse the influence of the core culture (and its potential emigrants). Conversely, we also anticipate greater opportunities for people to vary from this 'core' expression through the localised input of indigenes, or autonomous regeneration and variation. While John Robb (2013, 672) argued that we should consider past individual actions and motivations, we have seen a shift to viewing Neolithic practices seen more widely (macro-patterning) as indicating 'trans-regional human-material relationships' (Högberg *et al.* 2023, 3), thereby downplaying the roles of individuals and their motivations in favour of groups. Yet, compelling evidence is emerging from new scientific work from the coastal site of Syltholm II on Lolland, Denmark. Genetic evidence retrieved from chewing gum from birch tar revealed the existence of a woman who was of Western Hunter-Gatherer descent (Jensen *et al.* 2019). She lived on the site around 3700 BC, well into the Neolithic transition, where hunter-gatherers had adopted the material expressions of agrarian societies such as funnel beakers, lithic knapping, husbandry practices and so on. Therefore, the possibility of immigrant and indigenous communities living contemporaneously, practising different economic strategies, may have had greater longevity than we currently see evidenced in the larger aDNA analyses. There could be several reasons for this scenario:

- the hunter-gatherer population was too small to leave a genetic impact
- genetic admixing was limited due to culturally or socially imposed taboos
- many of the hunter-gatherers died of communicable diseases, following contact with farming groups, thus resulting in even smaller population sizes (see Booth, this volume)
- the hunter-gatherers lived in small refugia in landscape peripheries after 3700 BC
- hunter-gatherers migrated further north living along the Swedish west coast and in southern Norway, resulting in population growth and denser activities in these regions

In this article we wish to explore and challenge these models through analogy with Douglas Adams' Babel fish, which is itself a play on the Biblical story in Genesis of the Tower of Babel. In the Bible, the people gathered at Shinar and sought to build a tower to reach heaven, but were hampered in their completion of this by God. Thinking that if humans could speak the same language, their possibilities were endless, God acted to prevent them speaking the same language and scattered them across the world (King James Bible, Genesis 11:1–9). The convergence of a united human language and physical proximity to heaven through constructing a tower was seen as dangerous to God's power. In contrast, in the *Hitchhiker's guide to the galaxy* Adams proposed a reversal of this view through positing an alien symbiotic fish (the Babel fish) that could be inserted into one's ear, where it translated all languages spoken and heard. His novel suggests that this caused 'more and bloodier wars than anything else in the history of creation' by 'effectively removing all barriers to communication between different races and cultures' (Adams 1995 [1979], 52–3).

This paradox of how cultural similarity, language, communication and economic productivity can both enable and prevent human interaction is repeatedly encountered within discussions of the spread of the Neolithic in northern Europe, through our interpretations of material culture, monumentality and archaeogenetics (Cummings *et al.* 2022). While we do not have direct access to a spoken or written language of this past, recent phylogenetic analysis of the origin of the Indo-European language group date it to after the initial spread of farming into Europe (Heggarty *et al.* 2023). Therefore, we assess the degree of cultural similarities in order to suggest where, and to what extent, people may have been speaking and understanding the same 'cultural' language in different geographical areas. For Britain and south Scandinavia, these have taken on more resonance in different ways. Whilst the new aDNA evidence seems to refute a wholly indigenous Neolithic (Allentoft *et al.* 2024; Brace *et al.* 2019), for south Scandinavia the material evidence for a long period of interaction between hunter-gatherers and farmers has led to a greater subtlety of social argument (Cummings *et al.* 2022; Jensen and Sørensen 2023). Nevertheless, in both Britain and south Scandinavia the start of the Neolithic occurs abruptly and gains speed quickly, with a particular repertoire of novel social, subsistence and cultural activities manifested (Gron and Sørensen 2018; Sheridan 2010; Thomas 2022; Whittle *et al.* 2011). This paper approaches the innovation of flint mining from the view of the Babel fish — does a greater convergence of similarity automatically suggest social coherence, or avoidance, or could there be alternative explanations? Further, how can we (or should we) differentiate between archaeological past practices that were within the Neolithic cultural package (monumentality, pottery and pastoralism) and the way these things were enacted?

Geology and practice: axe heads and flint mining in primary chalk

Humans have exploited flint for tool production for over a million years, but it is only at the beginning of the Neolithic in northern Europe that we find a consistent temporal expression of flint mining in primary chalk deposits demonstrated in the archaeological record.

However, grinding or even polishing the surfaces of stone tools was not completely new. Peter Topping (2021, 11–6) has demonstrated that both quarrying for stone and ground stone technology were evident in northern Europe during the Mesolithic. For example, ground stone tools were excavated dating from *c.* 8000 BC in both Sweden and southern Norway (Olsen and Alsaker 1984); the Trindøkse and Limnhamnøkse type greenstone axe heads in Sweden and Denmark had ground surfaces (Lindgren and Nordqvist 1997; Nicolaisen 2009); in Ireland a burial of a ground adze head in a cremation pit at Hermitage by the River Shannon was dated to 7530–7320 cal BC (Little *et al.* 2016); and ground stone axe heads were excavated in Mesolithic contexts at the sites of Lough Boora and Mount Sandel (Sheridan *et al.* 1992; Topping 2021, 11). Therefore, the novelty or innovation of flint mining in the Early Neolithic of northern Europe is not concerned with the technological advances of a new cultural group, but rather the cohesion of the new social group itself.

The independent and indigenous development of deep shaft and gallery flint mining in chalk-limestone geology has always been considered highly unlikely, and therefore the cultural and technological knowledge to mine must have been transmitted. Jon Baczkowski (2014) was the most recent advocate of this opinion, arguing that the morphology of mining sites and the dating evidence for European flint mines suggests that flint mining as a practice spread due to the migration of people with specialist knowledge. However, concurrently it has been too common to separate flint mining practices, and quarrying, from wider forms of monumentality or social practices. This is due partly to the massive scale of some sites, and what we in the present have identified as evidencing specialised knowledge. Nevertheless, there is no evidence that there was any cultural separation of miners from people that formed other Neolithic communities; deposits of material culture in the flint mines in Britain largely reflect those practices from other contemporary monuments such as long barrows or causewayed enclosures (Teather 2016) and art markings on chalk within mines across Europe are similar (Teather and Sørensen 2021).

Therefore, it has always proved problematic for scholars of prehistoric flint mining in primary chalk to engage with wider arguments that advocated a degree of indigenous development, where it can only be evidenced that there are minor changes in the repertoire of mining extractive activities across continental and island Europe. These variations are primarily around the mechanics of flint mining; whether axes are used to extract chalk; whether flint is extracted from the floor or the ceiling of the gallery; or how deep tunnels are, as these appear to be primarily a product of variations in mining techniques in response to local variations in the natural geology. For example, at Spiennes the flint was extracted from the ceiling of the gallery (Topping 2021, 127), enabling the flint to fall to the floor of the gallery and break; in the softer chalk of the Sussex mines, flint was pulled up from the floor of the gallery (Barber *et al.* 1999, 50). In effect, this has meant that scholars of these sites have never been confident that there was indigenous development of certain

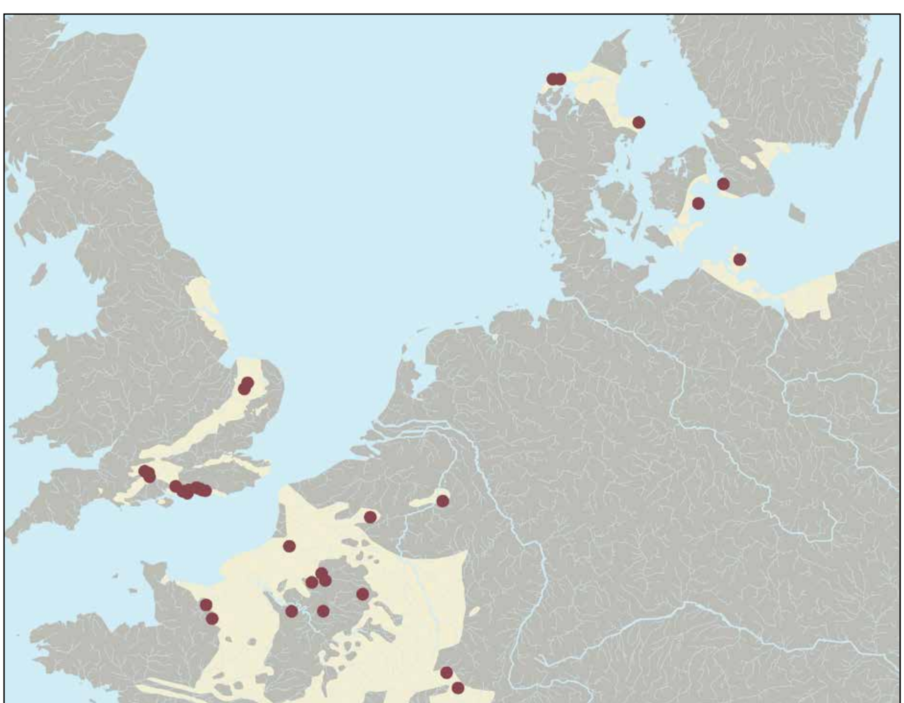

Figure 1. Distribution of flint-bearing chalk located near the surface combined with the distribution of Early Neolithic flint mines in western Europe, where pointed- and thin-butted roughouts, planks, preforms and axes have been found (after Duke and Steele 2009; Sørensen 2014, 182).

types of flint mining in different places. Rather, there was local sympathetic variation to the geology in order that flint mining, as opposed to surface quarrying, was successful. Furthermore, the geographical spread of flint mining is related to its particular geological requirements, which could be identified by humans in the past. This suggests that people with knowledge of not just mining techniques, but also insights into ecological landscapes where mining would prove fruitful, moved between places and identified areas that may be productive for gaining flint through mining (Figure 1).

To explore this question of diversity of past immigrant experiences in more depth, two distinct case studies are detailed below: the Neolithic settlement at Ftelia, Mykonos, and the historic fur trade on the west Californian coast in the nineteenth century. The first case study illustrates that a process of 'landscape learning' can be an important component of successful migration processes, and the second case study discusses how a lack of that process of landscape learning may be mitigated by increasing the diversity and knowledge base of a migrant population through cooperation with indigenous groups.

Landscape learning: comparative case studies

Case study: initial Neolithic occupation at Ftelia, Mykonos, Cyclades

Mykonos is one of the Cycladic islands in the southern Aegean Sea, the island group itself comprising 30 islands that are mainly small, with only six being over 50 km^2, eight being larger than 100 km^2 and three over 200 km^2 (Broodbank 2000). While intermittent human occupation is evidenced from the Mesolithic and Early Neolithic on some islands, the first continuous Neolithic occupation of the Cyclades only occurs in the Late Neolithic, at *c.* 5000 BC, 2000 years after the establishment of the Neolithic on the mainland (Phoca-Cosmetatou 2011). It has been argued that the increase in seafaring within the southern Aegean, aided by the technology of polished axe heads (Strasser 2003), both enabled an increase in the size of boats constructed (which in turn were large enough to carry domesticated animals) and also provided an opportunity for people visiting the islands to understand their particular landscape ecologies, a process of 'landscape learning' (Rockman 2003), prior to establishing settlements (Phoca-Cosmetatou 2011). Landscape learning refers to the 'knowledge people have to amass and process so as to learn, adapt and survive in a new landscape', which is both environmental and social (Phoca-Cosmetatou 2011, 78). It has been argued that the Neolithic occupation that is evidenced at Ftelia, Mykonos, had already undergone adaptations prior to settlement, with a greater reliance on goat/sheep as domesticates (over 80 % in both the earlier and later phases) when these

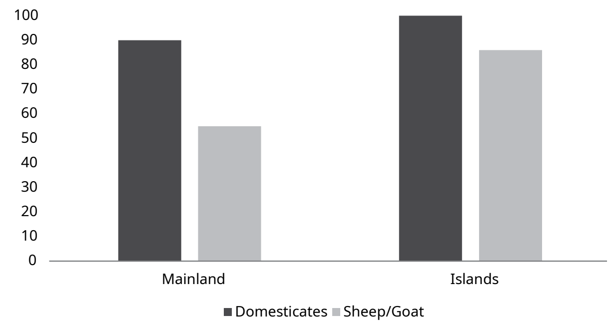

Figure 2. Comparative reliance of domesticated fauna and sheep/goat between the Greek mainland and four islands, shown as percentage NISP of total faunal assemblage on Late/Final Neolithic sites (redrawn from Phoca-Cosmetatou 2011).

species only account for 55 % of domesticates on mainland sites (Phoca-Cosmetatou 2011, 86) (Figure 2). Therefore, the Neolithic settlers that arrived at Ftelia had already imagined life there amongst the dry and arid conditions, and adapted their migration strategies to enable them to have a more successful settlement outcome. There is no evidence for failed attempts or a divergence of economic subsistence strategies between the two phases of settlement occupation, and therefore a familiarity with the island's climate and topography had been achieved prior to immigration. This case study has focused on the concept of landscape learning through visitation prior to immigration; the next case study will focus on social adaptions of human migrant communities.

Case study: a historic multi-ethnic cemetery at Fort Ross, California

During the early nineteenth century AD, the Russian-American Company (RAC) established a multi-ethnic colony on the north-western coast of California in Sonoma County and named it Ross (now Fort Ross; Lightfoot *et al.* 1991, 2–3). The RAC had founded more than sixty settlements across the North Pacific Rim from the Kuril Islands (north-west of Hokkaido in Japan) to California, and employed relatively few native Russian men (Fedorova 1973, 151; 1975, 8). As with other colonies, the population primarily consisted of other ethnicities and Fort Ross was constituted of Native Alaskans (Alutiiq and Sun'aq of Kodiak Island), Native Americans (Kashaya Pomo and Bodega Miwok) and Russians, who represented only 8–12 % of the population (Lightfoot *et al.* 1991, 3). Inter-ethnic marriage was supported by the company and so increasingly the mixed-heritage population grew (known at the times as *Creole*; Fedorova 1973, 206). All were employees of the company, although pay scales varied, e.g. different ethnicities attracted differing rates of pay. The purpose

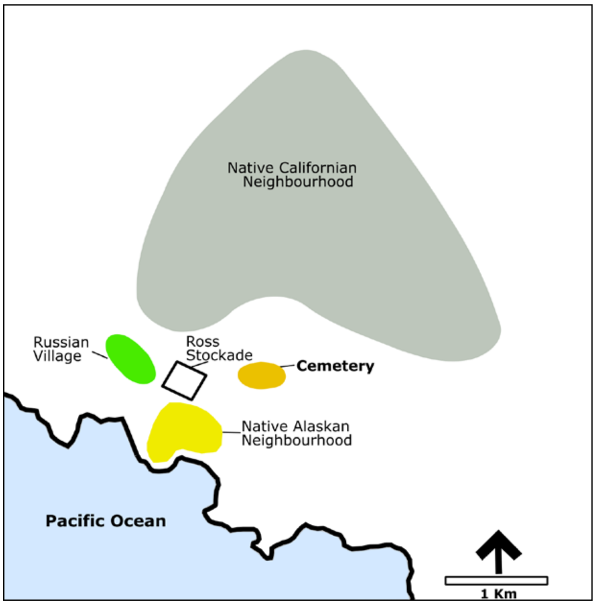

Figure 3. Area of Fort Ross with settlement and cemetery locations (adapted from Goldstein 2012, fig. 1; Lightfoot *et al.* 1991, fig. P1).

of the establishment of the colony was to both exploit the local sea mammal populations for fur hunting and, through agricultural activities, provide additional food resources for the company's employees in the north Pacific (an aim that was not realised due to the adverse ecology of the Fort Ross area). The colony operated here and further south along the Russian river routes, where Native Alaskans hunted sea otters for their furs for several decades until the sea mammal population declined due to overexploitation. There is a substantial amount of historical information about the colony and different areas of the fort were occupied by different ethnic groups (Figure 3). It was thought that an archaeological excavation of the historic cemetery at the fort, where records of interment exist, might aid in separating the graves of different ethnicities who practiced different religions when living, and were subsequently buried at the site.

Historic accounts by a new tenant of Fort Ross in 1845 had suggested that there were not more than 50 graves, however the archaeological excavation discovered 135, of which around half are thought to have been those of children, and four were empty (Goldstein 2012). Despite the ethnic differences that had been thought to be present given the settlement evidence, grave goods were largely consistent ranging from none to religious pendants and a large range of styles and colours of European beads (with perhaps a few made locally, Goldstein 2012, 238). The cemetery layout was consistent with the Russian Orthodox canon, whereby the graves were aligned west–east with the head at the west. Therefore, despite the likelihood from historical records that many Native Alaskans, Creoles and perhaps some Native Californians were buried there, the majority of the mortuary practices aligned with the Russian Orthodox church. Within the ethnic hierarchy of the fort, Russians were the most senior, followed by Native Alaskans and Native Californians, although there was no evidence for this differentiation being expressed in death (Goldstein 2012, 240).

Interpretively, the dominance of the Russian Orthodox church and the social and economic hierarchy of the minority Russian population seems to have established the way in which human burial was physically enacted in terms of spatial location and positioning in a cemetery. However, it did not extend to influence the presence of grave goods, which appear to have less or no conformity and include both imported and local artefacts. The hybridisation of the grave goods suggests a community that was both held within the dominance of the RAC and the Russian church, but also expressed a cultural integrity of its own, amongst the five Native tribes represented and the Russian population.

Discussion of case studies

When we examine models for prehistoric migration, we do not often consider the landscape learning and types of hybrid communities that may have been involved in establishing new communities. The establishment of the RAC settlement at Fort Ross had evidence of less landscape learning than at Ftelia, as the agricultural aims of the settlement proved unviable. Nevertheless, the community was able to exploit the sea mammals for fur, as they did further north in the Pacific. The integration of different ethnic communities at Fort Ross did create distinct areas of settlement: a wooden fort and village for the Russians, a camp on a promontory for the Native Alaskans and another camp for the Native Californians, although these groups do not appear to have been differentiated in death. Indeed, there appears to have been a hybridisation of culture in mortuary goods, if not in broader burial practice. At Ftelia, there is evidence for a Neolithic settlement that from its inception was planned to harmonise with its environmental affordances, and continued to flourish for centuries.

In considering the nature of the Early Neolithic in south Scandinavia and Britain, neither of these types of community are represented; instead, groups are often considered to be competing for access to resources, or living alongside each other but not integrating. If we discount pioneering Neolithic behaviour prior to immigration, there cannot be previous landscape learning and groups may be expected to have higher rates of immigrant failure evidenced in the archaeological record. Where contact with indigenous groups has been made, we should expect to find hybrid cultural expressions, but these may be within dominant frameworks of the immigrant community (and minor immigrant material signatures at indigenous archaeological sites). There is small yet increasing evidence for this, such as the example from Syltholm II around 3700 BC. Here, there was evidence for a woman with Western Hunter-Gatherer DNA at a site where hunter-gatherers had adopted the material expressions of agrarian societies such as funnel beakers, lithic knapping, husbandry practices etc. The only thing that differed was the location in the landscape, as Syltholm II was a coastal site, which was a familiar environment for these hunter-gatherers. Going further inland to clear the forest would require enacting different behaviour, which we would expect from the immigrating pioneering farmers settling on easily arable soils and often near richer flint sources (and where the settlement density of the indigenous population was low). Therefore, we could be observing a population duality in south Scandinavia from 4000 to 3700 BC, where hunter-gatherers were living on the coast and immigrant farmers were living further inland (Jensen and Sørensen 2023; Sørensen and Karg 2012). Major and recent genetic studies show that there was no real admixture with the indigenous hunter-gatherers and that they (in a genetic sense) disappear after 3700 BC (Allentoft *et al.* 2024; Brace *et al.* 2019), although some minor groups could have persisted by living in smaller refugia in the resource periphery of agrarian communities, as observed in the Blätterhöhle (Bollongino *et al.* 2013) or at Ostorf (Lübke *et al.* 2009) and possibly during the Early Neolithic in coastal environments in Scotland and Ireland.

Neolithisation was not one singular event, but a continuous social process lasting for several generations, containing several migrations of incoming central European farmers and varying degrees of interaction with the indigenous hunter-gatherers. The origins of the incoming pioneering farmers migrating to Britain and south Scandinavia point towards a direct or indirect connection to the Chasséen and Michelsberg cultures combined with other regions in central Europe (Klassen 2004; Sheridan 2010; Sørensen 2014; Whittle *et al.* 2011). This is primarily based on similarities observed in the pottery traditions involving carinated bowls and short-necked funnel beakers, the establishment of flint mines and production of pointed-butted axes. The reasons behind these migrations are still discussed, but a different use of the agrarian landscape could be one of the main reasons for the expansion during the late fifth to the early fourth millennium BC. During these periods some agrarian communities in the Chasséen and Michelsberg tradition began to cultivate more marginal areas and make clearances outside of the loess soils (Sørensen 2014), thus becoming independent of the loess soil, which is rich in nitrogen. This resulted in a cultivation strategy that depended on animal manuring and long fallow periods, which could prevent soil exhaustion of the agrarian fields. If these western and central European agrarian societies managed to invent such cultivation advances, a nitrogen revolution, then it could pave the way for migrations towards Britain and northern Europe.

The first farming settlements likely represented a system of interconnected small-scale frontier farms which expanded and impacted the forested landscape gradually (Sørensen 2014). Early farmers appear to have preferred to cultivate sandy soils in regions rich in flint sources, indicating deliberate choice and preconceived ideas about agrarian practice and controlling the accessibility of flint sources (Sheridan 2010; Sørensen and Karg 2012; Topping 2021; Whittle *et al.* 2011). A few centuries later, from 3700 to 3300 BC, a homogenisation phase began with enlarged exploitation of the landscape comprising the increased exploitation of flint sources and the building of large-scale monuments, which show some clear concentrations in the regions rich in flint sources in both Britain and south Scandinavia (Gron and Sørensen 2018; Whittle *et al.* 2011).

In south Scandinavia, refugia of indigenous hunter-gatherer populations (having adopted the material culture of the Funnel Beaker culture) could be located in regions lacking megalithic structures, such as some regions of Denmark and along the coast of western and eastern Sweden, together with southern Norway (Fritsch *et al.* 2010; Jensen and Sørensen 2023). Recent demographic studies in southern and western Norway suggest that an increased habitation density can be observed from 3900 to 3700 BC, together with the first appearance of locally produced ceramics reminiscent of funnel beakers and imported pointed- and thin-butted flint axes of south Scandinavian origin. This participation in a Funnel Beaker network resulted in the appearance of agrarian material culture, but was not accompanied by the adoption of agriculture (Bergsvik *et al.* 2021; Nielsen 2021; Solheim 2021; Solheim and Persson 2018). Could the increased habitation activities in southern and western Norway be the result of hunter-gatherers in southern Scandinavia migrating to refugia further north? Such a hypothesis could be tested by future genetic analysis of fourth millennium BC human remains from southern and western Norway and western Sweden, which should show the appearance of Western Hunter-Gatherer DNA if present. Clear connections between western Norway and northern Jutland have recently been presented by studies of Vittrup Man, dated from 3368 to 3104 cal BC (Fischer *et al.* 2024). His childhood home was in a coastal region of the Scandinavian Peninsula, where the climate was colder than Denmark, so the western part of Norway could be a realistic possible place of origin. What is clear is that farmers from south Scandinavia and hunter-gatherer groups in central parts of the Scandinavian peninsula with poor flint resources were in contact with each other, and were also involved in reciprocal exchange. The distribution of the thin-butted flint axes, basalt adzes and knives, as well as arrowheads made of slate, appears to reflect a routinisation of routes in dugout canoes or skin boats from as early as the Early Neolithic between south Scandinavia and the south-western coast of Norway and Sweden (Fischer *et al.* 2024; Sørensen 2014).

Knowledge about the environment and landscape

The key issues to consider are thus *gaining* knowledge about the unfamiliar environments in connection with a pioneering behaviour involving different stages of migrations, and *learning and adapting strategies* about the novel landscapes. However, the understanding of an environment can mean different things depending on what would have been important for humans settling in a previously inhabited landscape, and where some types of information could relate to the archaeological evidence. Marcy Rockman (2003, 4) has suggested three overall types of environmental knowledge of the landscape. The first focuses on 'locational information', where different locations and physical characteristics of possible resources, such as lithic sources that could be exploited in a specific region, are identified. The second concentrates on the 'limitational information' which refers to the familiarity, usefulness and reliability of various resources, including the combination of multiple resources within an environment and its boundaries or seasonal variations. The third includes 'social information', which is the collection of behaviour patterns in relation to natural features, thus transforming the previously natural environment into a cultural landscape. These three types of knowledge information each serve to reinforce the others, which can be a helpful perspective when exploring trends of humans colonising and exploiting an unfamiliar environment and landscape as a *landscape-learning* process. Such an approach should also consider potential barriers to landscape learning such as population activity and density; the social barriers that might include territoriality; and barriers to gaining enough environmental information to ensure success. Integrating such a landscape-learning approach serves as a methodological tool to identify different social and possible ethnic entities that may have had particular strategies of exploiting the environment in a specific region, especially with regard to lithic procurement strategies (Hardesty 2003).

The evidence of landscape learning and flint mining

Flint mining during the Neolithic normally took place in areas where chalk (a pure limestone of the Cretaceous age) is located near the surface. Localities with underlying chalk are generally revealed by their distinctive topography of smoothly rounded hills and valleys, and particular flora of trees, bushes and herbs adapted for growing in a calcite-rich environment. Mining is nevertheless a labour-intensive way of extracting flint, particularly in areas located near the coast, when excellent nodules of flint of the right length, shape and quality for producing axes of various sizes can easily be found on beaches in southern Scandinavia and southern parts of England (Becker 1980; 1993; Berggren *et al.* 2016; Glob 1951; Högberg *et al.* 2023; Topping 2021; Vang Petersen 1993). Throughout the Mesolithic period, beaches and coastal cliffs had been the preferred places to obtain flint, which also continued to be exploited at a small scale during the Neolithic. The emergence of flint mining with deep shafts and wide galleries that produced large quantities of flint axes, far beyond a local community's own use, enabled a much larger procurement strategy where axes could be distributed further afield and across northern Europe, sometimes into areas where flint sources were poor (Barber *et al.* 1999; Sørensen 2014). Additionally, flint mine sites became prominent anthropogenic features in the landscape, associated with larger areas of forest clearance and with meanings associated with ritualised behaviour before, during and after the exploitation and production of commodified flint blanks suitable for further axe production (Topping 2021). Certain desirable objects, such as flint axes, could be transformed into commodities that resulted in a cultural consensus regarding their value, and so they were suitable for circulating through economic systems and being exchanged for other things (Kopytoff 1986). Igor Kopytoff (1986) supports the idea of the emergence of the commodification of objects, where some types of objects are mass produced using the same raw materials and morphology, and so become recognisable to the human mind (Malafouris 2013). The consequence is a cultural singularisation and agreement regarding the value of these objects in some exchange systems, although the value and desirability of the objects could change in other systems of exchange, depending on different cultural preferences (Appadurai 1986). There is evidence that the large-scale depositional hoarding of flint axes increases through the Neolithic in both south Scandinavia and in Britain (Sørensen 2014; Topping 2021).

The abundance of, and easy access to, flint sources may have been one of the more important pull factors of migration, which could explain why some of the first immigrating farmers settled near places rich in flint sources in both south Scandinavia and England (Allentoft *et al.* 2024; Brace *et al.* 2019; Sheridan 2010; Sørensen 2014). The constant demand for axes to clear a heavily forested British landscape for farming could have been advantageous for participants in these networks, and the ritualised practices associated with gaining axe heads may have aided social cohesion to create and maintain larger agrarian networks in these newly settled regions.

The novel practice of flint mining can be interpreted as the result of an intentional choice of immigrating agrarian communities originating from areas where mining took place further inland (Sørensen 2014). These pioneering agrarian communities in Scandinavia had the opportunity to change the procurement strategy in their novel environment by rejecting the time-consuming deep shaft mining in favour of the less demanding behaviour of collecting flint nodules at the beach (Högberg *et al.* 2023). Such a shift in behaviour did, however, not occur, as the exploitation of flint nodules at the coast and within the mines continued. Both the deep shaft mining of flint and the coastal exploitation of flint nodules were associated with a specific set of rules and symbolic rituals, which these groups of immigrating and indigenous communities could or would not change because of their embedded set of culturally constrained practices, deployed when digging up flint nodules from either the white chalky deposits or within the coastal zone (Teather 2016; Teather and Sørensen 2021).

The axe heads produced from this deep shaft mining were also different to the ones produced from beach nodules, not always in quality, but in the way they are visually distinctive, thus showing different preferences. Observations of pointed- and thin-butted axes in south Scandinavia, which were procured from mined flint, display a characteristic trait, in that many retain a chalky cortex on the butt, which is a visible feature for the owners of these axes (Rudebeck 1998). The chalky cortex could be interpreted as an indication that these axes had their origin from mines and had been produced according to certain conventions and rituals, which contrasted with the axes without such markings from the chalky cortex (e.g. this is often abraded from beach flint). Such information is not only associated with axes, but a wide range of artefacts recorded in various ethnographic records (e.g. Hodder 1982; Højlund 1979; Hughes 1977; Pétrequin and Pétrequin 1993).

Evidence of landscape-learning processes is therefore documented in the appearance of deep mining behaviour probably by immigrating farmers in Scandinavia and the continuation of coastal exploitation of flint nodules by the indigenous population, thus indicating a population duality (Högberg *et al.* 2023). The same two procurement strategies could also be expected in Britain during the Neolithic transition, but more studies are needed of the provenance of the lithic materials from indigenous hunter-gatherer sites of the Early Neolithic in the future (Lawrence *et al.* 2022). For flint mining in chalk geology, deep mining behaviour required a suite of practices different from landscape prospection, as well as extraction and flint working that was also accompanied by a range of subsistence, cultural and mortuary activities. Different populations could have had both a distinct and overlapping set of complex traditions and rituals when using, exploiting and living in the landscape within the habitation activities of these early agrarian communities, although other cultural elements may suggest hybridisation. Therefore, as with the example from Fort Ross, we may not see these differences reflected in micro-cultural practices where degrees of hybridisation may vary within a short timescale of decades.

Conclusion

Recent palaeogenetic studies have created a scientific breakthrough, particularly with regards to the migration hypotheses associated with the appearance of the first farmers at the start of the Neolithic in both south Scandinavia and in Britain from around 4000 cal BC. Individuals of the early agrarian communities were associated with Anatolian ancestry and the data demonstrate that several migrations did occur. Often migration hypotheses have been criticised as being too simplistic. When a migration is detected, it raises many other unsolved questions centred on the place of origin of the migrants, where a similar behaviour is observed, and more importantly the reasons behind emigration. There is also the important question regarding how the indigenous populations reacted and perhaps interacted with the incoming groups. These are comparative questions which require the involvement of novel theoretical frameworks, multifaceted hypotheses and complex models in order to answer them. However, the changes in material culture, subsistence economy and changed behaviour, as in the appearance of deep mining activities, correlate with the appearance of different ancestries.

The Babel fish analogy posited at the beginning of this article asks us to consider when the 'cultural' aspects of ingrained and cohesive behaviour make the spread of cultural traits stronger in the archaeological record. Is it simply that people with different cultures will seek to communicate and collaborate or engage in conflict? We have argued that the proposed models of cultural change at the beginning of the Neolithic have increasingly moved away from anthropological considerations that could have encompassed individual or group motivations, which were proposed by Robb (2013). Furthermore, the existing models imagine a spread of a cultural group, and meetings between groups, of which neither have a strong cultural belief system concerning the 'right way' to do things, and thus underestimate the understanding that some landscapes were particularly important for specific economic, cultural and symbolic activities. We argue that enacting these activities, such as flint mining, must have involved embedded landscape learning, potentially prior to emigration. Furthermore, groups that displayed strong cultural cohesion may have sought to maintain their lifeways through physical relocation and/or refugia. A longer period of Neolithic migration to Britain could have permitted these actions to take place with little archaeological evidence remaining.

While there may be some excavated vertical shafts intended for flint mining on unsuitable geology in Britain (Thomas 2013), these are isolated occurrences and there is simply not enough evidence to demonstrate that there was a lack of preparation prior to migration to Britain or Scandinavia. The presence of similar deposits in mines and artistic expressions across wide areas suggest continuing contact over several hundred years between communities in Britain, Scandinavia and Belgium. Therefore, this evidence suggests that the arrival of the Neolithic in south Scandinavia and in Britain was not one singular event, but a continuous and increasing social process of landscape learning that lasted for several generations and contained several migrations of incoming central European farmers and various degrees of interaction with the indigenous hunter-gatherers.

The lifeways of the Neolithic required a social investment of daily practices to be repeatedly performed, within a structure where there were activities that were appropriate to those social norms and where people were, at least initially, highly mobile. The challenge for future research is to perform more detailed investigations to disentangle the interactions between different groups of immigrants and the indigenous populations, which in some cases can be revealed, while others are invisible. The innovative and technological aspects of the Neolithic are not as important as the presence of these activities in these specific landscapes.

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NEOLITHISATION IN SWEDEN, BASED ON DIRECTLY DATED CEREALS

Karl-Göran Sjögren

Abstract

In recent decades, the number of direct dates on cereals and domestic animals from Neolithic Scandinavia has increased rapidly, mainly as a result of large-scale rescue archaeology projects. A compilation of published Neolithic cereal dates from Denmark, Sweden, Norway and Finland comprises 366 dates, of which 133 fall in the Early Neolithic period of Scandinavia (*c*. 4000–3300 cal BC). Here, this database is used to estimate the speed of the initial spread of domesticates through the Scandinavian peninsula, and the possible driving forces and social mechanisms are also discussed. It is argued that an initial establishment of agricultural settlements may have taken place in southernmost Sweden and on Bornholm already before 4000 cal BC, with a very rapid subsequent dispersal to the north up to the Mälardalen region, probably in a leapfrog pattern. After this, an almost 1500-year-long standstill can be observed, interrupted by a renewed expansion at *c*. 2200 cal BC. The necessity of planning, scouting, negotiation and navigating social and political networks in this pioneering phase is emphasised, as well as the active role of indigenous hunter-gatherer populations.

Keywords: Neolithisation; TRB culture; cereal dates; Scandinavia

Introduction

The introduction of cultivated plants and domestic animals into southern Scandinavia has usually been viewed as a rapid process, covering Denmark and southern Sweden within the limits of chronological resolution, or in other words some 100–200 years around or shortly after 4000 cal BC (e.g. Hallgren 2008; 2012; Persson 1999; Rowley-Conwy 2013). This change in subsistence economy has been closely connected to a cultural change, evidenced by new forms of pottery and stone tools, settlements with substantial timber longhouses, and of new ceremonial practices such as wetland depositions of humans, animals and artefacts. This cultural complex, covering much of northern Europe, is subsumed under the heading of Funnel Beaker culture (TRB).

The longstanding debate as to whether this development was driven primarily by immigration, acculturation, or a combination of both, has now been at least partly resolved by developments within bioarchaeology, mainly aDNA and isotopic studies (Allentoft *et al*. 2024a; 2024b; Mittnik *et al*. 2018; Skoglund *et al*. 2014). These studies have increasingly demonstrated that individuals connected to the TRB complex were genetically different from Mesolithic populations in the region. The TRB individuals carried a predominantly European Farmer ancestry, ultimately derived from Anatolian groups, but to some extent admixed with various European hunter-gatherer groups. The amount of admixture with local, Scandinavian groups seems to have been very small, at least in the earliest phase.

In D. Hofmann, V. Cummings, M. Bjørnevad-Ahlqvist and R. Iversen (eds) 2025, *The early Neolithic of Northern Europe. New approaches to migration, movement and social connection*, 205–232. Leiden: Sidestone Press.

For Denmark, a detailed genomic study has revealed a distinct shift in ancestry at *c.* 3900 cal BC, concomitant with an equally distinct shift in dietary isotopes (Allentoft *et al.* 2022; 2024a). For Sweden, the picture is less clear since the number of analysed individuals from the transition period is still small and geographically restricted, and bone preservation is poor in most regions of the Scandinavian Peninsula. In fact, only three Early Neolithic individuals have been analysed for DNA, two from the Malmö region in southernmost Sweden with European Farmer ancestry and one from Evensås in Bohuslän showing Danish Mesolithic ancestry (Allentoft *et al.* 2024a; 2024b; Mittnik *et al.* 2018).

As noted by Per Persson (1999, 103) the number of reliable dates pertaining to the earliest agriculture in Scandinavia was in fact rather small, only nine direct dates on cereals were available for the area north of Scania. This situation has changed, and direct dates on short-lived material such as cereals and domestic animals can now be counted in the hundreds. This gives us much better possibilities to follow the introduction and spread of domesticates, and to make some inferences as to the speed and mechanisms behind it.

One such study was published by Joaquim Fort and colleagues (2018), based on 60 cereal dates from a 4000-year period (*c.* 4000–1 cal BC) as well as ten pollen cores from Sweden, Norway and Finland. Here, it was concluded that the mean speed of dispersal was only 0.44–0.66 km per year, only half of what has been calculated for the European Neolithic. The authors use this to argue for an incremental spread driven by local demographic growth, similar to what was suggested by Albert Ammerman and Luca Cavalli-Sforza (1971) for the central European Neolithic. In this paper, this question will be re-evaluated on the basis of the much larger dataset now available.

Data and methods

This paper is based on published direct dates of cereals from Denmark, Finland, Norway and Sweden, dating to the Scandinavian Neolithic. The cutoff has here been set to dates that are 3500 uncal BP or older, corresponding to *c.* 1700 cal BC. At present, 366 such dates are in the database. Additionally, 42 dates from northern Germany are available, but are not discussed here. The database has been compiled from previous publications (Andersson *et al.* 2016; Fort *et al.* 2018; Friman and Lagerås 2023; Hadevik 2009; Hallgren 2008; Kirleis 2019; 2022; Nielsen and Nielsen 2020; 2022; Persson 1999; Rudebeck 2021; Sand-Eriksen and Mjaerum 2023; Sjögren 2012; Solheim 2021; Sørensen 2014; Vanhanen *et al.* 2019) with corrections and additions from a number of excavation reports (see Appendix). When possible, determinations to species have been included, but such data are not always available in the publications. The database can be regarded as rather complete for Sweden, with the reservation that small excavation reports may have been missed, but there is probably room for additions particularly for Denmark and northern Germany. The sample is heavily dominated by Swedish data, which make up almost two thirds of the collection. Several factors contribute to this. First of all, the research focus has been on collecting Swedish data, but it should also be emphasised that rescue archaeology in Sweden has been very active in sampling for and dating macrofossils, and this material has been growing rapidly during the last decades. Further, regions like Norway and Finland have been late adopters of cereal cultivation, and the lower numbers of dates likely reflect real conditions in prehistory.

Direct dates on short-lived materials such as cereals and domestic animals are the preferred material for overview studies such as this one, also since they are not affected by reservoir effects from marine or freshwater diets (except possibly for pigs and dogs). Biases can be introduced by poor bone preservation in many Scandinavian regions, a problem that does not affect cereal dates. For these, the remaining issues are varying intensity and focus of archaeological fieldwork.

The dates have been calibrated in Oxcal 4.4 using the Intcal20 calibration curve (Reimer *et al.* 2020). Median calibrated values have also been calculated. These are here not used for modelling, but only to select samples for inclusion in plots. Point estimates do not account for uncertainty (Millard 2014), which leads to some ambiguity in these choices. As these plots are intended to show large-scale patterns, this ambiguity has been accepted here.

Results

Looking broadly at the chronological distribution, we get the picture in Figure 1. The figure shows a concentration in the Early Neolithic, with a peak at *c.* 3500 cal BC, after which the numbers decrease in the Middle Neolithic and rise again in the Late Neolithic, after *c.* 2200 cal BC. Such patterns have

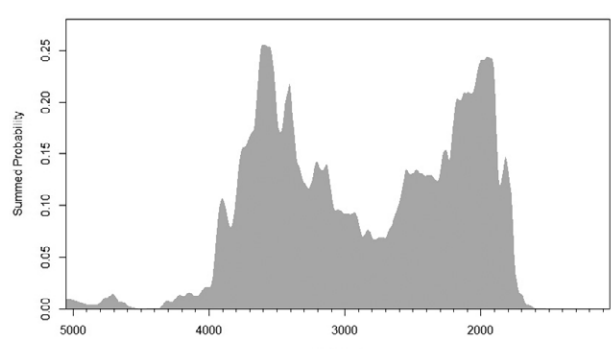

Figure 1. Summed probability plot of cereal dates, with 50-year binning and smoothed by 50-year running mean. Calculated in rcarbon 1.5.1 (Crema and Bevan 2021).

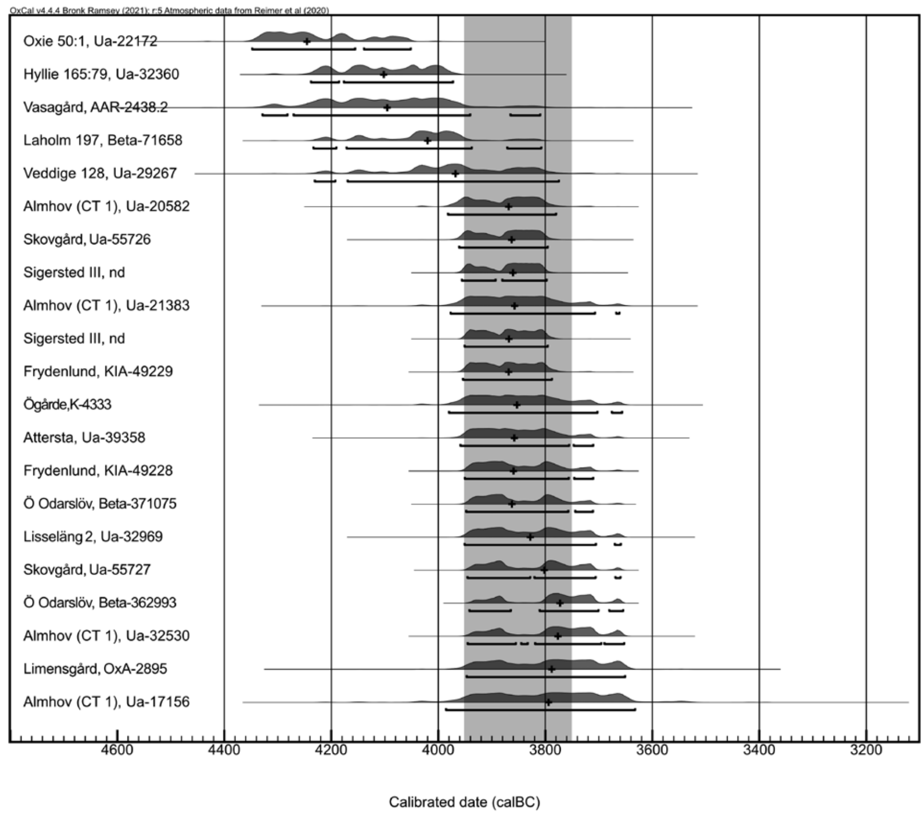

Figure 2. Calibration of the 21 earliest ^{14}C dates. BP uncal ≥5000. Grey band shows the introduction of European Farmer ancestry in Denmark, taking dating uncertainty into consideration (revised after Allentoft *et al*. 2024b).

sometimes been interpreted as signs of demographic boom and bust, but could also be explained by a preference to date cereals from Early Neolithic sites. Twelve dates gave unrealistic results and were rejected, and one date was rejected since the material turned out to be hazelnut shells and not cereals. These dates were older than 5800 uncal BP, i.e. Palaeolithic and Mesolithic, scattered geographically, and not associated with any corresponding archaeological traces. Theoretically, some of the more recent of these dates could result from contacts with continental farmer groups, but as no other signs of this have been noted the dates have been left out of consideration here (for further discussion, see Berggren 2018; Rudebeck 2021; Sørensen 2020).

A more continuous series of cereal dates starts at *c.* 5400 uncal BP, corresponding to 4200–4000 cal BC (Figure 2), and is followed by a large number of grains dated to *c.* 4000–3800 cal BC. Most of these dates fit very well with the dating of the genetic transition in Denmark at around 3900 cal BC, but there are four or five cases that are clearly older and could point to an earlier phase of cultivation. The contexts of these samples are more convincing than for the rejected dates, as they are found in association with Early Neolithic material on TRB settlement sites. Geographically, these earliest dates occur on Bornholm and in south-west Scania, while dates from Denmark and from regions further north are slightly later (Figures 2–3). A survey of early dates of domestic fauna (Rowley-Conwy 2013) gives a very similar picture.

If these early dates are accepted, which I think is reasonable, a certain discrepancy appears between these cereal dates and the genetic data from Denmark. There may be a number of explanations for this.

1. The introduction of TRB material culture and domestic species was 100–200 years earlier in Scania and on Bornholm than in Jutland and the Danish islands. Whether this was associated with a genetic change or not is difficult to say due to the low number of analysed individuals from Early Neolithic Sweden. It is quite possible that the earliest persons from these areas carrying European Farmer ancestries have not yet been sampled. This would resolve the discrepancy, but also introduce new questions, since the often proposed Michelsberg origin of early Scandinavian farmers would be more compatible with a route through the Jutland peninsula (e.g. Sørensen 2014).
2. The earliest cereals from Jutland and the Danish islands have not yet been dated. Since the genetic development in Denmark is well investigated, it is unlikely that such early agriculture was carried by incoming European Farmers. Instead, this would suggest a phase when domesticates were used by Ertebølle communities.

3. Cereal dates before *c*. 4000 cal BC are wrong and should be discarded. Ultimately, this can only be evaluated by further macrofossil analysis and dating of cereals from the transition period. However, these dates are already numerous enough to merit serious consideration.

Widening the chronological scope to dates earlier than 3800 cal BC (Figure 3) and then to the whole Early Neolithic (>3300 cal BC) (Figure 4), we see the establishment of cereal cultivation over Denmark and southern Sweden up to the Mälaren Valley near Stockholm. After this early expansion, cereals do not progress further north but only disperse locally from these early core sites. It is notable that the earliest sites are mainly located close to the coast, while later sites also occur further inland. Even the site at Attersta in Närke, now inland, may be regarded as near to the Baltic coast, since land rise has changed the coastline dramatically in this area. This would point to the importance of coastal travel in the first phase of agricultural dispersal, while later phases are characterised by local infill, probably supported by demographic increase, but we cannot exclude the possibility of ongoing influx of groups from further south.

While the overall picture is clear enough, it should be remembered that some regions are underrepresented due to uneven amounts of fieldwork, and also due to varying regional traditions in the use of flotation and macrofossil analysis. Such factors could perhaps explain gaps along the Baltic coast, on the islands of Öland and Gotland, or in Falbygden in western Sweden.

In Figure 4, median dates are plotted against the linear distance from Oxie in Scania, using the same method as in Fort and colleagues (2018). Oxie on the outskirts of Malmö was chosen as origin since this site has the earliest cereal date from Scandinavia (site Oxie 50:1, 5395±60 uncal BP, Ua-22172). The find consists of a pit with undiagnostic Neolithic pottery and a fragment of a polished axe (Brusling 2003). It was suggested by Lasse Sørensen (2020, 305) to represent remains from a scouting expedition of southern farmer groups. The figure gives the impression of a linear progression from south to north, if we look at the earliest dates. This is an illusion, however, since the sites are along two different routes, one along the Swedish west coast and one along the east coast.

The question of how fast the earliest cereals spread depends largely on how one evaluates the first dates from Scania. One possibility, suggested by Kurt Gron and Lasse Sørensen (2018) and Sørensen (2020), is that the dates older than 4000 BC represent scouting expeditions, leading to more large-scale migrations after 4000 BC. Alternatively, they might be seen as indicating small-scale pioneer settlements within a predominantly hunter-gatherer environment.

If we accept the oldest date from Oxie as representing actual farmer settlement, we can compare this with the earliest date from the Stockholm region, which is the one from Lisseläng 2 (5025±45 uncal BP, Ua-32969). Using the Oxcal Interval command to calculate the time difference gives a wide range of possibilities: from less than 507 years (68.3 %) to less than 1289 years (95.4 %), with a median of 256 years. The distribution is highly skewed towards the lowest values. Using the median value for a distance of *c*. 500 km gives an average speed of *c.* 1.95 km/year while the 68.3 % value results in 0.99 km/year. This is two to three times as fast as calculated by Fort and colleagues (2018). If this date is regarded as an outlier, we arrive at even higher average speeds, and if no dates earlier than 4000 BC are accepted as valid, the dispersal from Scania to Mälardalen becomes almost instantaneous, well within the precision of radiocarbon dating.

Discussion

Given the calculations of average speed above, it is not likely that such speeds could occur only as result of demographic growth, but would imply some other factor motivating longer jumps to certain preferred locations. Even if the data are still rather patchy, we can propose a two-step model. In a first phase, before 4000 cal BC, agriculture was established on Bornholm and in southernmost Sweden, i.e. the provinces of Scania and southern Halland. In a second phase, around 3900 cal BC, we see a rapid spread from this core area up to *c*. 500 km further north. This spread is unlikely to result from incremental demographic growth as suggested by the wave of advance model, although it probably was carried by immigrant groups. Presumably, it occurred in a leapfrog fashion, involving a series of longer jumps, and seems to have taken place within a very short period of time. This is also the time when we see the genetic transition in Denmark, and the number of ^{14}C dates in Scania rises sharply, suggesting a population increase.

Since no genetic studies of individuals from the transition period north of Scania are available, it is not possible to say whether a genetic transition also took place in these regions, although this may appear plausible. It does seem likely that TRB material culture accompanied these early cereals (Hallgren 2008; Persson 1999; Sørensen 2020), which is also an argument against the possibility that the earliest cereals were acquired by hunter-gatherer groups through trade with TRB groups further south. Furthermore, there are dates of cattle from the Mälardalen region which are as early as the cereal dates (Hallgren 2008; 2012). The two earliest are from Skumparberget, Närke (4227–3795 cal BC, 5170±65 uncal BP, Ua-18717) and Trössla in Sörmland (4033–3787 cal BC, 5105±45 uncal BP, Ua-22409). Both are TRB settlement contexts. It should be noted that TRB material culture mainly occurs at separate TRB settlement sites, not as isolated finds on Mesolithic sites, arguing for an actual TRB presence in the area and against the possibility of traded TRB material and/or domestic species.

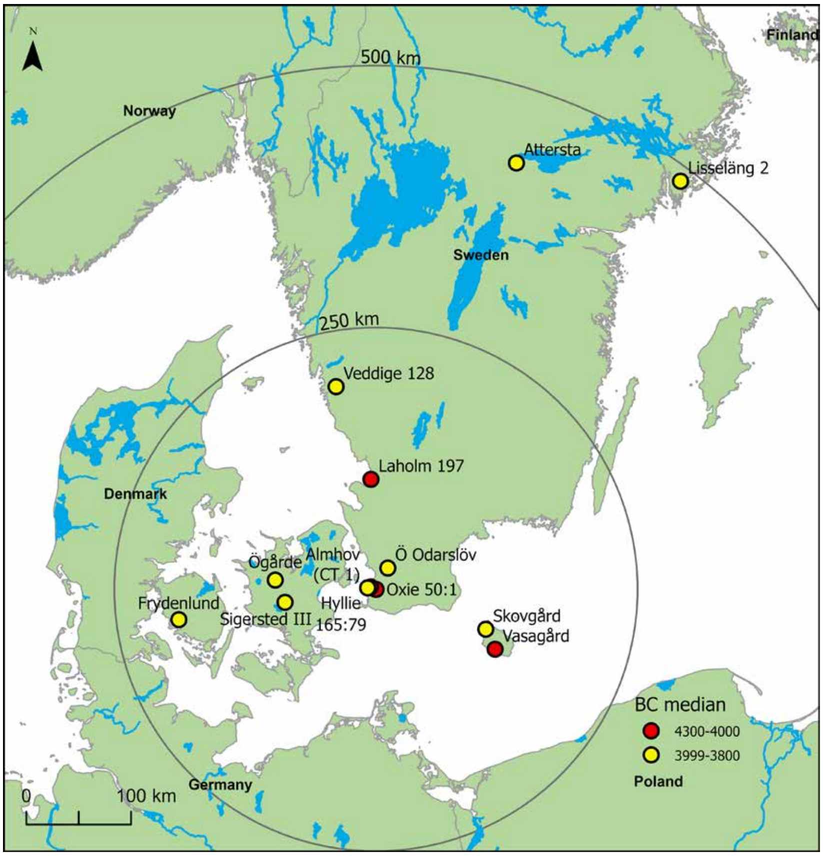

Figure 3. Location of sites with median cereal dates before 3800 cal BC, and 250 km distance bands from Oxie.

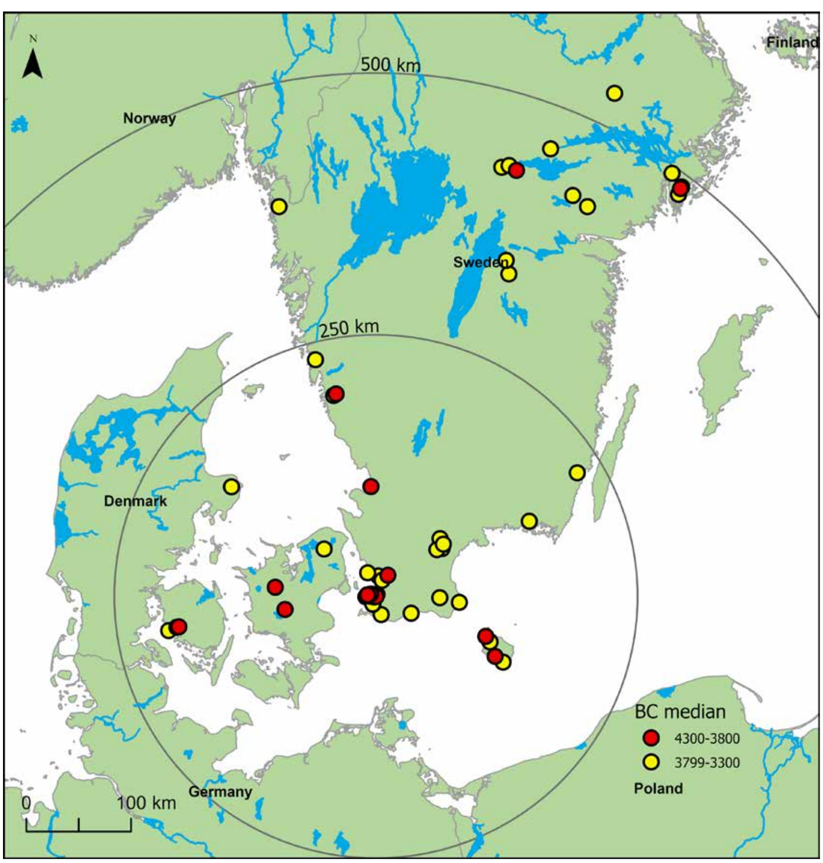

Figure 4. Location of cereals dated to the Early Neolithic, with median dates before 3300 cal BC.

After this rapid expansion, a period of standstill ensues, lasting some 1500 years (*c*. 3800–2300/2200 cal BC) and covering the Early Neolithic and most of the Middle Neolithic period. In the later part of this standstill the first dated grains from Norway and Finland appear, the latter from a Pitted Ware site in the Åland archipelago. To the north of this border, hunter-gatherer groups persisted. The genetic composition of these groups is largely unknown, but they can be assumed to be of Scandinavian Mesolithic ancestry. This was the case for the Late Neolithic Steigen individual from northern Norway (Günther *et al*. 2018), and is also supported by two Middle Neolithic individuals found on Jutland, at Vittrup and Svinninge Vejle. Both carry Scandinavian Mesolithic ancestry and isotope studies suggest they were migrants from a more northern coastal region (Fischer *et al*. 2024).

A new period of expansion starts in the Late Neolithic, at around 2300/2200 cal BC. Now, cereals are regularly found in the coastal regions of Norway and in northern Sweden. Mainland Finland, on the other hand, does not have any dated cereals until the Early Bronze Age (Vanhanen *et al*. 2019).

From these data is seems clear that the dispersal of cultivated crops through Scandinavia was not a gradual and piecemeal process, but should be seen as stepwise, characterised by periods of rapid advance interspersed with long periods of standstill. It is also likely that the first dispersal primarily followed the coasts, establishing initial settlements in certain preferred locations, from where further settlements could be founded by local or regional infill. Such a pattern of Neolithisation is not unique to Scandinavia but has also been proposed for the Early Neolithic of central Europe, i.e. the LBK culture (Persson 1999), and for the western Mediterranean (e.g. Zilhão 2001). Indeed, the Neolithisation of Scandinavia was preceded by an almost 1500-year-long standstill in the north European lowlands (Persson 1999; Sørensen 2014).

What could be the drivers of such a rapid dispersal? Several factors have been discussed in the literature, the most common being climate changes and demographic growth. As an example of the former, Lisa Warden and colleagues (2017) noted a rise in surface water temperature in the central Baltic at *c*. 4000 cal BC, followed by a slow decrease. They proposed this as an explanation for the expansion of agriculture, not only for this region but also for the whole of southern Scandinavia. However, temperature reconstructions in other regions, more central to Neolithic economies, fail to detect any temperature change in this period (e.g. Butruille *et al*. 2017 for Skagerrak seawaters; Seppä *et al*. 2005 for inland western Sweden). In these studies, climate appears favourable and stable through most of the Neolithic, up until the climatic deterioration in the Late Neolithic, known as the 4.2 ka BP event. Climatic change therefore does not seem to be a convincing explanation for the expansion of Neolithic economies after *c*. 4000 cal BC.

The rate of demographic growth in prehistoric societies is notoriously difficult to estimate and depends on a range of parameters which are largely unknown to us. Logically, the rapid spread of Neolithic genetic ancestry, settlement and economy over a vast region from northern Germany to southern Scandinavia in a short period of time would not be possible without a considerable demographic growth rate in the source population or populations. This is also supported by recent studies of Neolithic demography using summed probabilities of ^{14}C dates, most of which indicate rapid population growth after the first introduction of domesticates in a region (e.g. Friman and Lagerås 2023; Shennan *et al*. 2013).

According to Fort and colleagues (2018), the maximum dispersal rate in ethnographically recorded cases of colonisation/migration is *c*. 3 km/year. However, details were not provided for this number, and it may be doubted if it is relevant in the context of Neolithic Scandinavia. In a recently 'colonised' landscape such as northern Europe in the earliest Neolithic, demographic growth would likely not have necessitated founding new settlements very far away, as land would not be a restricted resource, and maintaining contact with the origin group would be advantageous in many ways (exchange, mutual assistance, marriages etc.). This would most likely lead to an 'infill' pattern of settlement, where pioneer sites are complemented with additional settlements as needed due to local demographic growth, as well as continued immigration.

I would propose that demographic growth is a prerequisite for the dispersal of Neolithic economies into Scandinavia, but that it cannot by itself explain the very rapid and wide geographical dispersal of new sites. Instead, other driving factors need to be considered. It is, however, not immediately clear what these other factors could be. Processes of social fission could well be at work, and founding of new and independent settlements could be linked to social prestige, but such factors are hard to demonstrate archaeologically.

As several authors have argued, leapfrog colonisation presupposes careful planning and a period of exploration, scouting and negotiations with indigenous groups in order to find suitable locations in a foreign landscape (Gron and Sørensen 2018; Sørensen 2020). The new locations would have to be suitable from an economic perspective, which requires knowledge most easily obtained from people already living there, but most importantly also from a social perspective. This means establishing friendly or at least neutral relations with local populations and avoiding areas where local groups are hostile. The role of pathfinders and scouts would be essential in this early and sensitive phase when pioneer settlements were established in certain core areas. It would also mean that

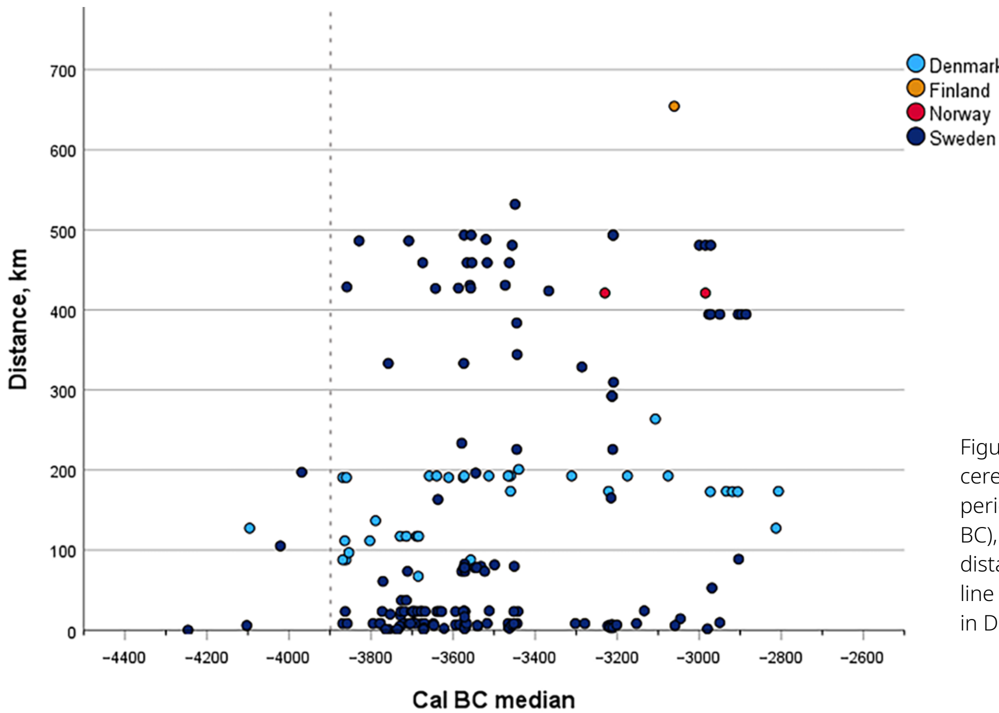

Figure 5. Scandinavian cereal dates from the TRB period (before *c.* 2800 cal BC), compared to linear distances from Oxie. Dotted line indicates genetic change in Denmark.

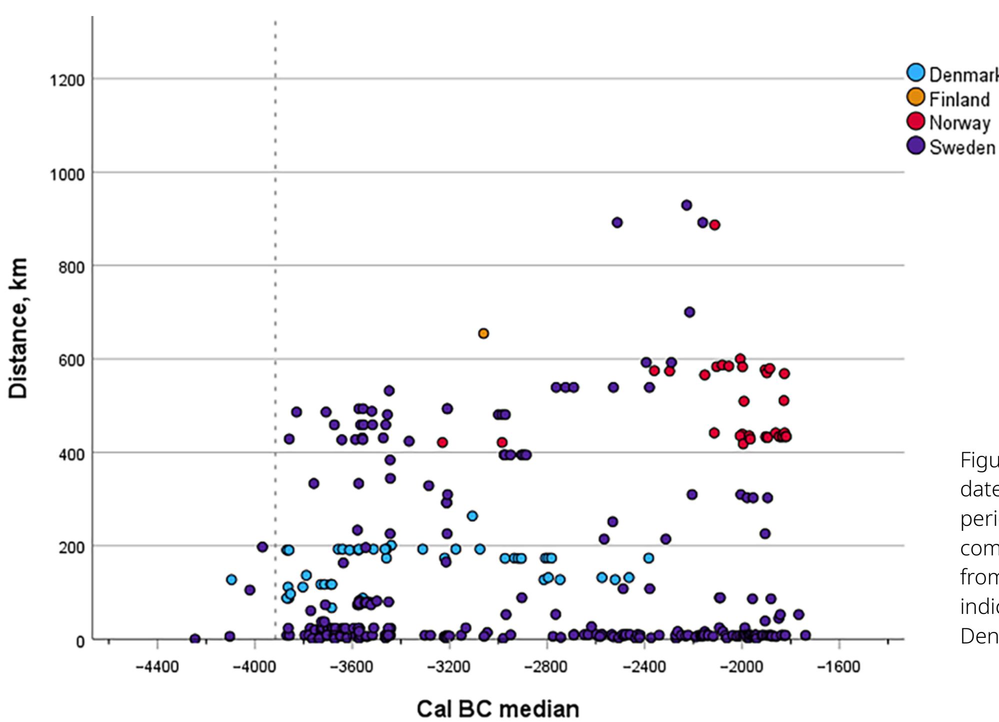

Figure 6. Scandinavian cereal dates from all Neolithic periods, up to *c.* 1700 cal BC, compared to linear distance from Oxie. Dotted line indicates genetic change in Denmark.

location of pioneer settlements to a large extent would depend on personal relations and established networks, positive or negative. Such factors could also contribute to wide and patchy dispersal of pioneer settlements, as some areas would not have been suitable or accessible due to strained political relations with indigenous populations. In this phase, the role of local groups was not necessarily one of passive submission to the incomers, but more likely one of active participation, involving a range of reactions from acceptance and collaboration to hostility. Further, the relations between incoming groups could well have involved elements of competition, leading to avoidance and wider dispersal.

Summary and concluding remarks

The data presented here strongly suggest that the dispersal of cereal cultivation in the Scandinavian peninsula cannot be seen as piecemeal and incremental, but is a stepwise process with rapid dispersals interrupted by long periods of standstill. This pattern is similar to what has been proposed for the Neolithisation of other European regions, such as central Europe and the western Mediterranean (e.g. Shennan 2018; Zilhão 2001).

The first indications of a Neolithic lifestyle appear already before 4000 cal BC in a restricted area in southern Sweden and Bornholm, suggesting limited pioneer settlements or possibly scouting expeditions. After 4000 cal BC, cereals spread very rapidly some 500 km to the north, up to the Mälardalen region. Although the data are patchy, the impression is that this dispersal was primarily coastal and followed a leapfrog pattern. After the initial dispersal, cultivation hardly progresses further north for a period of almost 1500 years, when instead processes of infill seem to occur around pioneer settlements and further inland. Only after *c.* 2200 cal BC do we see a renewed period of expansion, both further north and into previously unoccupied inland areas.

It is argued here that neither climatic change nor demographic growth offer sufficient explanations for the rapid dispersal periods (or indeed for the standstill periods). Instead, social and political factors are suggested to contribute to the patchy, leapfrog dispersal pattern in the first centuries of agricultural expansion. Planning, scouting, negotiating and establishing contact networks with indigenous populations are suggested to be necessary for the successful foundation of new sites at considerable distances from the origin settlements. This also means active involvement of indigenous forager groups as partners, rather than seeing them as submissive and passive. Such partnerships could help explain the continuities observed in aspects of material culture as well as in subsistence practices in the Early Neolithic.

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Appendix 1. List of ^{14}C dates used for the models in this article.

Country	Region	Site	Long	Lat	Site type	Lab Nr.	BP uncal	1s	BC from (95.4%)	BC to (95.4%)	BC median	Material	Species	Context	Reference
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-20582	5095	45	-3983	-3781	-3869	cereal	*Hordeum*	A23455	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-21383	5065	60	-3978	-3662	-3858	cereal	*Triticum aestivum/ compactum*	A19049	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-32530	5000	40	-3946	-3653	-3777	cereal	*Triticum dicoccum/ spelta*	A1942	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-17156	5000	95	-3986	-3633	-3795	cereal	*Triticum dicoccum/ spelta*	A6, pit	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	longbarrow	Ua-17158	4990	70	-3946	-3649	-3778	cereal		A61, posthole	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-32532	4940	40	-3796	-3641	-3708	cereal	*Triticum dicoccum/ spelta*	A32422	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-23873	4930	45	-3892	-3637	-3703	cereal	*Triticum aestivum/ compactum*	A3748	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-32533	4910	45	-3793	-3632	-3691	cereal	*Triticum dicoccum/ spelta*	A35862	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-20417	4885	40	-3771	-3537	-3676	cereal	*Triticum dicoccum/ spelta*	A918	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-32531	4880	45	-3776	-3532	-3670	cereal	*Triticum*	A31888	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-21382	4780	50	-3647	-3378	-3567	cereal	*Triticum aestivum/ compactum*	A4245	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-18753	4690	60	-3631	-3363	-3466	cereal	*Triticum dicoccum/ spelta*	A4130	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-21380	4575	55	-3513	-3097	-3302	cereal		A11772	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-21329	4570	55	-3511	-3095	-3279	cereal	*Triticum*	A2210	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-18748	4455	70	-3350	-2926	-3153	cereal		A2193	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-21378	4015	45	-2843	-2357	-2535	cereal		house 54	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-20577	3805	45	-2454	-2060	-2248	cereal	*Hordeum*	A21538	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-20421	3765	40	-2297	-2036	-2180	cereal	*Triticum aestivum/ compactum*	A3765	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-21381	3735	45	-2288	-1982	-2138	cereal	*Hordeum vulgare nudum*	A15189	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-22168	3735	45	-2288	-1982	-2138	cereal	*Triticum*	A23446	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-20575	3660	45	-2195	-1901	-2037	cereal	*Triticum dicoccum/ spelta*	A22833	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-20579	3640	45	-2139	-1892	-2009	cereal		A23814	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-20584	3630	45	-2137	-1888	-1996	cereal	*Hordeum vulgare nudum*	A22974	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-20418	3625	40	-2135	-1886	-1989	cereal	*Triticum aestivum/ compactum*	A2453	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-20578	3610	45	-2135	-1782	-1971	cereal	*Hordeum*	A21678	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-21375	3610	45	-2135	-1782	-1971	cereal	*Triticum aestivum/ compactum*	house 54	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-20420	3605	40	-2131	-1784	-1964	cereal	*Triticum aestivum/ compactum*	A2804	Gidlöf *et al.* 2006

Country	Region	Site	Long	Lat	Site type	Lab Nr.	BP uncal	1s	BC from (95.4%)	BC to (95.4%)	BC median	Material	Species	Context	Reference
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-18751	3605	70	-2194	-1751	-1967	cereal	*Triticum aestivum/ compactum*	A3608	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-18754	3600	70	-2189	-1751	-1960	cereal	*Triticum dicoccum/ spelta*	A3549, house 3	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-20419	3590	40	-2121	-1777	-1945	cereal	*Triticum*	A4155	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-20576	3590	45	-2128	-1775	-1946	cereal	*Triticum dicoccum/ spelta*	A22499	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-20586	3555	45	-2026	-1750	-1899	cereal		A33740	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-20587	3540	40	-2011	-1749	-1877	cereal	*Triticum*	A24716	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-20583	3515	45	-2008	-1694	-1833	cereal	*Triticum dicoccum/ spelta*	A22270	Gidlöf *et al.* 2006
Sweden	Skåne	Almhov (CT 1)	12.94567	55.55847	settlement	Ua-18755	3500	70	-2021	-1626	-1822	cereal	*Triticum dicoccum/ spelta*	A685, house 2	Gidlöf *et al.* 2006
Sweden	Närke	Attersta	15.22236	59.21837	settlement	Ua-39358	5050	46	-3959	-3711	-3859	cereal		A12648, house 5	Karlsen *et al.* 2013
Norway	Rogaland	Austbø	5.620596	58.7286	settlement	Tua-8895	3840	105	-2576	-1978	-2297	cereal			Fort *et al.* 2018
Sweden	Småland	Berga 341	14	56.9392	settlement	Ua-31180	4550	32	-3371	-3102	-3215	cereal	*Triticum dicoccum/ spelta*	A2135, pit	Rudebeck 2021
Sweden	Ånger-manland	Bjästamon	18.35319	63.09629	settlement	Ua-27101	3985	45	-2625	-2344	-2512	cereal			Gustafsson and Spång 2007
Sweden	Ånger-manland	Bjästamon	18.35319	63.09629	settlement	Ua-27100	3750	45	-2296	-1985	-2161	cereal	*Hordeum*		Iversen *et al.* 2021
Norway	Østfold	Bjørnstad	11.05379	59.30193	settlement	TUa-5618	3635	80	-2277	-1767	-2008	cereal	*Hordeum vulgare*		Solheim 2021
Norway	Østfold	Bjørnstad	11.05379	59.30193	settlement	TUa-5663	3610	40	-2132	-1828	-1970	cereal			Solheim 2021
Norway	Østfold	Borge Vestre	10.91909	59.347479	settlement	TUa-4633	3680	50	-2204	-1926	-2069	cereal	*Hordeum vulgare*		Solheim 2021
Sweden	Skåne	Bunkeflo 109:1	12.97104	55.55949		Ua-37379	4835	40	-3702	-3525	-3594	cereal		A2284	Hadevik 2009
Sweden	Skåne	Bunkeflo 8:2	12.94522	55.55985	longbarrow?	Ua-33027	4660	40	-3528	-3360	-3451	cereal		A300	Hadevik 2009
Sweden	Skåne	Bunkeflostrand 15:1	12.91965	55.54251		Ua-34229	4919	45	-3795	-3634	-3696	cereal		A117800	Brink 2009
Sweden	Skåne	Bunkeflostrand 15:1	12.91965	55.54251	palisade	Ua-24588	4110	40	-2872	-2501	-2689	cereal	*Hordeum vulgare nudum*	A2877	Brink 2009
Sweden	Skåne	Bunkeflostrand 15:1	12.91965	55.54251	palisade	Ua-34231	4085	45	-2868	-2488	-2647	cereal		A119384	Brink 2009
Sweden	Skåne	Bunkeflostrand 15:1	12.91965	55.54251	palisade	Ua-35116	4080	40	-2863	-2476	-2631	cereal		A119691	Brink 2009
Sweden	Skåne	Bunkeflostrand 15:1	12.91965	55.54251	palisade	LuS-7683	4055	50	-2859	-2467	-2597	cereal	*Hordeum*	A1815	Brink 2009
Sweden	Skåne	Bunkeflostrand 15:1	12.91965	55.54251	palisade	Ua-34235	4050	35	-2843	-2470	-2573	cereal		A125399	Brink 2009
Sweden	Skåne	Bunkeflostrand 15:1	12.91965	55.54251	palisade	Ua-34234	4050	40	-2847	-2469	-2577	cereal	*Triticum dicoccum/ spelta*	A120335	Brink 2009
Sweden	Skåne	Bunkeflostrand 15:1	12.91965	55.54251	palisade	LuS-7680	4010	50	-2844	-2348	-2534	cereal	*Hordeum vulgare nudum*	A 865	Brink 2009
Sweden	Skåne	Bunkeflostrand 15:1	12.91965	55.54251	palisade	Ua-24587	3970	35	-2575	-2348	-2491	cereal	*Hordeum vulgare nudum*	palisade	Brink 2009
Sweden	Skåne	Bunkeflostrand 15:1	12.91965	55.54251	palisade	Ua-35113	3960	40	-2575	-2307	-2473	cereal		A 3662	Brink 2009
Sweden	Skåne	Bunkeflostrand 15:1	12.91965	55.54251	palisade	Ua-34227	3960	35	-2574	-2343	-2476	cereal	*Hordeum*	A 10630	Brink 2009
Sweden	Skåne	Bunkeflostrand 15:1	12.91965	55.54251	palisade	Ua-34237	3950	35	-2571	-2305	-2459	cereal		A 128616	Brink 2009
Sweden	Skåne	Bunkeflostrand 15:1	12.91965	55.54251	palisade	Ua-34224	3940	40	-2570	-2297	-2429	cereal		A 5093	Brink 2009

Country	Region	Site	Long	Lat	Site type	Lab Nr.	BP uncal	1s	BC from (95.4%)	BC to (95.4%)	BC median	Material	Species	Context	Reference
Sweden	Skåne	Bunkeflostrand 9:5, 9:6	12.92778	55.56081	settlement	Ua-23733	4315	55	-3260	-2707	-2950	cereal	*Triticum*	A1026	Carlson 2006
Sweden	Uppland	Djurstugan	17.51929	60.31592	settlement	Poz-6249	3910	35	-2552	-2238	-2393	cereal	*Triticum*		Ytterberg 2006
Sweden	Uppland	Djurstugan	17.51929	60.31592	settlement	Poz-6251	3835	35	-2456	-2150	-2290	cereal	*Hordeum*		Ytterberg 2006
Sweden	Skåne	Dösemarken	12.94725	55.55949		Ua-41878	4657	36	-3520	-3365	-3452	cereal	*Triticum dicoccum/ spelta*	A23016	Berggren and Brink 2012
Sweden	Skåne	Dösemarken	12.94725	55.55949		Ua-41854	3740	42	-2287	-2027	-2145	cereal	*Triticum*	13555	Berggren and Brink 2012
Sweden	Skåne	Dösemarken	12.94725	55.55949		Ua-41870	3591	32	-2034	-1825	-1945	cereal		28546	Berggren and Brink 2012
Sweden	Skåne	Dösemarken	12.94725	55.55949		Ua-41853	3569	31	-2025	-1776	-1919	cereal		11022	Berggren and Brink 2012
Sweden	Skåne	Dösemarken	12.94725	55.55949		Ua-41865	3547	30	-2011	-1770	-1890	cereal	*Triticum*	27792	Berggren and Brink 2012
Sweden	Skåne	Dösemarken	12.94725	55.55949		Ua-41873	3506	31	-1924	-1743	-1823	cereal		10323	Berggren and Brink 2012
Sweden	Småland	E22 Möre omr 2A åkern	16.15444	56.6186	settlement	Ua-14141	4650	70	-3634	-3109	-3445	cereal	*Hordeum*	A732, posthole	Rudebeck 2021
Sweden	Småland	E22 Möre Söderåkra	16.15444	56.6186	settlement	Ua-15697	4520	70	-3494	-2935	-3211	cereal	*Triticum dicoccum*	A1373, posthole	Rudebeck 2021
Sweden	Småland	E22 Möre Söderåkra	16.15444	56.6186	settlement	Ua-15699	3560	85	-2141	-1644	-1905	cereal	*Hordeum vulgare nudum*	A1358, posthole	Rudebeck 2021
Sweden	Skåne	E22 Sätaröd-Vä lokal 15	13.98639	55.9611	settlement	Ua-58204	4949	30	-3784	-3648	-3711	cereal	*Hordeum*	A2030, pit	Rudebeck 2021
Sweden	Skåne	E22 Sätaröd-Vä lokal 15	13.98639	55.9611	settlement	Ua-58208	4830	31	-3652	-3528	-3579	cereal			Rudebeck 2021
Sweden	Skåne	E22 Sätaröd-Vä lokal 15	13.98639	55.9611	settlement	Ua-55402	4803	29	-3641	-3527	-3571	cereal	*Hordeum vulgare vulgare*	A1405, hearth	Rudebeck 2021
Sweden	Skåne	E22 Sätaröd-Vä lokal 15	13.98639	55.9611	settlement	Ua-55403	4730	30	-3631	-3377	-3523	cereal	*Triticum aestivum/ compactum*	A1288, pit	Rudebeck 2021
Sweden	Skåne	E22, Sätaröd-Vä lok 22	14.06804	55.97114	settlement	Ua-55409	6983	32	-5979	-5758	-5866	cereal		A1474 posthole	Berggren 2018
Sweden	Skåne	Elinelund 2A	12.93122	55.56282	settlement	Ua-11787	3740	55	-2340	-1971	-2147	cereal			Sarnäs and Nord Paulsson 2001
Sweden	Skåne	Elinelund 2B	12.93812	55.55973	settlement	Ua-12656	4110	60	-2879	-2494	-2691	cereal	*Triticum dicoccum/ spelta*	A13443, house 1	Sarnäs and Nord Paulsson 2001
Sweden	Skåne	Elinelund 2B	12.93812	55.55973	settlement	Ua-13946	3970	55	-2626	-2293	-2483	cereal	*Hordeum vulgare nudum*	A 1521, posthole	Sarnäs and Nord Paulsson 2001
Sweden	Skåne	Elinelund 2B	12.93812	55.55973	settlement	Ua-14974	3935	75	-2628	-2151	-2418	cereal	*Hordeum vulgare nudum*	fence	Sarnäs and Nord Paulsson 2001
Sweden	Skåne	Elinelund 2B	12.93812	55.55973	settlement	Ua-14975	3870	70	-2565	-2140	-2340	cereal		A1255	Sarnäs and Nord Paulsson 2001
Sweden	Skåne	Elinelund 2B	12.93812	55.55973	settlement	Ua-13945	3820	55	-2462	-2066	-2272	cereal		A1464	Sarnäs and Nord Paulsson 2001
Sweden	Skåne	Elinelund 2B	12.93812	55.55973	settlement	Ua-12657	3785	65	-2455	-2034	-2221	cereal	*Triticum dicoccum/ spelta*	house 2	Sarnäs and Nord Paulsson 2001
Sweden	Skåne	Elinelund 2B	12.93812	55.55973	settlement	Ua-13944	3750	55	-2343	-1978	-2162	cereal	*Hordeum vulgare nudum*	house 3	Sarnäs and Nord Paulsson 2001

Country	Region	Site	Long	Lat	Site type	Lab Nr.	BP uncal	1s	BC from (95.4%)	BC to (95.4%)	BC median	Material	Species	Context	Reference
Sweden	Skåne	Elinelund 2B	12.93812	55.55973	settlement	Ua-12658	3740	85	-2454	-1935	-2154	cereal	*Triticum dicoccum/ spelta*	house 3	Sarnäs and Nord Paulsson 2001
Sweden	Skåne	Elinelund 2B	12.93812	55.55973	settlement	Ua-13279	3565	70	-2135	-1696	-1912	cereal	*Hordeum vulgare nudum*	house 1	Sarnäs and Nord Paulsson 2001
Sweden	Skåne	Eskilstorp 2:6	13.02734	55.48115		Ua-51764	4868	35	-3758	-3532	-3648	cereal		A2328 pit	Brink and Olsson 2016
Sweden	Skåne	Fjelie 13:1, 45:1, 55	13.10158	55.72555	settlement	Ua-59107	4987	32	-3936	-3653	-3753	cereal	*Hordeum vulgare nudum*	A73000 pit	Schmidt Sabo and Lindberg 2019
Sweden	Skåne	Flackarp	13.16024	55.6875	settlement, graves	Ua-64587	7590	39	-6562	-6388	-6443	cereal		A67219	Andersson *et al.* 2021
Sweden	Skåne	Flackarp	13.16024	55.6875	settlement, graves	Ua-64584	4767	35	-3639	-3382	-3572	cereal	*Triticum dicoccum/ spelta*	A3470/A5184 grave	Andersson *et al.* 2021
Sweden	Skåne	Flackarp	13.16024	55.6875	settlement, graves	Ua-64586	3817	45	-2456	-2140	-2264	cereal	*Triticum dicoccum/ spelta*	A71123	Andersson *et al.* 2021
Sweden	Väster-götland	Fors 125	12.21559	58.22433	settlement	LT4620A	3616	50	-2139	-1782	-1979	cereal	*Triticum dicoccum/ Hordeum*	A832	Von der Luft *et al.* 2012
Sweden	Väster-götland	Fors 125	12.21559	58.22433	settlement	LT4617A	3596	60	-2137	-1771	-1954	cereal	*Hordeum vulgare nudum?*	A748	Von der Luft *et al.* 2012
Sweden	Väster-götland	Fors 125	12.21559	58.22433	settlement	LT4618A	3552	45	-2023	-1751	-1895	cereal	*Hordeum vulgare nudum?*	A786	Von der Luft *et al.* 2012
Sweden	Bohuslän	Forshälla 38?			rockshelter	Beta-126654	3770	60	-2451	-1985	-2194	cereal			Per Persson pers. comm.
Sweden	Bohuslän	Forshälla 75?			settlement	Ua-9585	3585	60	-2134	-1751	-1939	cereal	*Triticum*		Per Persson pers. comm.
Sweden	Skåne	Fosie 9A-B	13.03258	55.55404	settlement	Ua-16195	14055	135	-15471	-14707	-15150	cereal			Jönsson and Lövgren 2003
Sweden	Skåne	Fosie IIA	13.042	55.54998	settlement	Ua-15024	4845	75	-3794	-3378	-3622	cereal	*Hordeum*	A1065, pit	Hadevik and Gidlöf 2003
Sweden	Skåne	Fosie IIA	13.042	55.54998	settlement	Ua-15010	3945	95	-2851	-2144	-2437	cereal	*Triticum dicoccum/ spelta*	A264, house 12	Brink 2009
Sweden	Skåne	Fosie IIA	13.042	55.54998	settlement	Ua-15004	3675	65	-2281	-1886	-2062	cereal		A50	Brink 2009
Sweden	Skåne	Fosie IIB	13.05304	55.55007	settlement	Ua-15208	3820	90	-2560	-1984	-2271	cereal		A18	Hadevik and Gidlöf 2003
Sweden	Skåne	Fosie IIB	13.05304	55.55007	settlement	Ua-15032	3585	80	-2194	-1697	-1940	cereal		A71	Hadevik and Gidlöf 2003
Sweden	Skåne	Fosie IID	13.06306	55.55201	settlement	Ua-15037	4970	70	-3946	-3642	-3757	cereal		A18	Hadevik 2009
Sweden	Skåne	Fosie IID	13.06306	55.55201	settlement	Ua-15817	4970	85	-3961	-3633	-3764	cereal		A16	Hadevik 2009
Sweden	Skåne	Fosie IID	13.06306	55.55201	settlement	Ua-15818	4935	100	-3957	-3528	-3735	cereal		A17	Hadevik 2009
Sweden	Skåne	Fosie IID	13.06306	55.55201	settlement	Ua-15214	4935	105	-3966	-3521	-3736	cereal		A52	Hadevik 2009
Sweden	Skåne	Fredriksberg 13D	13.07986	55.56153		Ua-15362	4330	75	-3331	-2702	-2980	cereal		A588	Tennander 2005
Sweden	Skåne	Fredriksberg 13E	13.08777	55.56657	settlement	Ua-15444	4680	70	-3637	-3342	-3463	cereal	*Triticum dicoccum/ spelta*	A16, pit	Tennander 2005
Denmark	Fyn	Frydenlund	10.12865	55.20668	settlement	KIA-49229	5063	29	-3955	-3788	-3869	cereal	*Triticum turgidum/ durum*	A52	Kirleis 2019
Denmark	Fyn	Frydenlund	10.12865	55.20668	settlement	KIA-49228	5035	35	-3951	-3711	-3860	cereal	*Triticum turgidum/ durum*	A52	Kirleis 2019

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Denmark	Fyn	Frydenlund	10.12865	55.20668	settlement	Poz-62915	4840	40	-3704	-3526	-3611	cereal	*Hordeum vulgare nudum*	A18	Kirleis 2019
Denmark	Fyn	Frydenlund	10.12865	55.20668	settlement	Poz-62983	4820	35	-3649	-3527	-3575	cereal	*Triticum*	A18	Kirleis 2019
Norway	Rogaland	Frøyland	5.634231	58.75297	settlement	TUa-6803	3875	35	-2465	-2209	-2360	cereal		house 2	Fort *et al.* 2018
Sweden	Skåne	Färlöv 171 m fl	14.09497	56.0694	settlement	UGa-10871	3600	30	-2111	-1882	-1957	cereal	*Hordeum vulgare vulgare*	AS601, posthole	Rudebeck 2021
Sweden	Skåne	Färlöv 171 m fl	14.09497	56.0694	settlement	UGa-10873	3540	25	-1951	-1770	-1881	cereal	*Triticum dicoccum/ spelta*	AG921, pit	Rudebeck 2021
Norway	Møre og Romsdal	Gossen, site 30	6.944968	62.86574	settlement	TUa-4738	3720	45	-2284	-1974	-2112	cereal	*Hordeum*		Fort *et al.* 2018
Denmark	Bornholm	Grödbygård	14.94446	55.03471	settlement	AAR-2396	4230	90	-3088	-2501	-2795	cereal	*Hordeum vulgare nudum*	EQ1, posthole in house EQ	Nielsen and Nielsen 2020
Denmark	Bornholm	Grödbygård	14.94446	55.03471	settlement	K-5389	4030	85	-2874	-2310	-2575	cereal		posthole AC 54	Nielsen and Nielsen 2020
Denmark	Bornholm	Grödbygård	14.94446	55.03471	settlement	K-5375	3960	65	-2663	-2208	-2464	cereal		posthole AC 54	Nielsen and Nielsen 2020
Sweden	Skåne	Hammar 9:21	14.20554	56.02498	settlement	Ua-41986	6470	53	-5530	-5317	-5422	cereal		posthole	Berggren 2018
Sweden	Skåne	Hammar 9:21	14.20554	56.02498	settlement	Ua-41975	4288	38	-3017	-2781	-2904	cereal	*Hordeum vulgare vulgare*	A425, cooking pit	Helgesson *et al.* 2013
Sweden	Hälsing-land	Hedningahällan	17.0099	61.49215	settlement	Ua-5080	3780	110	-2557	-1901	-2215	cereal	*Hordeum vulgare nudum*	A5	Holm 1997, 247
Sweden	Skåne	Herrestorp	13.032	55.48	settlement	Ua-45718	4955	35	-3891	-3646	-3721	cereal	*Triticum*	A11912	Andersson *et al.* 2016
Sweden	Skåne	Herrestorp	13.0389	55.47204	settlement	Ua-5942	3545	80	-2135	-1641	-1884	cereal		420	Torstensson Åhlin 2000
Sweden	Skåne	Herrestorp	13.0389	55.47204	settlement	Ua-5943	3515	60	-2024	-1686	-1837	cereal		456	Torstensson Åhlin 2000
Sweden	Blekinge	Hjortsberga 326	15.4033	56.2083	settlement	Ua-56955	4850	33	-3706	-3528	-3637	cereal	*Hordeum vulgare vulgare*	AH1757	Rudebeck 2021
Sweden	Närke	Hjulberga 1	15.1	59.26	settlement	Ua-3369	4780	65	-3653	-3374	-3559	cereal	*Triticum compactum*		Hallgren 2012
Sweden	Närke	Hjulberga 1	15.1	59.26	settlement	Ua-3368	4695	65	-3632	-3365	-3473	cereal	*Hordeum vulgare nudum*		Hallgren 2012
Sweden	Östergötland	Hulje	15.09194	58.33056	settlement	Ua-31067	4963	86	-3960	-3540	-3758	cereal	*Hordeum vulgare nudum*	A 12163	Petersson 2014
Sweden	Östergötland	Hulje	15.09194	58.33056	settlement	Ua-38680	4784	35	-3643	-3386	-3574	cereal	*Hordeum vulgare nudum*	A 964	Petersson 2014
Norway	Akershus	Huseby	11.0322	60.00282	settlement	Ua-46747	3513	31	-1927	-1746	-1828	cereal	*Hordeum vulgare nudum*	posthole	Sand-Eriksen and Mjaerum 2023
Sweden	Skåne	Hyllie (CT 5)	12.98365	55.56702	palisade	Ua-21310	3720	65	-2339	-1931	-2118	cereal	*Hordeum vulgare nudum*	A 3524	Brink 2009
Sweden	Skåne	Hyllie 155:91	12.97485	55.56522	settlement	Ua-19668	4670	65	-3634	-3341	-3457	cereal	*Triticum dicoccum/ spelta*	A5	Sanden 2001
Sweden	Skåne	Hyllie 155:91	12.97632	55.56965	settlement	Ua-33974	4545	40	-3371	-3099	-3216	cereal	*Triticum*	A3494	Sanden 2001
Sweden	Skåne	Hyllie 155:91	12.97632	55.56965	settlement	Ua-33973	4535	35	-3366	-3101	-3211	cereal		A3541	Sanden 2001
Sweden	Skåne	Hyllie 155:91	12.97485	55.56522	settlement	Ua-19667	4490	50	-3361	-3022	-3201	cereal	*Triticum dicoccum/ spelta*	A6	Sanden 2001

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Sweden	Skåne	Hyllie 165:79	12.98937	55.56759	settlement	Ua-32360	5260	50	-4239	-3973	-4103	cereal		A2219	Rudebeck 2021
Sweden	Skåne	Hyllie 165:79	12.98937	55.56759	settlement	Ua-32362	4750	55	-3639	-3376	-3541	cereal	*Triticum*	A8628	Rudebeck 2021
Sweden	Skåne	Hyllie 165:79	12.98937	55.56759	settlement	Ua-32363	4395	75	-3336	-2896	-3059	cereal	*Hordeum*	A530	Rudebeck 2021
Sweden	Skåne	Hyllie vattentorn	12.98365	55.56702	settlement	Ua-21650	4785	40	-3645	-3383	-3572	cereal	*Hordeum vulgare nudum*	A2479	Hallgren and Sundström 2008
Norway	Rogaland	Håbakken	5.67381	58.91364	settlement	TUa-1838	3710	65	-2296	-1901	-2104	cereal			Fort *et al.* 2018
Sweden	Skåne	Ilstorp 28:21	13.6582	55.61799	settlement	Ua-8078	6130	100	-5307	-4801	-5064	cereal			Schmidt Sabo 1997
Finland	Åland	Jettböle	19.97262	60.13821	settlement	Ua-53765	4424	31	-3326	-2921	-3061	cereal	*Hordeum vulgare nudum*		Vanhanen *et al.* 2019
Norway	Rogaland	Jåsund	5.632574	58.9354	settlement	Tra-4035	3690	65	-2284	-1895	-2081	cereal	*Hordeum vulgare*	house I	Fort *et al.* 2018
Norway	Rogaland	Jåttå	5.714002	58.95681	settlement	TUa-1846	3670	55	-2201	-1897	-2054	cereal		house II	Fort *et al.* 2018
Denmark	Jylland	Kainsbakke	10.78862	56.43323	settlement	AAR-21678	4630	32	-3516	-3353	-3460	cereal	*Triticum dicoccum*		Philippsen *et al.* 2020
Denmark	Jylland	Kainsbakke	10.78862	56.43323	settlement	AAR-21676	4482	28	-3341	-3034	-3221	cereal	*Hordeum*		Philippsen *et al.* 2020
Denmark	Jylland	Kainsbakke	10.78862	56.43323	settlement	AAR-21677	4324	32	-3019	-2889	-2934	cereal	*Hordeum*		Philippsen *et al.* 2020
Denmark	Jylland	Kainsbakke	10.78862	56.43323	settlement	AAR-21675	4228	30	-2908	-2697	-2807	cereal	*Hordeum*		Philippsen *et al.* 2020
Denmark	Jylland	Kainsbakke	10.78862	56.43323	settlement	AAR-20515	4218	28	-2903	-2696	-2795	cereal	*Triticum*		Philippsen *et al.* 2020
Denmark	Jylland	Kainsbakke	10.78862	56.43323	settlement	AAR-21674	4195	28	-2892	-2672	-2782	cereal	*Triticum*		Philippsen *et al.* 2020
Denmark	Jylland	Kainsbakke	10.78862	56.43323	settlement	AAR-20518	3896	32	-2470	-2239	-2383	cereal			Philippsen *et al.* 2020
Sweden	Väster-götland	Karleby Klövagården	13.64256	58.15241	settlement	UBA-36107	4527	39	-3366	-3098	-3212	cereal			Sjögren and Axelsson forthcoming
Sweden	Väster-götland	Karleby Logården	13.64556	58.15514	settlement	UBA-21322	4523	43	-3368	-3044	-3213	cereal			Sjögren and Axelsson forthcoming
Sweden	Skåne	Karlsfält	13.90766	55.48659	settlement	AA-1842	4190	60	-2904	-2583	-2765	cereal	*Triticum dicoccum*	cultural layer	Larsson *et al.*1992
Sweden	Halland	Kimmersbo	12.00139	57.5589	settlement	Ua-30988	4822	42	-3701	-3520	-3579	cereal	*Triticum*	A351	Nieminen 2013
Denmark	Jylland	Kirial Bro	10.79621	56.43042	settlement	AAR-21681	4363	28	-3082	-2906	-2973	cereal	*Triticum*		Philippsen *et al.* 2020
Denmark	Jylland	Kirial Bro	10.79621	56.43042	settlement	AAR-21682	4319	27	-3011	-2890	-2919	cereal	*Hordeum*		Philippsen *et al.* 2020
Denmark	Jylland	Kirial Bro	10.79621	56.43042	settlement	AAR-21680	4299	26	-3010	-2881	-2906	cereal	*Hordeum*		Philippsen *et al.* 2020
Norway	Rogaland	Klepp	5.524673	58.74489	settlement	TUa-6809	3545	35	-2015	-1751	-1886	cereal		house I	Fort *et al.* 2018
Sweden	Skåne	Kroks mölla	12.97112	55.55975	settlement	Ua-35684	3750	35	-2286	-2036	-2161	cereal		A2264	Lindhé 2008
Sweden	Östergötland	Kvarnbacken	14.91473	58.43691	settlement	Ua-38338	8679	54	-7940	-7587	-7688	cereal	*Hordeum vulgare vulgare*	A 231	Eriksson 2009
Norway	Aust-Agder	Kvastad A2	8.899421	58.56799	settlement	Ua-52925	4551	56	-3496	-3033	-3230	cereal	*Hordeum vulgare nudum*		Solheim 2021

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Norway	Aust-Agder	Kvastad A2	8.899421	58.56799	settlement	Ua-52926	4351	55	-3316	-2882	-2985	cereal	*Triticum dicoccum*		Solheim 2021
Norway	Troms	Kveøya	16.1377	68.76024	settlement	Wk-26504	3936	30	-2565	-2302	-2422	cereal	*Hordeum vulgare*		Fort *et al.* 2018
Norway	Rogaland	Kvia	5.679531	58.64427	settlement	Tra-3597	3745	40	-2287	-2032	-2153	cereal	*Hordeum vulgare*	house I/II	Fort *et al.* 2018
Norway	Rogaland	Kvåle	5.730371	58.75168	settlement	TUa-3393	3555	65	-2128	-1695	-1898	cereal	*Hordeum vulgare nudum*	house II	Fort *et al.* 2018
Sweden	Söder-manland	Kyrktorp 8V	14.883	58.33	settlement	Ua-1405	4575	105	-3626	-2936	-3286	cereal		A129	Olsson 1997
Sweden	Halland	Laholm 197	12.95	56.49		Beta-71658	5200	60	-4234	-3808	-4021	cereal			Viking and Fors 1995
Denmark	Jylland	Lasbjerggård	8.9295	55.32339	settlement	KIA-4338	4440	40	-3335	-2927	-3107	cereal	*Triticum dicoccum*	pit	Ethelberg 2003
Sweden	Ånger-manland	Lill-Mosjön	18.93204	63.34829	settlement	Ua-25338	3790	55	-2454	-2037	-2227	cereal	*Hordeum vulgare nudum*		Färjare and Olsson 2000
Denmark	Bornholm	Limensgård	15	55	settlement	OxA-2895	5000	70	-3948	-3652	-3789	cereal	*Hordeum*	posthole house FJ	Nielsen and Nielsen 2022
Sweden	Skåne	Limhamn 155:135	12.94478	55.56097	settlement	Ua-48052	4727	32	-3631	-3376	-3517	cereal	*Hordeum vulgare vulgare*	A3391	Berggren 2015
Sweden	Skåne	Limhamn 155:135	12.94478	55.56097	settlement	Ua-48053	4686	32	-3605	-3368	-3444	cereal	*Hordeum vulgare vulgare*	A3458	Berggren 2015
Sweden	Skåne	Limhamn 155:135	12.94478	55.56097	settlement	Ua-44809	3757	36	-2289	-2037	-2170	cereal		A580	Berggren 2013
Sweden	Skåne	Lindängelund 1	13.00605	55.55254	settlement	Ua-29835	4709	39	-3629	-3372	-3465	cereal		A43026	Carlie and Lagergren 2014
Denmark	Jylland	Liselund	8.602492	56.95956	enclosure	AAR-7205	4688	49	-3626	-3367	-3458	cereal	*Triticum dicoccum*	N253, pit	Torfing 2016; pers. comm
Sweden	Söder-manland	Lisseläng 2	17.95222	59.02833	settlement	Ua-32969	5025	45	-3952	-3660	-3829	cereal	*Hordeum vulgare nudum*	posthole A414:4	Ahlbeck and Isaksson 2007
Sweden	Söder-manland	Lisseläng 2	17.95222	59.02833	settlement	Ua-32967	4940	40	-3796	-3641	-3708	cereal	*Triticum dicoccum/ spelta*	posthole A414:4	Ahlbeck and Isaksson 2007
Sweden	Skåne	Lockarp	13.03197	55.54665	settlement	Ua-21548	4880	50	-3784	-3529	-3671	cereal	*Hordeum*	A894	Hallgren and Sundström 2008
Sweden	Skåne	Lockarp	13.05004	55.54279	settlement	Ua-21553	4785	40	-3645	-3383	-3572	cereal	*Triticum*	A578	Hallgren and Sundström 2008
Sweden	Skåne	Lockarp (CT 6)	13.03197	55.54665	settlement	Ua-21546	3985	90	-2866	-2206	-2506	cereal	*Triticum*	A201, well	Brink 2009
Sweden	Skåne	Lockarp 7B	13.01713	55.54801	settlement	Ua-13063	4175	105	-3011	-2471	-2744	cereal	*Triticum dicoccum/ spelta*	A8, pit	Eliasson and Kishonti 2003
Sweden	Skåne	Lockarp 7E	13.02841	55.54937	settlement	Ua-16188	6110	75	-5287	-4839	-5039	cereal		A33233, posthole	Nord and Sarnäs 2005
Sweden	Skåne	Lockarp 7E	13.02841	55.54937	settlement	Ua-13576	4530	60	-3491	-3024	-3217	cereal	*Hordeum vulgare vulgare*	A1716	Nord and Sarnäs 2005
Sweden	Skåne	Lockarp 7E	13.02841	55.54937	settlement	Ua-16102	3935	90	-2845	-2142	-2420	cereal		house 26	Brink 2009
Sweden	Skåne	Lockarp 7E	13.02841	55.54937	settlement	Ua-16816	3900	85	-2623	-2069	-2373	cereal		house 23	Brink 2009
Sweden	Skåne	Lockarp 8	13.02816	55.54803		Ua-53876	4508	29	-3353	-3099	-3210	cereal	*Triticum dicoccum/ spelta*	A55029	Brink and Grehn 2019
Sweden	Skåne	Lockarp 8:4	13.03262	55.55425		Ua-21398	3615	45	-2136	-1827	-1977	cereal		A25536	Stamm Forsblad 2004
Sweden	Skåne	Lockarp 8:4	13.03262	55.55425		Ua-21394	3610	55	-2139	-1776	-1972	cereal		A18482	Stamm Forsblad 2004

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Sweden	Bohuslän	Lundby 333	11.87097	57.70507	settlement	Ua-29348	4020	33	-2624	-2467	-2531	cereal	*Triticum aestivum*	A2355, posthole house 1	Nordin 2011
Sweden	Skåne	Lunnebjär	13.06543	55.54928	settlement	Ua-18921	4880	70	-3932	-3518	-3672	cereal		A373	Björklund 2006
Sweden	Skåne	Lunnebjär	13.08926	55.58868	hoard/ settlement	Ua-23339	4005	40	-2662	-2356	-2528	cereal		posthole	Brink 2009
Sweden	Söder-manland	Lässmyran 1	17.97139	59.0411	settlement	Ua-32972	4735	65	-3638	-3372	-3520	cereal	*Hordeum vulgare nudum*	K294, pit	Hallgren and Sundström 2008
Norway	Østfold	Molteberg 23	11.12023	59.24629	settlement	TUa-4999	3605	55	-2138	-1775	-1966	cereal			Solheim 2021
Sweden	Skåne	Mossby	13.6123	55.41239	settlement	Ua-755	4925	115	-3971	-3382	-3726	cereal	*Hordeum*	A 8	Larsson *et al.* 1992, 74
Sweden	Skåne	Mossby	13.6123	55.41239	settlement	Ua-753	4915	110	-3962	-3382	-3714	cereal	*Hordeum*	A8	Larsson *et al.* 1992, 74
Sweden	Skåne	N Hyllievång	12.97632	55.56965	grave	Ua-33977	4540	35	-3369	-3101	-3212	cereal		grave I/A14169	Brink 2009
Sweden	Skåne	N Hyllievång	12.97632	55.56965	settlement	Ua-33451	3820	35	-2454	-2142	-2262	cereal	*Hordeum*	house 7	Brink 2009
Sweden	Skåne	N Hyllievång	12.97632	55.56965	grave	Ua-33975	3795	35	-2400	-2058	-2231	cereal		grave II/ A102808	Brink 2009
Sweden	Skåne	N Hyllievång	12.97632	55.56965	grave	Ua-33978	3755	35	-2288	-2037	-2168	cereal		grave II/A 120605	Brink 2009
Sweden	Skåne	N Hyllievång	12.97632	55.56965	grave	Ua-33976	3640	35	-2135	-1900	-2005	cereal		grave I/ A101969	Brink 2009
Norway	Vestfold	Nordby	10.11115	59.07971	settlement	Tua-6517	3555	35	-2021	-1770	-1901	cereal	*Hordeum vulgare*	house 1	Sand-Eriksen and Mjaerum 2023
Norway	Vestfold	Nordby	10.11115	59.07971	settlement	TUa-6516	3550	35	-2019	-1767	-1894	cereal	*Hordeum vulgare*	house 1	Sand-Eriksen and Mjaerum 2023
Sweden	Skåne	Nosaby 174 m fl	14.20765	56.02375	settlement	Ua-55013	3709	31	-2201	-1982	-2093	cereal	*Hordeum vulgare vulgare*	G459	Rudebeck 2021
Sweden	Skåne	Nosaby 174 m fl	14.20765	56.02375	settlement	Ua-55014	3702	31	-2200	-1979	-2089	cereal	*Triticum dicoccum/ spelta*	G65	Rudebeck 2021
Sweden	Uppland	Nyskottet	16.89958	59.86573	settlement	Ua-17860	4670	95	-3643	-3103	-3449	cereal	*Triticum aestivum*		Hallgren and Sundström 2008
Sweden	Söder-manland	Nävertorp	16.15839	58.99849	settlement	Ua-28712	4860	75	-3899	-3380	-3643	cereal	*Triticum*	A8507, pit	Edenmo *et al.* 2008
Sweden	Halland	Onsala 327	12.01835	57.38086	settlement	Ua-25653	4025	80	-2872	-2310	-2566	cereal			Westergaard 2004
Sweden	Halland	Onsala 327	12.01835	57.38086	settlement	Ua-25654	3850	80	-2565	-2041	-2313	cereal	*Hordeum*		Westergaard 2004
Norway	Østfold	Opstad Vest	11.03472	59.28396	settlement	LuS -16320	3555	30	-2015	-1773	-1902	cereal	*Hordeum vulgare nudum*	posthole	Sand-Eriksen and Mjaerum 2023
Norway	Østfold	Opstad Vest	11.03472	59.28396	settlement	LuS-16319	3530	35	-1953	-1746	-1844	cereal	*Hordeum vulgare nudum*	posthole	Sand-Eriksen and Mjaerum 2023
Norway	Østfold	Opstad Vest	11.03472	59.28396	settlement	LuS-16616	3530	40	-2008	-1744	-1847	cereal	*Triticum*	posthole	Sand-Eriksen and Mjaerum 2023
Norway	Østfold	Opstad Vest	11.03472	59.28396	settlement	LuS-16620	3520	35	-1941	-1746	-1834	cereal	*Hordeum vulgare nudum*	posthole	Sand-Eriksen and Mjaerum 2023
Norway	Østfold	Opstad Vest	11.03472	59.28396	settlement	LuS-16617	3515	40	-1948	-1700	-1832	cereal	*Hordeum vulgare nudum*	posthole	Sand-Eriksen and Mjaerum 2023
Norway	Østfold	Opstad Vest	11.03472	59.28396	settlement	LuS -16321	3500	35	-1924	-1699	-1819	cereal	*Hordeum vulgare nudum*	posthole	Sand-Eriksen and Mjaerum 2023

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Norway	Østfold	Opstad Vest	11.03472	59.28396	settlement	LuS-16318	3500	35	-1924	-1699	-1819	cereal	*Triticum*	pit	Sand-Eriksen and Mjaerum 2023
Sweden	Skåne	Oxie 50:1	13.07472	55.5478	settlement	Ua-22172	5395	60	-4349	-4052	-4246	cereal	*Hordeum vulgare vulgare*	A105	Rudebeck 2021
Sweden	Skåne	Petersborg 6	13.00232	55.54745	settlement	Ua-11857	4795	60	-3700	-3377	-3569	cereal	*Triticum*	A56	Siech and Berggren 2002
Sweden	Skåne	Petersborg 6	13.00232	55.54745	settlement	Ua-11858	3765	75	-2456	-1978	-2189	cereal		A363	Siech and Berggren 2002
Sweden	Skåne	Pilbladet 1	13.12116	55.58826	settlement	Ua-44931	6493	44	-5556	-5361	-5429	cereal			Berggren 2018
Sweden	Skåne	Pilbladet 1	13.12116	55.58826	settlement	Ua-50414	4556	34	-3487	-3102	-3223	cereal	*Triticum dicoccum*	A22002	Berggren 2018
Sweden	Skåne	Piledal	13.89404	55.46089	settlement	AA-1841	4320	80	-3331	-2676	-2969	cereal	*Hordeum*	A285	Larsson *et al.* 1992
Sweden	Skåne	Piledal	13.89404	55.46089	settlement	AA-1846	3524	50	-2016	-1696	-1843	cereal	*Hordeum/Triticum dicoccum*	posthole house 1	Larsson *et al.* 1992
Norway	Østfold	Rudskogen	11.25659	59.3667	settlement	LuS-16058	3635	35	-2134	-1896	-1999	cereal	*Triticum*	house floor	Sand-Eriksen and Mjaerum 2023
Sweden	Östergötland	Russingstorp	15.05134	58.44574	settlement	Ua-71413	4646	65	-3632	-3111	-3444	cereal			Vanhanen *et al.* 2019
Norway	Rogaland	Røyneberg	6.067952	58.95815	settlement	Tua-1858	3505	55	-2014	-1687	-1826	cereal		house B	Fort *et al.* 2018
Sweden	Skåne	S Sallerup 15C	13.11045	55.57996	settlement	Ua-14793	6430	85	-5555	-5217	-5396	cereal	*Hordeum?*	posthole A563, layer 6	Berggren 2018
Sweden	Skåne	S Sallerup 15D	13.11358	55.58469	settlement	Ua-15238	8360	70	-7578	-7190	-7414	cereal		A525, posthole	Berggren 2018
Denmark	Fyn	Sarup	10.1	55.2	enclosure	KIA-49234	4890	20	-3707	-3637	-3658	cereal	*Triticum dicoccum*	A1744	Kirleis 2019
Denmark	Fyn	Sarup	10.1	55.2	enclosure	KIA-49232	4855	35	-3709	-3528	-3640	cereal	*Triticum dicoccum*	A2873	Kirleis 2019
Denmark	Fyn	Sarup	10.1	55.2	enclosure	KIA-49235	4790	30	-3639	-3525	-3573	cereal	*Triticum dicoccum*	A2005	Kirleis 2019
Denmark	Fyn	Sarup	10.1	55.2	enclosure	KIA-49233	4725	30	-3630	-3377	-3513	cereal	*Triticum dicoccum*	A1655	Kirleis 2019
Denmark	Fyn	Sarup	10.1	55.2	enclosure	KIA-49236	4646	25	-3515	-3363	-3460	cereal	*Triticum dicoccum*	A1097	Kirleis 2019
Denmark	Fyn	Sarup	10.1	55.2	enclosure	KIA-49237	4619	25	-3507	-3351	-3466	cereal	*Triticum dicoccum*	A851	Kirleis 2019
Denmark	Fyn	Sarup	10.1	55.2	enclosure	K-2628	4580	70	-3522	-3036	-3311	cereal		A212, pit	Andersen 1977
Denmark	Fyn	Sarup	10.1	55.2	enclosure	K-2767	4480	90	-3486	-2913	-3175	cereal	*Triticum dicoccum*	pit	Andersen 1981
Denmark	Fyn	Sarup	10.1	55.2	enclosure	K-2910	4400	90	-3347	-2892	-3076	cereal	*Triticum dicoccum*		Andersen 1981
Denmark	Själland	Sigersted	11.70824	55.40797	settlement	nd	4780	70	-3700	-3372	-3557	cereal	*Hordeum*	pit A	Koch 1998
Denmark	Själland	Sigersted III	11.70824	55.40797	settlement	nd	5079	23	-3957	-3798	-3861	cereal	*Hordeum*		Nielsen and Nielsen 2020
Denmark	Själland	Sigersted III	11.70824	55.40797	settlement	nd	5065	23	-3952	-3796	-3869	cereal	*Hordeum*		Nielsen and Nielsen 2020
Sweden	Söder-manland	Sittesta	17.9153	58.98041	settlement	Poz-18293	4700	40	-3626	-3371	-3456	cereal	*Hordeum vulgare vulgare*		Vanhanen *et al.* 2019
Sweden	Söder-manland	Sittesta	17.9153	58.98041	settlement	Poz-23716	4390	35	-3283	-2906	-3000	cereal	*Triticum dicoccum/ spelta*		Vanhanen *et al.* 2019
Sweden	Söder-manland	Sittesta	17.9153	58.98041	settlement	Poz-23717	4375	35	-3094	-2907	-2985	cereal			Vanhanen *et al.* 2019
Sweden	Söder-manland	Sittesta	17.9153	58.98041	settlement	Poz-18291	4350	40	-3092	-2893	-2972	cereal			Vanhanen *et al.* 2019
Sweden	Väster-götland	Sjogerstad 106	13.8	58.3		Poz-5657	5870	50	-4887	-4557	-4742	cereal	*Hordeum*		Rudebeck 2021

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Sweden	Väster-götland	Sjogerstad 106	13.8	58.3		Poz-5674	4490	40	-3356	-3029	-3209	cereal			Axelsson pers. comm.
Sweden	Väster-götland	Sjogerstad 106	13.8	58.3		Poz-5672	3780	40	-2344	-2039	-2205	cereal			Axelsson pers. comm.
Sweden	Väster-götland	Sjogerstad 106	13.8	58.3		Poz-5673	3640	35	-2135	-1900	-2005	cereal			Axelsson pers. comm.
Denmark	Fyn	Skaghorn	9.981	55.168	settlement	AAR-2489	4650	80	-3636	-3104	-3440	cereal			Nielsen and Nielsen 2020
Norway	Akershus	Skedsmovollen	11.04561	59.99253	settlement	Ua-46720	3629	31	-2130	-1895	-1992	cereal	*Hordeum vulgare*		Solheim 2021
Sweden	Bohuslän	Skee 1616	11.2867	58.8536	settlement	Ua-26850	4615	40	-3521	-3137	-3445	cereal	*Hordeum*		Westergaard 2008
Sweden	Skåne	Skepparslöv 7:10	14.0396	55.54937		Ua-55047	5827	33	-4789	-4555	-4690	cereal	*Hordeum*	A945, pit	Edring 2017
Sweden	Skåne	Skepparslöv 7:10	14.0396	55.54937	settlement	Ua-59328	4998	34	-3944	-3653	-3771	cereal	*Hordeum*	A5676, context 2, posthole	Rudebeck 2021
Sweden	Skåne	Skepparslöv 81:1, 316, 317, Öllsjö 7:1	14.08461	56.009	settlement	Ua-42090	4719	31	-3629	-3375	-3499	cereal	*Hordeum vulgare nudum*	A55029, posthole in timber circle	Rudebeck 2021
Sweden	Västmanland	Skogsmossen	15.8	59.4	settlement	Ua-15200	4880	110	-3949	-3378	-3674	cereal	*Triticum*		Hallgren and Sundström 2008
Sweden	Västmanland	Skogsmossen	15.8	59.4	settlement	Ua-14835	4795	75	-3709	-3372	-3566	cereal	*Hordeum vulgare nudum*		Hallgren and Sundström 2008
Sweden	Västmanland	Skogsmossen	15.8	59.4	settlement	Ua-15198	4775	70	-3654	-3372	-3554	cereal			Hallgren and Sundström 2008
Sweden	Västmanland	Skogsmossen	15.8	59.4	settlement	Ua-15199	4735	75	-3640	-3370	-3517	cereal	*Triticum aestivo-compactum*		Hallgren and Sundström 2008
Sweden	Västmanland	Skogsmossen	15.8	59.4	settlement	Ua-14834	4680	70	-3637	-3342	-3463	cereal	*Triticum aestivo-compactum*		Hallgren and Sundström 2008
Denmark	Bornholm	Skovgård	14.739	55.221	settlement	Ua-55726	5084	32	-3962	-3796	-3864	cereal	*Triticum compactum*		Nielsen and Nielsen 2020
Denmark	Bornholm	Skovgård	14.739	55.221	settlement	Ua-55727	5016	32	-3946	-3660	-3803	cereal	*Triticum compactum*		Nielsen and Nielsen 2020
Denmark	Bornholm	Smedegårde	14.803	55.174	settlement	Ua-55182	4963	32	-3892	-3648	-3729	cereal	*Triticum*	A11	Nielsen and Nielsen 2020
Denmark	Bornholm	Smedegårde	14.803	55.174	settlement	Ua-55181	4951	32	-3791	-3647	-3714	cereal	*Triticum*	A10	Nielsen and Nielsen 2020
Denmark	Bornholm	Smedegårde	14.803	55.174	settlement	Ua-55183	4917	32	-3769	-3641	-3689	cereal	*Hordeum vulgare nudum*	A88	Nielsen and Nielsen 2020
Denmark	Bornholm	Smedegårde	14.803	55.174	settlement	Ua-55184	4904	32	-3767	-3637	-3684	cereal	*Triticum dicoccum*	A100	Nielsen and Nielsen 2020
Norway	Rogaland	Soma	5.628948	59.12508	settlement	Beta-118741	3640	40	-2136	-1897	-2007	cereal	*Hordeum vulgare*		Fort *et al.* 2018
Sweden	Söder-manland	Stensborg	17.82439	59.16198	settlement	LuS-9184	4800	50	-3653	-3380	-3573	cereal	*Triticum dicoccum/ spelta*		Larsson and Broström 2011
Sweden	Söder-manland	Stensborg	17.82439	59.16198	settlement	LuS-9570	4760	50	-3641	-3377	-3556	cereal	*Triticum dicoccum/ spelta*		Larsson and Broström 2011
Sweden	Söder-manland	Stensborg	17.82439	59.16198	settlement	LuS-8636	4510	50	-3366	-3029	-3210	cereal	*Triticum dicoccum/ spelta*		Larsson and Broström 2011
Sweden	Söder-manland	Stensborg	17.82439	59.16198	settlement	LuS-8637	4510	50	-3366	-3029	-3210	cereal	*Triticum dicoccum/ spelta*		Larsson and Broström 2011

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Norway	Østfold	Stensrød	10.80376	59.31865	settlement	Tua-4100	3720	50	-2285	-1961	-2114	cereal		house II, posthole A205	Sand-Eriksen and Mjaerum 2023
Norway	Østfold	Stensrød	10.80376	59.31865	settlement	Tua-4099	3535	40	-2010	-1746	-1862	cereal		posthole	Sand-Eriksen and Mjaerum 2023
Norway	Østfold	Stensrød	10.80376	59.31865	settlement	TUa-4502	3505	45	-1950	-1692	-1825	cereal	*Triticum*	posthole	Sand-Eriksen and Mjaerum 2023
Sweden	Skåne	Stångby	13.19094	55.75715	settlement	Ua-58370	3712	28	-2201	-1986	-2093	cereal		A1721	Artursson *et al.* 2018
Sweden	Skåne	Stångby	13.19094	55.75715	settlement	Ua-58143	3626	32	-2130	-1892	-1988	cereal		A1073	Artursson *et al.* 2018
Sweden	Skåne	Sunnanå 19A-F	13.11219	55.62186	settlement	Ua-14961	3615	55	-2141	-1777	-1979	cereal		5780	Steineke *et al.* 2005
Sweden	Skåne	Sunnanå 19A-F	13.11219	55.62186	settlement	Ua-14959	3590	65	-2136	-1751	-1946	cereal		5613	Steineke *et al.* 2005
Sweden	Skåne	Sunnanå 19A-F	13.11219	55.62186	settlement	Ua-14962	3585	55	-2133	-1767	-1939	cereal		5841	Steineke *et al.* 2005
Sweden	Skåne	Svågertorp 8 B-C	12.99228	55.54719	settlement	Ua-16418	4760	75	-3649	-3371	-3540	cereal	*Triticum dicoccum/ spelta*	A51000	Hadevik 2009
Sweden	Skåne	Svågertorp 8A	12.98271	55.54699	settlement	Ua-11719	3615	80	-2200	-1749	-1981	cereal		776	Rosberg and Lindhé 2001
Sweden	Skåne	Svågertorp 8A	12.98271	55.54699	settlement	Ua-11713	3595	55	-2136	-1771	-1953	cereal		204	Rosberg and Lindhé 2001
Sweden	Skåne	Svågertorp A	12.99901	55.55233	settlement	Ua-19304	4950	55	-3941	-3637	-3730	cereal			Hadevik 2009
Sweden	Skåne	Svågertorp D	12.99937	55.55112	settlement	Ua-19306	4025	45	-2846	-2459	-2543	cereal	*Hordeum*	house 14	Brink 2009
Sweden	Skåne	Svågertorp S	12.98409	55.55561	settlement	Ua-18392	4210	75	-3010	-2505	-2776	cereal	*Hordeum*	house 6	Brink 2009
Sweden	Närke	Säby	14.97461	59.24572	settlement	Ua-28358	4830	45	-3705	-3520	-3587	cereal			Hallgren 2012
Sweden	Närke	Säby	14.97461	59.24572	settlement	Ua-28357	4755	45	-3639	-3378	-3557	cereal			Vanhanen *et al.* 2019
Sweden	Skåne	Södra Sallerup 15C	13.11613	55.58873	medieval ditch	Ua-14791	4035	85	-2875	-2344	-2583	cereal		medieval ditch	Brink 2009
Norway	Rogaland	Tjora	5.591954	58.84944	settlement	Tra-1172	3635	30	-2132	-1900	-1998	cereal		house 13	Fort *et al.* 2018
Norway	Østfold	Torpum 9a	11.26398	59.17173	settlement	Tua-3918	3630	40	-2135	-1890	-1995	cereal	*Hordeum*	posthole	Fort *et al.* 2018
Sweden	Skåne	Trafikplats Lunds Södra	13.18336	55.67837	settlement	Ua-55426	3744	29	-2280	-2036	-2153	cereal	*Triticum compactum*		Carlie 2017
Sweden	Skåne	Truls hoj	12.9358	55.74967	cult building	LuS-12124	4725	40	-3632	-3374	-3512	cereal	*Hordeum vulgare nudum*	A14376	Andersson 2017
Sweden	Skåne	Truls hoj	12.9358	55.74967	passage grave	LuS-12271	4445	45	-3337	-2928	-3134	cereal	*Triticum dicoccum*	chamber floor	Andersson 2017
Sweden	Uppland	Tråsättra	18.35	59.47	settlement	Ua-55115	4171	33	-2884	-2631	-2763	cereal	*Triticum aestivum*	A8258, central area	Artursson *et al.* 2023
Sweden	Uppland	Tråsättra	18.35	59.47	settlement	Ua-55118	4129	33	-2871	-2580	-2724	cereal	*Hordeum*	A11166, pit	Artursson *et al.* 2023
Sweden	Uppland	Tråsättra	18.35	59.47	settlement	Ua-55113	4113	33	-2869	-2574	-2691	cereal	*Hordeum*	A10159, central area	Artursson *et al.* 2023
Sweden	Uppland	Tråsättra	18.35	59.47	settlement	Ua-55116	4009	32	-2621	-2464	-2528	cereal	*Hordeum*	A8457, hut 3	Artursson *et al.* 2023

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Sweden	Uppland	Tråsättra	18.35	59.47	settlement	Ua-55117	3891	32	-2469	-2237	-2380	cereal	*Hordeum*	A2425, hut 5	Artursson *et al.* 2023
Sweden	Skåne	Tygelsjö 41:1	13.00378	55.5208	settlement	Ua-21235	3535	35	-1960	-1747	-1860	cereal		A802	Grehn 2006
Sweden	Skåne	Tygelsjö 76:1	12.93792	55.67182	settlement	Ua-43334	3684	34	-2196	-1956	-2078	cereal		A378	Frejd 2013
Denmark	Själland	Ullerødgård	12.26044	55.93944	settlement	KIA-36139	4890	90	-3946	-3384	-3685	cereal			Fort *et al.* 2018
Sweden	Skåne	Uppåkra 37	13.12926	55.67182	cemetery	Ua-58171	4416	32	-3322	-2918	-3046	cereal		A30650, grave	Bolander and Söderberg 2019
Denmark	Bornholm	Vasagård	14.88	55.05	settlement	AAR-2438.2	5250	90	-4329	-3810	-4096	cereal	*Triticum dicoccum*	pit	Nielsen and Nielsen 2020
Denmark	Bornholm	Vasagård	14.88	55.05	settlement	AAR-2438.1	4245	60	-3011	-2630	-2813	cereal	*Triticum dicoccum*	pit	Nielsen and Nielsen 2020
Denmark	Bornholm	Vasagård	14.88	55.05	settlement	AAR-2437.2	4170	70	-2904	-2506	-2747	cereal	*Triticum dicoccum*	pit	Nielsen and Nielsen 2020
Denmark	Bornholm	Vasagård	14.88	55.05	settlement	AAR-2437.1	3995	65	-2848	-2296	-2521	cereal	*Triticum dicoccum*	pit	Nielsen and Nielsen 2020
Sweden	Halland	Veddige 128	12.3536	57.27306	wetland find	Ua-29267	5160	78	-4232	-3775	-3969	cereal	*Triticum*		Johansson *et al.* 2011
Sweden	Halland	Veddige 258	12.31583	57.2589	settlement	Ua-27592	4750	50	-3638	-3377	-3545	cereal	*Triticum dicoccum/ spelta*	A1184, pit with peas	Ryberg 2006
Sweden	Skåne	Vintrie IP	12.95674	55.55262	settlement	Ua-22543	3965	40	-2577	-2342	-2482	cereal	*Triticum spelta*	house 26	Brink 2009
Sweden	Skåne	Vintrie Park	12.98091	55.55059		Ua-43394	4867	34	-3756	-3531	-3647	cereal	*Hordeum*	A11317	Brink and Hammarstrand Dehman 2013
Sweden	Skåne	Vintrie park, område C3	12.97923	55.54818		Ua-36343	3650	35	-2139	-1925	-2021	cereal	*Triticum dicoccum/ spelta*	1660	Brink 2010
Sweden	Skåne	Vintrie park, område C3	12.97923	55.54818		Ua-36344	3630	45	-2137	-1888	-1996	cereal	*Hordeum vulgare vulgare*	1698	Brink 2010
Sweden	Skåne	Vintrie park, område C3	12.97923	55.54818		Ua-39131	3539	36	-2008	-1750	-1876	cereal	*Triticum dicoccum/ spelta*	1539	Brink 2010
Sweden	Skåne	Vintriediket	12.96269	55.55471		Ua-16204	4820	75	-3768	-3376	-3584	cereal	*Triticum*	A6	Hadevik 2009
Sweden	Skåne	Vintriehemmet 3B	12.94476	55.55517		Ua-14491	4910	80	-3945	-3526	-3704	cereal		A2778	Hadevik 2009
Sweden	Skåne	Vintrieleden A	12.96151	55.56148		Ua-19367	3680	55	-2267	-1900	-2068	cereal		A1499	Friman 2007
Norway	Rogaland	Voll 27	5.68609	58.8206	settlement	TUa-2601	3560	55	-2114	-1744	-1905	cereal	*H. vulgare var.*		Fort *et al.* 2018
Sweden	Blekinge	Vä 124:1, lok 22	14.06417	55.97083	settlement	Ua-55405	4820	30	-3648	-3528	-3572	cereal	*Hordeum vulgare vulgare*	A524, pit	Rudebeck 2021
Sweden	Blekinge	Vä 124:1, lok 22	14.06417	55.97083	settlement	Ua-55408	4757	30	-3636	-3382	-3574	cereal	*Hordeum vulgare vulgare*	A1037, pit	Rudebeck 2021
Sweden	Blekinge	Vä 124:1, lok 22	14.06417	55.97083	settlement	Ua-55407	4751	29	-3635	-3381	-3572	cereal	*Hordeum vulgare vulgare*	A818, posthole	Rudebeck 2021
Sweden	Blekinge	Vä 124:1, lok 22	14.06417	55.97083	settlement	Ua-56021	4738	30	-3633	-3378	-3547	cereal	*Hordeum vulgare vulgare*	A1980, layer	Rudebeck 2021
Sweden	Blekinge	Vä 124:1, lok 22	14.06417	55.97083	settlement	Ua-55406	4737	29	-3633	-3378	-3542	cereal	*Triticum aestivum/ compactum*	A680, pit	Rudebeck 2021
Sweden	Skåne	Väg 116, Råby	14.49282	56.09761		Ua-25178	3975	70	-2846	-2209	-2488	cereal	*Hordeum vulgare nudum*	A14838	Gustafsson *et al.* 2004
Sweden	Skåne	Väg 116, Råby	14.49282	56.09761		Ua-25177	3905	70	-2573	-2150	-2379	cereal	*Hordeum vulgare nudum*	14838	Gustafsson *et al.* 2004

Country	Region	Site	Long	Lat	Site type	Lab Nr.	BP uncal	1s	BC from (95.4%)	BC to (95.4%)	BC median	Material	Species	Context	Reference
Sweden	Skåne	Väg 934	13.11021	55.78592	settlement	Ua-7642	4060	70	-2875	-2462	-2618	cereal			Munkenberg 1999
Sweden	Skåne	Västkustbane-projektet, 3:6, 3:7	12.82912	55.92307	settlement	Ua-9218	3525	65	-2033	-1645	-1849	cereal		12983	Strömberg and Thörn Pihl 2000
Sweden	Östergötland	Åby	16.17741	58.66348	settlement	Ua-51523	4363	34	-3091	-2901	-2977	cereal			Vanhanen *et al.* 2019
Sweden	Östergötland	Åby	16.17741	58.66348	settlement	Ua-51526	4355	34	-3087	-2898	-2972	cereal			Vanhanen *et al.* 2019
Sweden	Östergötland	Åby	16.17741	58.66348	settlement	Ua-51522	4329	36	-3076	-2887	-2950	cereal	*Hordeum vulgare nudum*		Vanhanen *et al.* 2019
Sweden	Östergötland	Åby	16.17741	58.66348	settlement	Ua-51525	4292	34	-3011	-2877	-2905	cereal	*Hordeum vulgare nudum*		Vanhanen *et al.* 2019
Sweden	Östergötland	Åby	16.17741	58.66348	settlement	Ua-51520	4274	33	-3010	-2707	-2897	cereal			Vanhanen *et al.* 2019
Sweden	Östergötland	Åby	16.17741	58.66348	settlement	Beta-353396	4250	30	-2916	-2704	-2886	cereal	*Triticum*		Vanhanen *et al.* 2019
Sweden	Skåne	Ö Nöbbelöv 30:1	14.33589	55.51187	settlement	Ua-7703	4755	90	-3708	-3356	-3532	cereal	*Triticum*	A8228, pit	Rudebeck 2021
Sweden	Skåne	Ö Nöbbelöv 30:1	14.33589	55.51187	settlement	Ua-7702	4660	70	-3635	-3123	-3451	cereal	*Triticum*	A4927, pit	Rudebeck 2021
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-371075	5030	30	-3949	-3712	-3863	cereal	*Triticum dicoccum*	A146474 hearth	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-362993	5000	30	-3943	-3655	-3773	cereal	*Hordeum vulgare nudum*	A34228 hearth	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	LuS-11175	4960	35	-3896	-3647	-3727	cereal	*Triticum aestivum*	A36065 layer	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-371068	4950	40	-3896	-3642	-3719	cereal	*Hordeum vulgare nudum*	A20001 pit	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-371070	4940	30	-3779	-3647	-3701	cereal	*Hordeum vulgare nudum*	AA141672 hearth	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-340085	4930	30	-3771	-3645	-3693	cereal	*Hordeum vulgare nudum*	A27949	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	LuS-11176	4925	40	-3783	-3640	-3697	cereal	*Triticum dicoccum*	A20001 pit	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-362995	4910	30	-3766	-3638	-3686	cereal	*Hordeum vulgare nudum*	A29754 pit	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-371062	4890	30	-3763	-3632	-3677	cereal	*Hordeum vulgare nudum*	A143269 stone packing	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-371074	4890	30	-3763	-3632	-3677	cereal		A26643 ditch	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-340087	4880	40	-3772	-3533	-3668	cereal	*Triticum dicoccum*	A3185 pit	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	LuS-11177	4855	35	-3709	-3528	-3640	cereal	*Triticum aestivum*	A38946 hearth	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	LuS-11172	4850	45	-3753	-3523	-3634	cereal	*Triticum*	A3185 pit	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-374044	4840	30	-3701	-3528	-3628	cereal	*Hordeum vulgare nudum*	A36085 pit	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	LuS-11173	4835	40	-3702	-3525	-3594	cereal	*Hordeum vulgare nudum*	A15440 hearth	Larsson and Brink 2017

Country	Region	Site	Long	Lat	Site type	Lab Nr.	BP uncal	1s	BC from (95.4%)	BC to (95.4%)	BC median	Material	Species	Context	Reference
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-362998	4820	30	-3648	-3528	-3572	cereal		A20344 ditch	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-371076	4810	30	-3644	-3528	-3571	cereal		A3665 pit	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	LuS-11174	4805	40	-3651	-3386	-3574	cereal	*Triticum dicoccum*	A20001 pit	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-362994	4800	40	-3649	-3516	-3574	cereal	*Triticum dicoccum/ spelta*	A29754 pit	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-367671	4780	30	-3640	-3518	-3575	cereal	*Hordeum vulgare nudum*	A27869 pit	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-362992	4690	30	-3605	-3370	-3442	cereal	*Hordeum vulgare nudum*	A34296 hearth	Larsson and Brink 2017
Sweden	Skåne	Ö Odarslöv	13.24552	55.73332	settlement	Beta-362997	4660	30	-3516	-3368	-3452	cereal	*Hordeum vulgare nudum*	A3759 hearth	Larsson and Brink 2017
Denmark	Själland	Ögårde	11.543	55.5937	settlement	K-4333	5060	65	-3981	-3657	-3854	cereal			Koch 1998
Sweden	Skåne	Önnestad 20:1, 112:1	14.0325	56.05556	settlement	Ua-55780	4764	34	-3638	-3382	-3572	cereal	*Hordeum vulgare vulgare*	A1208, cooking pit	Rudebeck 2021
Sweden	Skåne	Örja 1:9	12.87	55.8774	settlement	Ua-29905	3558	34	-2021	-1772	-1905	cereal		A20750	Schmidt Sabo 2013
Sweden	Skåne	Östervång 2:6	13.1588	55.39333	settlement	Ua-52640	4963	31	-3889	-3649	-3728	cereal	*Hordeum*	A763	Frejd 2016
Sweden	Söder-manland	Östra Vrå	16.4	58.9	settlement	Ua-6937	4600	60	-3524	-3101	-3367	cereal	*Triticum dicoccum/ spelta*		Hallgren 2012
Sweden	Östergötland	Åby	16.17741	58.66347	settlement	Ua-51524	4220	34	-2906	-2675	-2794	cereal			Lindström 2024
Finland	Åland	Svinvallen			settlement	Ua-53759	4082	31	-2857	-2493	-2626	cereal			Lindström 2024
Sweden	Söder-manland	Norvik	17.957	58.93	settlement	Ua-63184	4074	33	-2855	-2488	-2615	cereal			Lindström 2024
Sweden	Söder-manland	Norvik	17.957	58.93	settlement	Ua-63186	3915	33	-2553	-2289	-2400	cereal			Lindström 2024
Sweden	Söder-manland	Norvik	17.957	58.93	settlement	Ua-63188	3918	33	-2557	-2291	-2403	cereal			Lindström 2024
Sweden	Söder-manland	Norvik	17.957	58.93	settlement	Ua-65842	3805	31	-2399	-2139	-2243	cereal			Lindström 2024

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TIMES OF UNCERTAINTY AT THE END OF THE EARLY NEOLITHIC IN SOUTH-EAST NORWAY?

Depositions of long thin-butted flint axes in the Inner Oslo Fjord area indicate social interaction and negotiation across Scandinavia in a period of change

Almut Schülke

Abstract

In south-east Norway extensive farming, animal husbandry and farmsteads are first seen from around 2300 BC — more than a thousand years later than in southern Scandinavia, from where this new economy is believed to have been introduced. How and to what extent the people who lived in south-east Norway were connected to people further south in the centuries before full-scale farming was adopted is still a major research question. The archaeological material and its spatial and chronological context show that impulses from the south did not come into the region concurrently as a 'package', but were introduced gradually over centuries. This article explores the topic by focusing on the thin-butted flint axes from the Inner Oslo Fjord region. These axes are portable objects which were introduced from abroad. Special attention will be given to the few long thin-butted axes, finely worked long axes in high-quality material, which show no signs of use. It is argued that the phenomenon of their (ritual) deposition in the study area, as marking of land or of an important spot, can give useful insights into social encounters between people from abroad and local people between *c.* 3500 and 3300 BC and attests to a time of interregional negotiations in what was most likely a period of uncertainty.

Keywords: Early Neolithic; south-east Norway; hoarding; thin-butted flint axes; social interaction; ritual

Introduction

The period of the Early Neolithic has differing temporalities and encompasses diverse socio-cultural situations in different areas of northern Europe. Despite a diversified spectrum of material, there is also a number of similar material traits across regions. This makes the question of the extent and character of interconnectedness and social contact of people in this period into one of the most debated questions in archaeological research — against the background of the introduction of farming and animal husbandry. Even though recent DNA research indicates the migration of people from the south (presumably practising farming) to e.g. Denmark (Allentoft *et al.* 2024), the picture is not that clear in other areas (Booth, this volume). How ideas or 'new' lifestyles spread, and to which extent the movement of people

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was involved — in contrast to the movement of things and ideas — is therefore still an urgent question.

This article deals with a region at the periphery of the continental Neolithic world — the Inner Oslo Fjord area in south-east (SE) Norway (for definition see below). Here, extensive evidence of farming, animal husbandry and farmsteads is first seen from around 2300 BC — in the so-called 'Late Neolithic' in Norwegian terms (Sand-Eriksen and Mjærum 2023; Solheim 2021). This is more than a thousand years later than in southern Scandinavia, from where this new economy is believed to have been introduced. The question is to what extent and in which ways the people that lived in the Oslo Fjord region were connected to people in southern Scandinavia in the centuries before full scale farming was introduced.

Among many aspects to be studied in this respect, I will here focus on the thin-butted flint axes from the study area — portable objects, which do not originally come from SE Norway. Discussing them in their broader material, spatial and chronological context shows that impulses from the south did not come into the region concurrently as a 'package' but were introduced gradually. This indicates different phases and types of contact. Special focus will be given to the few long thin-butted axes (the term 'axe' denotes 'axehead'), which are longer than 260mm and by some termed 'ceremonial axes'. I will argue that the phenomenon of the deposition of such finely worked long axes in high quality material, which show no signs of use, in the study area, as marking of land or a point and most likely with a ritual character, can give useful insights into social encounters between people from abroad and local people and attests to a time of interregional negotiations in the region in the time between *c.* 3500 and 3300 BC — most likely a time characterised by some uncertainty.

Background and approach

The character of social and economic settings and their developments throughout the Neolithic period and before the introduction of full-scale farming in SE Norway is still a major research question. The application of the southern Scandinavian chronology to frame the 'Neolithic' in the region, spanning from 3900 to 1700 BC, still hampers our understanding of these processes (Prescott 1996), as the material record in SE Norway has its idiosyncrasies, with specific chronological and regional developments. Here, I will focus on the Early Neolithic period (EN) and the early Middle Neolithic A, consisting of EN I (3900–3500 BC) and EN II–MNA II (3500–3000 BC) — a chronological division based on the southern Scandinavian chronology (definition e.g. in Schülke 2009). It corresponds to Einar Østmo's (2007) 'Early' and 'Middle' TRB (TRB = *Trichterbecherkultur* = Funnel Beaker culture) for the Oslo Fjord area, chronological terms which I would like to avoid as they suggest ties with a certain cultural expression, a situation which can be confusing. In cases where a closer chronological delimitation is possible, I will use the designation EN II (3500–3300 BC), which corresponds to the Early Neolithic phase C in Poul Otto Nielsen's (1978) scheme.

The study area is the Inner Oslo Fjord, SE Norway, here defined by the administrative borders of 19 municipalities grouped around the fjord; these are subject to an ongoing study conducted by the author. In this area, archaeological surveys have in recent years revealed a number of coastal sites, attested through lithic finds, which are shoreline-dated to the Neolithic (Amundsen 2012); some of these have EN dates (S.V. Nielsen 2021a). Being placed at locations which are exposed towards the Oslo Fjord, they show a clear relatedness to the sea and are interpreted as specialised hunting and fishing sites (Amundsen 2012; for shoreline dating see Berg-Hansen *et al.* 2023). They differ in size and placement from the more sheltered shore-based Late Mesolithic base camps in the region (Amundsen 2012). Lithic materials indicate a break in major traditions in the Latest Mesolithic, after *c.* 4500 cal BC, which suggest a shift of population in the region (Eigeland 2015, 382–4). Another significant difference to the Later Mesolithic is that coastal hinterland areas became important for people between the EN I and MNA, as shown by finds of stone and flint axes in the coastal hinterland (Amundsen 2012). In addition, stray finds indicate EN settlement on agrarian soils (Amundsen *et al.* 2006). Recently, in connection with excavations at Iron Age farmsteads, several fragmented settlement structures with EN radiocarbon dates have been identified on arable land away from the coast; they are interpreted as so-called 'farming sites', where farming is supposedly practised between 3850 cal BC until around 3300 cal BC (S.V. Nielsen 2021a). Against a background of continuity of some Latest Mesolithic traits into the EN, such as some aspects of lithic technology and coastal settlement, it is argued that local hunter-fishers themselves adopted farming (S.V. Nielsen 2021a). However, while pollen profiles and directly dated features indicate potential 'gardening' or very small-scale arable farming already in the fourth millennium BC, there is no evidence of full-scale farming in the region before the last centuries of the third millennium BC (Reitan *et al.* 2018; Sand-Eriksen and Mjærum 2023; Solheim 2021; Wiekowska-Lüth *et al.* 2017). Poor preservation conditions for organic material, including bones or macrofossils, further hampers potential insights into economic aspects such as animal husbandry (Solheim 2021), as well as isotope or ancient DNA studies. Topics such as mobility, exchange and migration must therefore still mainly be studied in traditional archaeological terms: based on material, typological and technological comparison.

For a long time, artefacts or structures whose style, material and/or mode of production corresponds to material culture traits known from the core area of the TRB material distribution — mainly modern-day Denmark

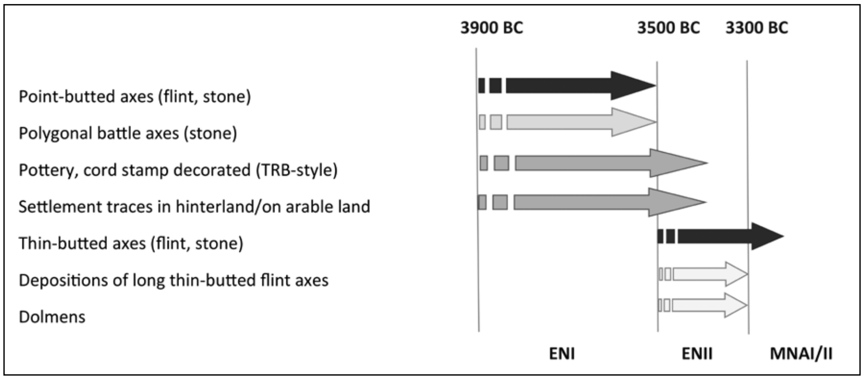

Figure 1. Schematic diagram of the temporal development of material traits related to the southern Scandinavian TRB complex and early farming in south-east Norway. The different shades of grey roughly indicate the relative intensity of the material signatures in relation to each other, between few finds (lightest) and a higher number of finds (darkest).

and Scania — have been discussed as traces of contact with the south. In SE Norway such finds are concentrated in the Oslo Fjord region and include TRB-style pottery decorated with cord stamps (Reitan *et al.* 2018; Østmo and Skogstrand 2006), polished flint axes (point-butted, thin-butted), polygonal battle axes in stone (Mikkelsen 1984) and the few megalithic tombs — two documented and two reported but unverifiable dolmens at Holtnes (Rødtangen, Hurum), and one polygonal dolmen in Skjeltorp (Østfold) (Østmo 2007). Stone axes made on local rock with similar forms as the point-butted and thin-butted flint axes occur; they are interpreted as locally produced, but copying the shape of imported flint axes (Glørstad 2005; Mjærum 2004).

These artefacts and structures have been interpreted in different ways. Some authors argue that indigenous hunter-fisher-gatherer groups were living in the region, with the 'foreign' (TRB) material reflecting well-developed exchange networks with southern Scandinavia (Glørstad 2009; Solheim 2012). Areas around river mouths with accumulations of flint axes were suggested as meeting places for such exchange (Solberg 2012). Others interpret the material as indicating migration of at least some south Scandinavian people (Reitan 2012; Østmo 2007) to the area, the Oslo Fjord region being characterised as 'the periphery of the Funnel Beaker culture' (Østmo 2007). The context and potential social circumstances of such migrations are, however, still little discussed. Lasse Sørensen, exploring the spread of farming in a broader northern European perspective, argues that farming could not have just been taken up by hunter-fisher-gatherers, but needed people with the right know-how to be present (L. Sørensen 2014a, 259). He suggests several episodes of pioneering expeditions to the area during the Early Neolithic, during which prestigious objects were exchanged with the locals, amongst them 'ceremonial axes' (L. Sørensen 2014b, 67–9).

Looking more closely at the chronology of the named material phenomena (Figure 1) shows that the impulses from the south by no means are a contemporaneous 'package', but rather a process which indicates long-standing and intertwined social connections, stretching across generations, and which are not so easy to grasp with a simple model. An understanding of these 'foreign' artefacts as more than just representing a general 'cultural influence' requires us to look more closely at their specific character, context and temporality — and to discuss these aspects against the background of their appearance in other areas.

Figure 1 shows different types of material which attest to contacts to the south. They stretch across a large time span — at least six centuries, or around 24 to 30 generations — and represent diverse kinds of contact through time, which could include exchange of knowledge, objects and ideas, or even small-scale migration. Some (lithic technology, transverse arrowheads) might have been a continuation of material used in the Latest Mesolithic after 4500 cal BC, which has affinities to southern Scandinavia (e.g. Eigeland 2015; S.V. Nielsen 2021b; Solheim 2012). From 3900 cal BC onwards and until about *c.* 3500/3400 cal BC, cord-stamp decorated pottery in TRB-style, the first pottery in the region, occurs on some sites, mainly near the coast (S.V. Nielsen 2021a; Reitan *et al.* 2018; Østmo and Skogstrand 2006). During almost the same time span, settlement structures in the coastal hinterland and inland are attested at several locations (S.V. Nielsen 2021a). Point-butted flint and stone axes occur in the EN I, while polygonal battle axes are found only as fragments. Thin-butted flint axes first appear in large numbers in the centuries 3500 BC to 3300 BC, in the EN II, close to or at the end of the occurrence of sites on arable land and of sites with TRB-style pottery. This is also when the few megalithic tombs (dolmens) are built and some offerings in the form of flint axe deposits occur (Østmo 2007). From a southern Scandinavian perspective, where especially the time 3500–3000 BC (EN II–MNA II) is a phase of intensified ritualisation with thousands of monumental buildings (megalithic tombs/dolmens) being erected and offerings of different kinds being made, often at the same places (e.g. Andersen 2000; Jensen 2000), ritual expressions in SE Norway are rather few at this time — but this is rarely discussed. The large and numerous wetland offering places in Denmark and Scania, where pottery, axes and other items were deposited over centuries (Berggren 2010; Karsten 1994; Koch 1998; Müller 2020; Schülke 2019), do not seem to occur in SE Norway (Østmo 2007). This is one of the aspects which makes the situation in the region so different from the TRB core area. Instead, the middle of the second half of the fourth millennium in southern Norway sees a decrease in material expressions, characterised as 'de-Neolithisation' (Hinsch 1955) and recently reinforced by a statistical study, which has interpreted this as population decline (S.V. Nielsen *et al.* 2019).

On this basis, I will argue in the following that the relatively reduced impact of ritual expressions between 3500 and 3300 BC might give insights into social encounters in SE Norway in the EN II to MNA II. I will develop this thought using the thin-butted flint axes from the Inner Oslo Fjord region, especially discussing the long thin-butted flint axes.

The thin-butted flint axes in the Inner Oslo Fjord area

For this study the thin-butted flint axes from the Inner Oslo Fjord region in SE Norway (Figure 2; Appendix), were compiled from the Directorate for Cultural Heritage's database *Askeladden*, from the museum database *Gjenstandsbasen* and from the literature. It was beyond the scope of this article to study the material directly.

The finds from the study area can be summarised as follows (C-numbers below refer to the Appendix):

Fifty thin-butted flint axes are known, 45 can be typologically dated to the EN II–MNA II (by applying P.O. Nielsen's 1978 types), while five (C14178; C21254; C23413; C20204a; C20204b) are of later types (MN/MNA).

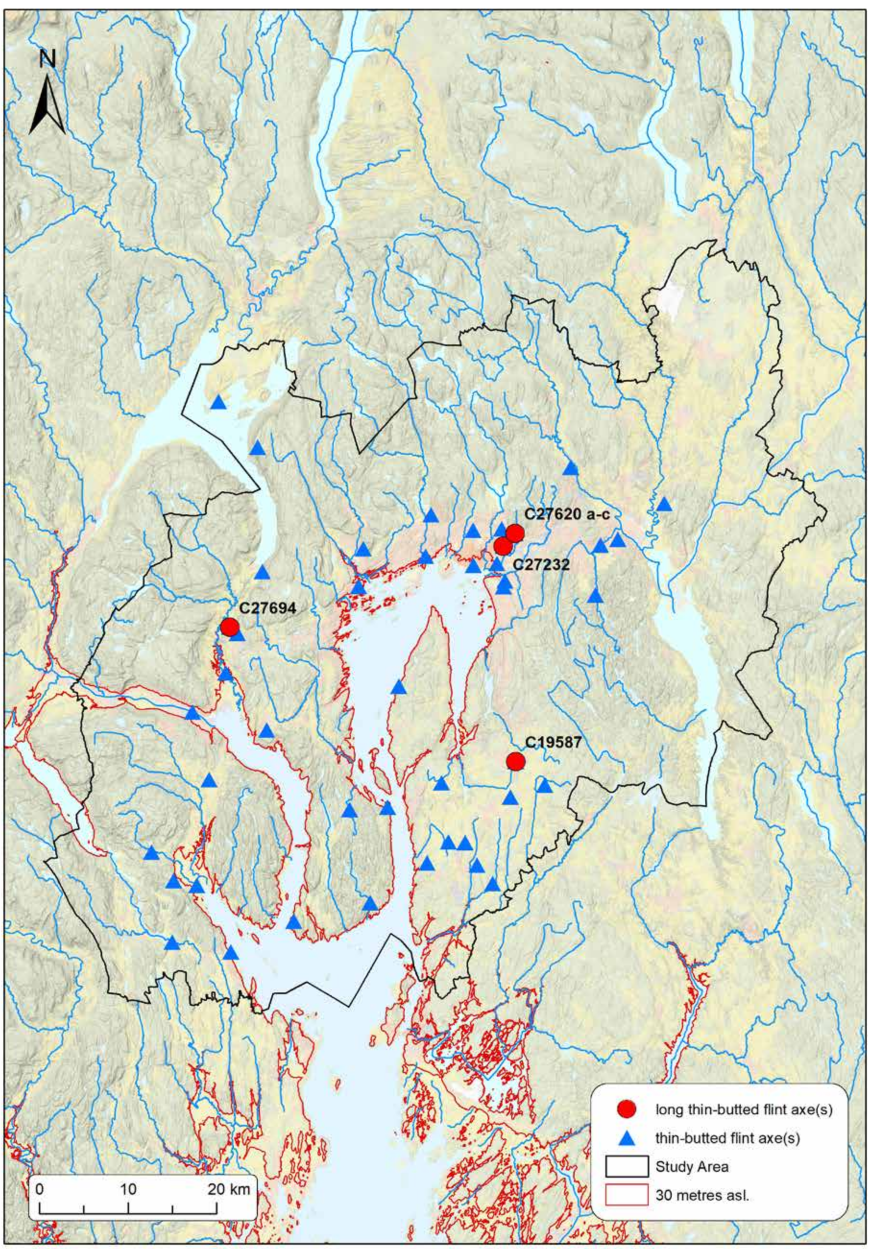

Figure 2. Map of the find spots of thin-butted flint axes in the study area, delimited by the administrative borders of 19 municipalities in the Inner Oslo Fjord. The Neolithic sea level, which was at around 30 metres asl, is marked (map: Steinar Kristensen, Museum of Cultural History, University of Oslo; background maps: Norwegian Mapping Authority/GeoNorge).

Most axes are single finds made a long time ago. In almost all cases, the find spot is not properly mapped, but mostly the name of the farmstead on whose grounds the axe was found is recorded. This allows to roughly map the finds and reconstruct the approximate elevation above sea level of the find spot.

In the EN II–MNA II the sea level in the area was around 30 metres higher than today (R. Sørensen 1979). Figures 2 and 3 show that most finds (almost 50 %) are made at elevations between 100 and 200 metres above today's sea level, situated away from the coast on terrain that was also rather elevated in the Neolithic, and often related to arable land. Two axes are even discovered above 200 metres asl. Six axes (C18572; C18976; C21254; C20656; C27354; C17385) were found at elevations below the Neolithic shoreline, which might indicate that they were deposited or lost in the sea.

Information on the find context is often scarce, but there are some exceptions. Five axes were found on arable land/in a field/while ploughing or harvesting (C24871; C15227; C27354; C24012; C28944); four in the ground/while digging, often quite deep (C27694; C26564; C2051; C27232); two close to a bog/in a wetland (C57156; C27620a–c); and one in a narrow rock crevice (C19587). In only two cases was the find mapped to within a few metres' accuracy (C27232; C27620a–c). Two axes, both of later MNA types, were found deep in the earth, each within a heap of stones, and could be interpreted as grave finds (C20204a; C20204b), while C20656, a delicate little axe, was reportedly found under the floor paving of a now destroyed stone cist, probably a dolmen at Holtnes (Østmo 2007). These three potential grave contexts all lack closer documentation (Østmo 2007).

The lengths of the flint axes range from 70 to 397 mm (Figure 4). Most of them (24 items) are today between 100 and 150 mm long, two under 100 mm. Six are longer than 260 mm and therefore of specific relevance here (see below). Some of the axes are broken either at the butt end or the edge and were originally significantly longer; they are marked with f in the Appendix and in Figure 4. For some others, re-shaping is attested, so these were also originally longer.

The axes were made from high-quality flint, which was not available in Norway in the Neolithic. Alongside the technological and typological similarities with axes from the TRB core area and the lack of flint axe production sites, this indicates that finished axes were brought to the region from abroad — as 'foreign' objects. The question is which role the flint axes played, what they were used for and which meaning they had — apart from most likely being precious objects due to their raw material. They have been interpreted as exchange items, either as mythical and important objects in a system of gift exchange with southern Scandinavia or as commodities (Glørstad 2005; Mjærum 2004; Solberg 2012), but they could equally well

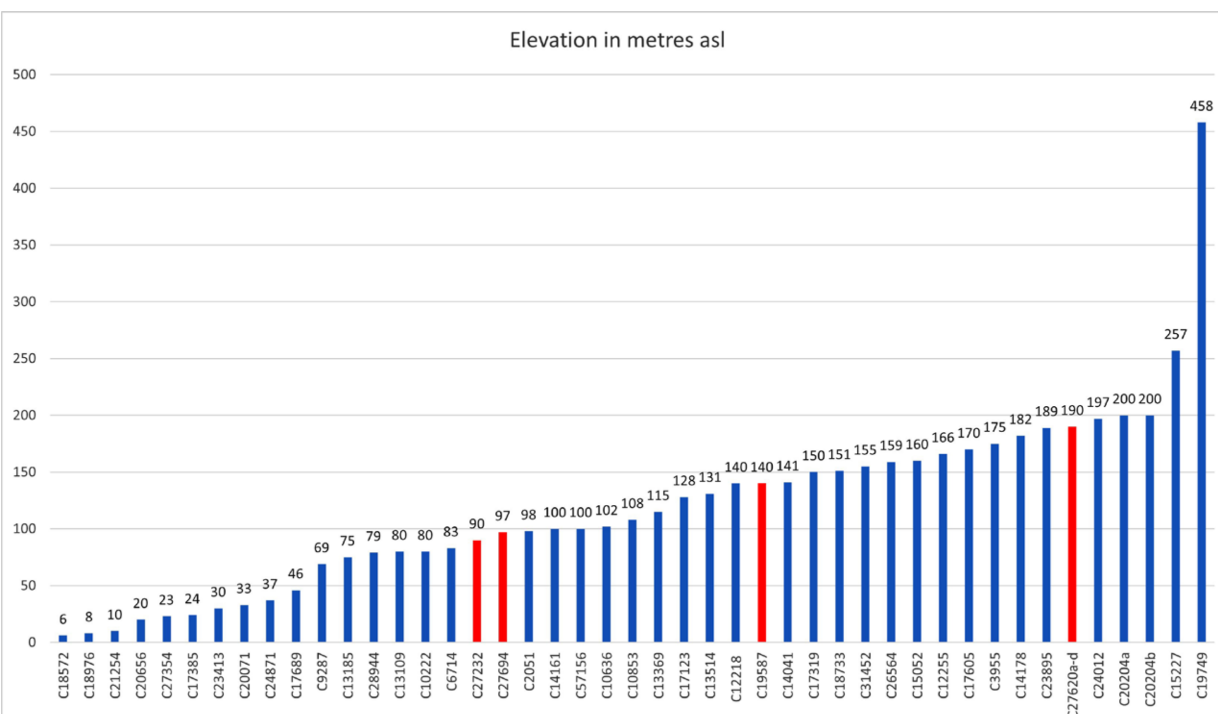

Figure 3. The current elevation (in metres asl; today's heights) of the find spots of thin-butted flint axes in the study area. Each find is marked with its museum number (C…). The long thin-butted flint axes are shown in red.

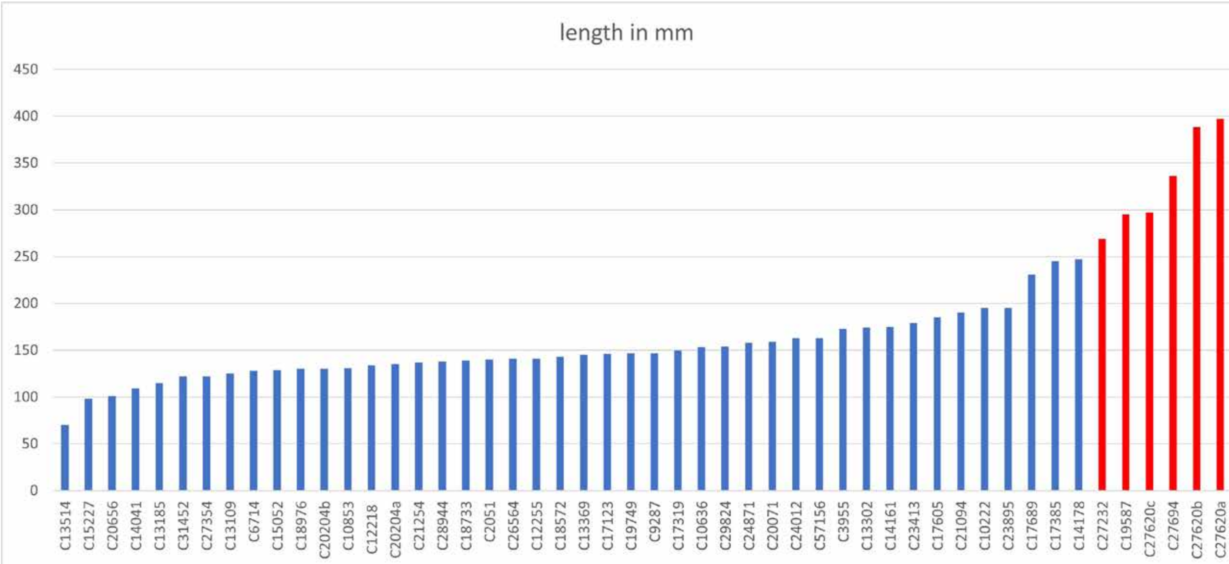

Figure 4. Lengths of the thin-butted flint axes in the study area, pictured per item, each marked with museum number (C…). The long thin-butted flint axes are shown in red.

have been introduced as working tools. Starting to use thin-butted stone and flint axes can indicate that these strong tools were needed, for example to clear the forest, for woodworking or in preparing the land for gardening and farming, as they are better suited to these tasks than earlier tools — in contrast to southern Scandinavia (L. Sørensen 2012, 133–42) no lithic axes are known from the last phase of the Mesolithic in the study region. Maybe the stone axes on local raw material were produced as copies of flint axes from the early part of the EN onwards, when the first stone axes occur (Reitan *et al.* 2018). Alternatively, they could have been made due to a lack of flint or flint axes, or they were useful additional tools beyond flint axes. Who produced them, people from abroad or locals, is still the question. All in all, the fact that the southern forms are reproduced in stone already shows a certain level of contacts from the EN onwards.

Long thin-butted flint axes from the study area

The six thin-butted flint axes from the study area which are longer than 260 mm (Figure 5) will be discussed more closely here. These axes stand out due to their length and meticulous craftmanship, as well as the absence of use-wear traces (Figure 5). All are of type IIIb according to P.O. Nielsen (1978) and date to the EN II (L. Sørensen 2012, fig. 5; 2014a, 175). The axes from Skoro (C19587), Sinsen (C27232) and Rød Østre (C27694) are single finds, while the three thin-butted axes and the flint nodule from Disen (C27620a–d) were found together at one spot and are known as the Disen hoard.

Their length varies between 269 and 397 mm (Figure 4), with C27620c being broken at the butt and therefore originally longer than 297 mm. Five of the six axes are polished on all sides, while C27232 is meticulously knapped on all sides. C19587 has remaining cortex at the butt. They all have small areas of damage or (intended?) chipped sections but otherwise do not seem to have been used as working tools. Only proper use-wear analysis of the axes could identify further traces of use — a topic for future research. The weight of the axes is only indicated in one case, for the find from Rød Østre, which weighs 1772 g (C27694). The Disen hoard also contained a flint nodule (C27620d) with a maximum diameter of 303 mm and a thickness between 6 and 8 cm.

Depositional context is recorded with differing level of accuracy. The Skoro axe (C19587) was found in a narrow rock crevice between a steep rocky slope and a large boulder. The exact context of the Sinsen axe (C27232) is unclear, but it was reportedly found near a house wall while harvesting; its patina (red 'bog patina') could suggest that this was a secondary location and that the find was originally placed in water or into a wetland (Figure 5). The find from Rød Østre (C27694) was made in connection with groundworks. The four items at Disen (C27620a–d) were found in 1946 close to or in a little wetland on a mountainside at 190 metres asl and with good views into the Inner Oslo Fjord and the adjacent valley. Some traces of fire were observed at the place where the items were found: 'The items lay at the same spot about ¾ of a metre under today's surface [… Below this] secondary layer of earth was a *c.* 25 cm thick layer of dark bog-like earth and the items were found at the transition between this and

Figure 5. Compilation of all long thin-butted flint axes in the study area, including the flint nodule from the Disen hoard (figure: Almut Schülke; photos: Kirsten Helgeland (axes a, b, d) and Ulla Schild (axe c), all Museum of Cultural History, University of Oslo).

the sand layer below. Clear traces of burning with a diameter of 1.5 m were found' (from Gjenstandsbase, translation by the author). In sum, apart from C27694 the find spots are either related to water or to a marked rock formation, which are usual topographic features for deposits or hoards in the EN I–MNA II in the TRB area.

Discussion and conclusion

The long thin-butted flint axes from the study area display high craftsmanship and were made from excellent raw material not naturally available in Norway. They are very similar to axes found in the TRB area in southern Scandinavia and the North European Plain.[1] Long thin-butted flint axes — defined as being more than 260 mm long — are interpreted as prestige objects or even 'ceremonial axes', because they often occur in hoards and/or have no functional value (discussion in Olausson 1983; L. Sørensen 2014a, 176; Wentink 2008). Even though experiments have shown that long thin-butted axes can be used for wood working, depending on criteria such as weight, hafting or the material to be worked (Olausson 1983), they seem to have had a symbolic or ritual function, as indicated by their find context, treatment, form and traces of use (or lack thereof). Karsten Wentink (2008) conducted a functional analysis of TRB axes from waterlogged deposits from the Drenthe plateau in the Netherlands, in the western area of the TRB, where hoards with thin-butted axes and flint nodules are reported (Wentink 2008, fig. 7). He identified typical traits for what he called 'ceremonial axes', concluding amongst others that the axes are meticulously worked with high levels of craftsmanship, that they include both polished and unpolished items, that they often exhibit remains of cortex to indicate that the whole nodule was used when producing the axe, which was a sign of high craftmanship, and that flint axes longer than 218 mm did not have any traces of hafting or use — instead, some of them showed traces of wrapping and unwrapping. For Denmark it is observed that such prestigious axes, which here already appear at 3800–3500 cal BC, were produced from high-quality dark flint that might come from flint mines (C. Sørensen *et al.* 2022; L. Sørensen 2012; 2014a, 175–6).

Against this background it is obvious that the long thin-butted axes discussed here resemble other finds from the core regions of the TRB complex and neighbouring areas. How can the depositions of these special axes be contextualised — at a time when diverse forms of contact with southern Scandinavia were already long established? In the following, I would like to argue that the objects were produced abroad by expert crafters, who had first-hand experience with flint axe technology, that they were brought into the region from the TRB core area and that they were deposited by people from abroad with knowledge on how to handle the objects in the right way.

The large number of thin-butted flint axes from the core areas of the TRB makes an overview of this find category almost impossible. In Denmark, P.O. Nielsen (1978) counted 47 deposits of type IIIb axes alone. In recent years, the practice of axe hoarding has been studied in detail for the southern Limfjord area, where some well-documented hoards of long thin-butted flint axes have been excavated, providing contextual information which otherwise is very rare for this find category. The items are mainly of P.O. Nielsen's (1978) type IV, dating to EN I–EN II, and were found in wetlands (C. Sørensen *et al.* 2020; 2022). Of these, the two thin-butted polished flint axes found in 2016 at Kardyb, originally *c.* 500 mm long, and the six thin-butted polished axes from Rydhave, of which the longest was 440 mm long, resemble the axes from Disen, Skoro and Rød Østre, although the Danish examples are of a slightly earlier type (P.O. Nielsen's type IV, which already appeared in the later EN I). The two axes from Vestergård Øst, dated to the EN II, resemble the axe from Sinsen (C27232). Similar hoards occur outside the core area of the TRB, such as for instance on Gotland or in the Netherlands (Müller 2020, fig. 1; Wentink 2008).

Finds of portable objects of TRB character in areas outside the TRB core area have mainly been interpreted as indicating exchange. Axes are often seen as prestige objects in a world where competition and power are most important among rivalling groups or as needed to build bonds, for instance on scouting expeditions — especially since point-butted flint axes imitate copper axes, which were already circulating in continental Europe at this time (C. Sørensen *et al.* 2022). Anette Solberg (2012) interprets flint axes found in Østfold, SE Norway, and Bohuslän, south-west Sweden, as exchange of prestige objects between indigenous hunter-fisher-gatherer communities and people from southern Scandinavia in connection with marriage alliances — an exchange which would lead to a change of meaning of the artefact. Wentink (2008), in contrast, argues that the 'ceremonial' axes represent ancient craftsmanship and therefore had sacred power. He stresses the importance of the right handling of these objects (e.g. through wrapping and the right form of deposition), which indicates knowledge of the original cosmological meaning of these items by the locals who receive and deposit them. Beyond the more traditional interpretations of hoarding, such as hoards representing offerings or the storing of valuables, Casper Sørensen and colleagues (2020) suggest that hoarding episodes involving the concurrent deposition of several objects could be understood as communal events — and as such were materialised witnesses of events or social contracts between different groups.

Combining some of these approaches can be useful for a better understanding of the role and meaning of the few long thin-butted flint axes in SE Norway. After centuries with influences from southern Scandinavia in the Oslo

1 It should be mentioned that other long thin-butted axes (C8463; C9019; C16140; C21401; C34164; C34779; C36517) are found in south-east Norway outside the study area (Østmo 2007).

Fjord region, starting presumably already in the Latest Mesolithic, these become more obvious in the EN I, with pottery, portable objects such as polygonal battle axes, point-butted axes and a more intense interest in and use of the hinterland. From the EN II onwards, a few specific ritual footprints can be observed in the material, such as the building of dolmens in two places (of which only the dolmens at Holtnes are in the study area; Østmo 2007), and the depositions of long thin-butted flint axes discussed here. These ritual expressions are indeed few compared to the overwhelming ritualisation in southern Scandinavia at this time, involving depositions, offerings and megalithic monuments used as graves, shrines and places of memory, and culminating in the building of large, collective tombs (passage graves) from 3300 BC onwards (e.g. Andersen 2000; Jensen 2000; Müller 2020; Schülke 2019). Thus, the way of life and the social, economic and cosmological situation was most likely very different between SE Norway and the TRB core area, which also reflects a certain regionalisation in all of southern Scandinavia at this time. The question then is: why was the deposition of these special items performed in the Oslo Fjord region — and in which context?

While most find contexts of long thin-butted axes are unclear, the Disen hoard might help to understand the situation better: the traces of fire, if contemporaneous to the placement of the three axes and one flint nodule, could indicate that rituals connected to the deposition of these items were not totally hidden, as the fire would have been visible in the form of light or smoke. In any case, the removal from circulation of the three carefully crafted special axes would have been the temporary end of a long journey for these items, which began with raw material procurement and expert crafting before they were transported with great care, and most likely knowledge of the right ritual treatment, over large distances into the Oslo Fjord area. The items are heavy (approximately 7–8 kg altogether), and perhaps parts of the voyage were made by boat. But to get to Disen, one would have to carry the items to the place of deposition, located away from navigable waterways. The Disen context might represent the sealing of a social contract — maybe between those who brought in these items and the people that lived in the area, or of people having interests in the area, between people and the surroundings, or maybe even between people and 'spirits'. The low number of such depositions in SE Norway, compared to Jutland for example (Müller 2020; P.O. Nielsen 1978), attests to single, but most likely important events, which took place in a period of social and political change and negotiation.

During the EN I up to around 3500 BC, there was an intensification of contacts with southern Scandinavia in some areas, such as in the Inner Oslo Fjord, in Østfold/Bohuslän (Solberg 2012) and along the south Norwegian coast (Glørstad and Solheim 2015). The phenomenon of the so-called Pitted Ware culture developed around 3400 cal BC along the south-eastern shores of the Scandinavian peninsula, including Jutland and the Skagerrak coasts of Sweden and Norway (Iversen *et al.* 2021). In the MNA, from around 3300 BC onwards, finds-rich settlements were established along the rocky shores of the Skagerrak coast to the south of the Inner Oslo Fjord (Nielsen *et al.* 2023; Østmo 2008), with an economic focus on fishing and hunting, including of sea-mammals. At around the same time, from the middle of the fourth millennium BC onwards and some time between 3500 and 3300 BC, 'foreign' ritual expressions appear in the Inner Oslo Fjord region, such as depositions of highly crafted long flint axes and the erection of a few megalithic tombs at Holtnes — low in number, but materially expressive.

The deposition of long thin-butted flint axes can be seen as material testimonial of social events, where ritual experts from abroad deposited these items in the Oslo Fjord region following TRB rituals. The backgrounds and social or even political contexts for these missions are unknown, and a remaining question is for what purpose the rituals were performed and for whom — by people from abroad for themselves, or directed at and visible for (specific?) locals, or maybe even together with the inhabitants of the region. In any case, depositions of these special axes indicate social encounters at a time which may have been characterised by uncertainty, and probably required the negotiation of differing lifestyles in the region in either friendly or unfriendly settings. This surely needs further research. The case of the recently analysed individual from Vittrup in northern Jutland, the so-called 'Vittrup man', whose interdisciplinary analysis concluded that he grew up far to the north of modern-day Denmark (in Norway?) and (was?) moved to Jutland as a juvenile person (Fischer *et al.* 2024), shows that there were mutual visits and perhaps migrations between these regions at the time. The visits, missions or meetings, which the depositions of long thin-butted flint axes might be witnesses to, most likely had important social and even political significance.

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Appendix.

List of locations with thin-butted flint axes from the study area. The table is sorted alphabetically by municipality and by inventory number. Translation of the find circumstances from Norwegian to English by the author.

Inventory number (*Museumsnummer*)	Registered under: municipality, farmstead	ID-Number according to the database of the Directorate of Cultural Heritage (*Askeladden*)	Type	Phase*	Length (max.) in mm** f indicates that the axe was originally longer	Breadth (max.) in mm**	Thickness (max.) in mm**	Found in/deposited in according to Askeladden and/or Museum database (*Gjenstandsbasen*)	Level of mapping: y= find spot known; fs = farmstead known; no = not mappable	Height in metres asl	Reference
Asker municipality											
C12218	Røyken, England	–	Thin-butted	EN, EN II–MNA II	134	68	28	Unclear if found together with C12219 and C12220 (two thick-butted axes), also registered under C12207	fs	140	Hinsch 1955, 25; Østmo 2007, 218–9
C13109	Roed Vestre (338)	–	Thin-butted	EN II–MNA II	125	25	27	Not reported	fs	80	
C13514	Sætre Bruk (301)	–	Thin-butted	EN II–MNA II	70	29	10	Not reported	fs	131	
C20656	Hurum, Holtnes	–	Thin-butted	EN II–MNA II	101	–	–	According to oral tradition found in a stone cist built of four raised slabs. The cist was c. 1.5 m long and 1 m wide. The axe was found 1.5–2 feet deep, under some smaller stone slabs which the finder described as floor tiles of the cist.	Y	20	Østmo 2007, 128–9
C24871	Hurum, Slottet	42517-1	Thin-butted	EN II–MNA II	158	68	–	Field	Y	37	
C31452	Hekleberg (281)	–	Thin-butted	EN II–MNA II	122	65	–	Not reported	fs	155	
Enebakk municipality											
C15052	Enebakk	–	Thin-butted	EN II–MNA II	129f	69	28	Not reported	no	160	
Haslum municipality											
C6714	Huseby Østre/ Huseby Vestre (32,31)	–	Thin-butted	EN II–MNA II	128	65	24	Not reported	fs	83	
Hole municipality											
C10222	Bønsnes (212)	–	Thin-butted	EN II–MNA II	195	77	30	Not reported	fs	80	
C19749	Frøyhov (203)	–	Thin-butted	EN II–MNA II	147f	65	30	Not reported	fs	458	
Holmestrand municipality											
C17319	Teigen Østre (315)	–	Thin-butted	EN II–MNA II	150f	83	45	Not reported	fs	*c.* 150	
C17689	Hillestad Søndre/ Lille/ Høie/ Nordre	–	Thin-butted	EN II–MNA II	231	68	32	Not reported	fs	*c.* 46	
C18572	Aasnes (307)	–	Thin-butted	EN II–MNA II	143	59	37	Not reported	fs	*c.* 6	
C18976	Rævo Nordre/ Søndre/Mellom (320, 318, 319)	–	Thin-butted	EN II–MNA II	130f	70	29	Not reported	fs	*c.* 8	

Inventory number (*Museumsnummer*)	Registered under: municipality, farmstead	ID-Number according to the database of the Directorate of Cultural Heritage (*Askeladden*)	Type	Phase*	Length (max.) in mm** f indicates that the axe was originally longer	Breadth (max.) in mm**	Thickness (max.) in mm**	Found in/deposited in according to Askeladden and/or Museum database (*Gjenstandsbasen*)	Level of mapping: y= find spot known; fs = farmstead known; no = not mappable	Height in metres asl	Reference
C20071	Aasen med Sjøskogen (76)	–	Thin-butted	EN II–MNA II	159	71	34	Not reported	fs	*c.* 33	
Lier municipality											
C15227	Hennum (141, 146, 145, 144, 142)	–	Thin-butted	EN II–MNA II	98f	48	18	Ploughing	fs	*c.* 257	
C18733	Enger Vestre/ Østre/ Mittre	–	Thin-butted	EN II–MNA II	139	84	37	Not reported	fs	*c.* 151	
C27354	Ila (94)	–	Thin-butted	EN II–MNA II	122	54	–	Ploughing	fs	23	
C27694	Rød Østre (133/6-8)	–	Thin-butted	EN II–MNA II, type IIIb	336	86	40	In connection with groundworks	fs	*c.* 97	
Lillestrøm municipality											
C24012	Asak Mellem (7/1)	–	Thin-butted?	EN II–MNA II	163	64	32	In a freshly ploughed field, right beside the larger of two burial mounds	y	197	
Drammen municipality											
C14161	Oddevall under Unnelsrød	–	Thin-butted	EN II–MNA II	175f	67	32	Not reported	fs	*c.* 100	
C17385	Grønland/ Øvre Sund (110)	–	Thin-butted	EN II–MNA II	245f	67	32	Not reported	fs	*c.* 24	
Lørenskog municipality											
C14178	Losby	–	Thin-butted	MN A	247	83	55	Not reported	fs	*c.* 182	
C26564	Haneborg (107)	–	Thin-butted	EN II–MNA II	141f	73	–	Found 30 cm deep in the ground	y	159	
Nesodden municipality											
C57156	Kvistemyr av Granerud (28/10)	–	Thin-butted	EN II–MNA II	163	74	33	Found close to a small bog	fs	*c.* 100	
Nittedal municipality											
C14041	Hauger (9)	–	Thin-butted	EN II–MNA II	109	52	28	Not reported	fs	*c.* 141	
Nordre Follo municipality											
C13369	Gryteland Store/ Gryteland Lille (9, 8)	–	Thin-butted	EN II–MNA II	145f	63	37	Not reported	fs	*c.* 115	
C17123	Østby (63)	–	Thin-butted	EN II–MNA II	146f	65	25	Not reported	fs	*c.* 128	
C19587	Nordre Follo, Skoro (135)	–	Thin-butted	EN II–MNA II, type IIIb	295	78	35	According to oral tradition found in a narrow rock crevice between a rocky steep slope and a large boulder	fs	*c.* 140	
Oslo municipality											
C2051	Sogn Vestre/Sogn Østre (49, 50)	–	Thin-butted	EN II–MNA II	140f	63	28	Found in the ground on the farm	fs	*c.* 98	
C3955	Oslo, Voksen	140132-1	Thin-butted	EN II–MNA II	173	72	29	Not reported	fs	175	
C12255	Grefsen Vestre/ Grefsen Østre	–	Thin-butted	EN II–MNA II	141	48	26	Not reported	fs	*c.* 166	

Inventory number (*Museumsnummer*)	Registered under: municipality, farmstead	ID-Number according to the database of the Directorate of Cultural Heritage (*Askeladden*)	Type	Phase*	Length (max.) in mm** f indicates that the axe was originally longer	Breadth (max.) in mm**	Thickness (max.) in mm**	Found in/deposited in according to Askeladden and/or Museum database (*Gjenstandsbasen*)	Level of mapping; y= find spot known; fs = farmstead known; no = not mappable	Height in metres asl	Reference
C21094	Oslo	140690-6	Thin-butted	EN II–MNA II	190	68	37	Not reported	no	–	
C21254	Oslo, Grønland	32540-1	Thin-butted/ thick-butted	MNA	137f	63	32	Found when cleaning out a well in Bækkegaten 20	Y	10	
C23413	Oslo	140670-1	Thin-butted	MN	179	68	39	Not reported	Y	30	
C23895	Oslo, Åsli, Sandstuveien	129079-1	Thin-butted	EN II–MNA II	195f	80	34	Found in 1925 behind the mountain 'Brannfjellet' quite high up, in clay c.1 m under the surface	Y	189	Østmo 2007, 121
C27232	Oslo, Sinsen	129116-1	Thin-butted, type IIIb	EN II–MNA II	269	90	40	Found by the wall of the house in Knut Alfsøns vei 15 (gnr. 83, brnr. 147), Sinsen, Ø. Aker pgd., Akershus, during harvest	Y	90	
C27620a	Oslo, Disen	32532-1	Thin-butted, type IIIb	EN II–MNA II	397	85	–	Found in 1946 while digging a path to a house in Østerheimsveien 5, Østre Disen. The axes were found together, the flint nodule was found some days later during excavation by Dr Bjørn Hougen. The items were found at the same spot about 0.75 m under the modern surface. However, about 0.5 m of this layer was raised when building the Østerheimveien lane a few years previously. Under this secondary layer of earth, a layer c. 0.25 m deep with dark bog-like earth was identified, and the items were found between this and the underlaying layer of sand. There were also clear traces of fire in a spot of c. 1.5 m diameter. The house is built in the area of a former small bog, and the old name of the location is 'Myraskauen' (roughly translatable as 'bog-forest')	Y	190	Østmo 2007, 118
C27620b	Oslo, Disen	32532-1	Thin-butted, type IIIb	EN II–MNA II	388	80	37		Y	190	Østmo 2007, 118
C27620c	Oslo, Disen	32532-1	Thin-butted, type IIIb	EN II–MNA II	297f	72	27		Y	190	Østmo 2007, 118
C27620d	Oslo, Disen	32532-1	Flint nodule		303	190	80		Y	190	Østmo 2007, 118
Rælingen municipality											
C17605	Strøm Store (106)	–	Thin-butted	EN II–MNA II	185	73	29	Not reported	fs	*c.* 170	
Ullensaker municipality											
C20204a	Ullensaker, Aas (81)	–	Thin-butted	MNA	135	70	20	Deep in the ground in a heap of stones — grave?	fs	*c.* 200	Østmo 2007, 121; similar to Petersen 1999, fig. 181
C20204b	Ullensaker, Aas (81)	–	Thin-bladed	MN	130	40	–	Deep in the ground in a heap of stones — grave?	fs	200	Østmo 2007, 121; Petersen 1999, fig. 182
Vestby municipality											
C9287	Kjærstad Østre/ Kjærstad Vestre (88, 89)	–	Thin-butted	EN II–MNA II	147	61	29	Not reported	fs	*c.* 69	
C10636	Hvitstein (32)	–	Thin-butted	EN II–MNA II	153	71	34	Not reported	fs	*c.* 102	
C10853	Kalføes (18)	–	Thin-butted	EN II–MNA II	131	63	27	Not reported	fs	*c.* 108	
C13185	Knaldstad/ Knaldstad Søndre	–	Thin-butted	EN II–MNA II	115	75	31	Not reported	fs	*c.* 75	

Inventory number (*Museumsnummer*)	Registered under: municipality, farmstead	ID-Number according to the database of the Directorate of Cultural Heritage (*Askeladden*)	Type	Phase*	Length (max.) in mm** f indicates that the axe was originally longer	Breadth (max.) in mm**	Thickness (max.) in mm**	Found in/deposited in according to Askeladden and/or Museum database (*Gjenstandsbasen*)	Level of mapping: y= find spot known; fs = farmstead known; no = not mappable	Height in metres asl	Reference
C28944	Sørjordet på Galby Vestre (40)	–	Thin-butted	EN II–MNA II	138	65	–	Ploughing	fs	*c.* 79	
Ås municipality											
C13302	Unknown farmstead, Aas, Akershus	–	Thin-butted	EN II–MNA II	174	77	39	Not reported	fs	–	
C29824	Secondary find		Thin-butted	EN II–MNA II	154f	71	–	Not reported	no	–	

* According to typological dating. None of the finds can be absolutely dated.

** According to the measurements in the museum database *Gjenstandsbasen.* In the column 'Length' the 'f' indicates that the axe was missing either its butt or its edge und thus was originally longer. Axes without 'f' might have been re-sharpened, which would have led to a slight reduction of the axe's original length.

ENTANGLED DATA

A review of data biases in archaeology and their effect on European Neolithisation

Alfredo Cortell-Nicolau

Abstract

Archaeologists are well aware that the archaeological record is biased, fragmented and incomplete. However, this awareness seldom goes further than a vague acknowledgement of how these data problems might hinder our hypothesis-building process. In general, at best these are accounted for during the actual research process with more or less explicit references, whilst in the worst-case scenario the problem is happily dismissed with the recurrent 'preliminary results' trope, or even not referred to at all. The objective of the present paper is to raise further awareness and enumerate some of the most common biases in the archaeological record, and how they can affect general and particular narratives. In doing so, it will focus specifically on contexts from the European Neolithic and show how different elements, with properly developed analytical tools, can lead us to more robust inferential processes.

Keywords: archaeological record; Neolithisation; generative processes; post-depositional processes; research bias

Introduction

That the problems derived from the quality of the archaeological record have conditioned hypothesis building since the very first years of the discipline is very well known within the archaeological research community. As a matter of fact, when we switch the focus from the grand narratives, usually built on large amounts of data, and concentrate on local or regional patterns, problems with the archaeological record are usually at the core of some of the most heated discussions. In this regard, for example, understanding the path of the spread of farming throughout the Mediterranean has always been conditioned by the quality of the record, and has been changing through the archaeological literature of the twentieth and twenty-first centuries until reaching a certain consensus in some of its aspects. However, the debate is certainly still open, and old and supposedly settled topics are regularly brought back in the light of new findings and interpretations.

Taking one paradigmatic example for the spread of the Mediterranean Neolithic, the routes followed by the early Cardial farmers were elements of discussion during the 1930s and 1940s. This was due to the lack of existing reliable data, and it would not be until 1956 that Luigi Bernabó Brea, through his discoveries at the site of Arene Candide (Italy), settled the debate advocating for a northern route (as opposed to the North African route). Yet how the changing and inconstant nature of the archaeological record shapes the theoretical frame of the discipline as we move forward continued to be paramount.

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Once the route of the spread was consensually accepted, the timing became the next important argument, and it was not possible to assess such timing until radiocarbon dates were present in sufficient number so that Albert Ammerman and Luigi Cavalli-Sforza could develop their widely known wave of advance model (1971; 1984). Again, as some questions were answered, new ones continued to appear, and these were always conditioned by the quality of the record and what it would allow us to answer. The late 1970s and 1980s were a key turning point for the study of interaction and cultural transmission during the spread of farming. While in central and northern Europe the work of Marek Zvelebil and Peter Rowley Conwy (1986) became one of the cornerstones for the definition of the interaction between the last hunter-gatherers and early farmers, in the Mediterranean James Lewthwaite's (1986) island-filter model represented one way of understanding the spread of farming. Other models, such as Javier Fortea Pérez's proposal (1987), which would later become the well-known Dual Model by Joan Bernabeu Aubán and colleagues (1993), would focus on more specific contexts.

By the turn of the century, our potential explanations of the Mediterranean farming expansion increased with Jean Guilaine's school and his proposal of arrhythmic expansion (2001), and from this stage things increasingly gained in complexity. Paradoxically, and in some kind of general Dunning-Kruger effect (Sanchez and Dunning 2022; Williams *et al.* 2013), by increasing the number of excavations and the quality of the archaeological data through all of the works developed in the twentieth century, we have increased our awareness of everything we do not know and, therefore, several previously settled hypotheses are being reassessed. In this regard, one of the most important examples is the recently acknowledged spread of the so-called *Impressa* pottery, predating the Cardial style, through France and Iberia (Bernabeu Aubán and Martí Oliver 2014; Manen and Guilaine 2002; Manen *et al.* 2019; Pardo-Gordó *et al.* 2020), but also the periodic reassessment of the temporalities and routes of the spread of Neolithisation (García-Puchol *et al.* 2017, and see the debate between Manen *et al.* 2019; 2021 and Ammerman 2021), including the potential involvement of North Africa in the transition to farming in the north-west Mediterranean (Manen *et al.* 2007; Zilhão 2014).

The point of this very brief historiographic review of the Neolithisation of the Mediterranean is to show how most of these advances come due to an increase of archaeological data, and how this provides new insights. It follows that the nature of archaeological inference is, by definition, a changing one, and new findings will continue to shape and change our understanding of the past. This is ultimately the consequence of the present state of biases in the archaeological record, and it leads unavoidably to a *cul-de-sac*. Essentially, a solid experiment design always involves an initial assessment of the total population under study and its basic characteristics. After this is done, we should address what type of technique we will be using to answer our research question and, from there, design the data collection process, where the samples must always be sufficient to answer the research question and randomised in order to fully represent the population under study. However, this is practically impossible to achieve in most archaeological research, where we must rely on data that has been collected for different purposes and following very heterogeneous protocols, which do not ensure either its randomness or its diversity. Additionally, and because we do not know the total amount of record we could be looking at, we cannot even know what fraction of that record could be considered representative of the complete population under study, nor how different depositional and post-depositional processes have affected the record in the state we find it today. Therefore, and given this theoretical conundrum, it is safer to always assume bias within the record and develop our research from that assumption.

This view can indeed be, to a certain extent, discouraging. In his excellent assessment of the problems of archaeological data, Charles Perreault (2019) mentions how the archaeological record is, by definition, underdetermined. He proposes a reduction in the ambition of archaeological research questions where, following the palaeontological revolution of the modern synthesis (see Huxley 1942; for more recent approaches Dickins 2021; Eldredge 1985; Mayr 1996), we should switch our scope to focus only on patterns of variation and macroscale trends, where only long-term processes can be successfully addressed. While this makes sense in terms of solid hypothesis-building, if we limited ourselves to macroscale patterns, as those occurring during time spans in the magnitude of thousands of years, then most Holocene processes would have to be left aside. In this sense, most archaeologists refuse to abandon several of the research questions that, with greater or lesser degrees of certainty, can help us to unveil the past. Additionally, the sparsity of data generally decreases as we approach the present (see Bailey 2008; Bluhm and Surovell 2018; Kelly *et al.* 2023; Surovell and Brantingham 2007; Surovell *et al.* 2009), which demands additional caution when treating archaeological data as a homogeneous entity. Within this context, understanding the changing nature of any current state of hypotheses, and being open to changes in the light of new proposals and discoveries, is key for the advancement of the discipline. Likewise, and in the absence of other possibilities, being fully aware of how different biases can affect our inferential process is key to adding strength and caution to our different proposals. While these are widely acknowledged across different publications, they are often treated on an individual basis, but not as a specific set of problems and conditionings that must be studied. The objective of this contribution is to provide a concise, but fairly comprehensive view of what the different biases affecting the archaeological record are and how these can undermine the strength of our hypothesis-building processes. In doing so, it will also try to raise awareness regarding these processes and caution on our ways to understand the past.

Types of biases

Archaeology tries to understand past societies, and this is a bold ambition. This means trying to understand virtually every aspect of human life, but limited by the restrictions imposed of how the available data have been produced and then lost through time. In order to do this, and as has been rightly pointed out, we focus on the waste produced and left by the societies under study (Barton 1990; Dibble 1984). Therefore, we can focus on the interplay of three key elements that result in the data as we know them today, these three being

1. the generative processes that led to the creation of different types of data by the societies living in the past;
2. the post-depositional processes that condition the loss of the record and which can be different depending on the time that has passed, the region under study and the nature of the proxy; and
3. research biases, which include different types of research-specific conditions, ranging from the availability of funding, the research interests of different groups involved, or even the way in which such data are understood, coded and made available for the broader community.

Generative bias

By generative bias we refer to the process where, because different social groups have different ways and rates of producing archaeological remains, the abundance of such remains can have different interpretations and implications on several grounds, from demographics to social aspects. In a simple, almost naïve example, hunter-gatherer groups basing their food consumption on game should deposit a higher rate of animal bones per individual at any given site than full farming groups, where other non-meat derived elements presumably have more importance in the diet. This can be further extended to several aspects of our understanding of the past, some of which have been more thoroughly assessed than others. In this regard, some key biases are briefly presented.

Socio-economic bias

The social and economic structures of any specific group have their own rate of producing different kinds of archaeological proxies and, therefore, comparison between groups with different social structures might always be challenging, since similar elements can have different meanings and ratios depending on the moment and place where they were generated. Burials and grave goods are a good example of this type of bias, as these are frequently associated with sex or different degrees of status. While this engendered some uncritical views of gender roles, based on association with specific artefacts, recent discoveries (e.g. Haas *et al.* 2020), as well as current theoretical perspectives and more thorough reflection on identity and gender (e.g. Anderson *et al.* 2023; Cintas-Peña and García Sanjuán 2019; Soriano *et al.* 2021; Venkataraman *et al.* 2024) are leading to a rethink on how we understand past social structures, both in terms of gender roles, but also in terms of social hierarchies. Additionally, and when using burials, the problem of representativeness and selective burial has been widely discussed (e.g. Garrido Pena *et al.* 2012; Jackes *et al.* 2008; Thompson *et al.* 2020), and it relates to the question of whether an assemblage of burials for any specific region and time period is representative of the entire society that generated it or just of some of its members. Evidently, this leads to concerns regarding in how far we are capturing extended social practices within a group, or just a fraction of that group.

Mobility bias

Mobility is one of the main topics when addressing hunter-gatherer societies (Binford 1980; G. Clark *et al.* 2018; Grove 2009; 2010; Kelly 1983; Preston and Kador 2018), but it gains part of its meaning from contrasts with agricultural sedentism. If for hunter-gatherer groups mobility can be assessed in terms of general mobility (e.g. migratory waves) or seasonal mobility (e.g. how different groups occupy and move through the land at different times of the year in their search for resources), with the advent of farming the latter takes on a very different character and it is mainly general movements, usually related to migratory patterns, that monopolise archaeological attention. For the case of research biases, I would like to focus on seasonal mobility, because this can have an impact when comparing groups of late hunter-gatherers and groups of early farmers.

The volume of the archaeological record generated at a site is directly proportional to the number of people occupying that site, given the same generative processes. Likewise, the amount of record surviving from the moment of its deposition until today is, all else being equal, a direct proportion of the record generated at that moment. Following this, larger sites will have bigger chances that at least a small fraction of their record will survive. Conversely, sites that originally had minimal amounts of archaeological material (e.g. logistic hunting camps) will disappear. This creates a fundamental problem because social groups with larger sites, as a consequence of their mobility patterns, will have a higher per-site survival rate given the same number of people. Thus, this presents the risk that sedentary societies may be demographically overrepresented compared to groups of foragers, since small camps are more prone to disappearance, turning into a problem of presence/absence what originally was just a problem of proportion. Taking an extreme example, a hunting spot occupied some weeks every year by a group of hunter-gatherers would likely produce a meagre assemblage unlikely to survive until today. If we multiply this by several small hunting camps, the vast majority of them would potentially be lost, whereas the survival of a single larger site with the same amount of generated archaeological waste would be more plausible. This is an additional element to take into account when comparing groups with different mobility patterns, more particularly groups with different levels of sedentism.

Functional bias

The case of polyfunctionalities has also been discussed in the archaeological literature (Barandiarán and Cava Almuzara 2000; Binford 1982; Soares and Tavares da Silva 2018). Camps with specific functions may differ in the type of record they produce regarding, for example, multipurpose sites, and this can lead to the establishment of cultural differences where the dissimilarities of sites relate to their ultimate purpose, not their cultural affiliation. Some cases such as, for example, the Neolithic mining sites of Casa Montero in Spain (Consuegra *et al.* 2004; 2018) or Grimes' Graves in Britain (Healy *et al.* 2018) are very well defined and do not create major problems. But what about different roles of sites in connection networks? What about differences between coastal and high-altitude sites? What about purpose-specific sites? These and other differences may yield variability in the record, and how this is produced must be accounted for.

Post-depositional bias

Post-depositional biases are perhaps some of the most addressed biases in archaeological literature (Butzer 2008; A.E. Clark 2017; Goldberg and Mandel 2008; Mallol and Goldberg 2017). In general, these refer to the different processes that affect the archaeological record after its deposition. While some of them are common and depend on the general environmental conditions of specific regions (e.g. acidity of the soil, climatic conditions etc.), others are specific to site types (e.g. caves *vs* open-air sites) or even to particular proxies. In what follows, some of the most common biases are listed.

Taphonomic bias

Taphonomic bias has a well-defined meaning in archaeological literature as the effect that time has in the preservation of archaeological material. Todd Surovell is one of the most active researchers in this field. Through his different works, and along with other colleagues (Bluhm and Surovell 2018; Kelly *et al.* 2013; Surovell and Brantingham 2007; Surovell and Pelton 2016; Surovell *et al.* 2009), he has realised how sites are lost through time at specific rates, creating the fake impression of an exponential-like population growth, where that pattern would actually relate to site preservation. In further works, the team have continued to refine their preservation model with specific values slightly deviating from a pure exponential process.

However, taphonomic biases and problems are also often referred to more broadly as the effects that different factors, such as stratigraphic disturbance, might have on our understanding of the record. In this sense, another view of how taphonomic bias affects the record would be Geoff Bailey's (2008) time perspectivism, which was also observed by Bernabeu Aubán and colleagues in their excavation at the Neolithic site Cova de les Cendres, Spain (Bernabeu Aubán and Molina Balaguer 2009; Bernabeu *et al.* 1999). According to this, the accumulation of archaeological remains of different periods, especially in moments of slow deposition rates, can give place to palimpsests which in turn give the wrong impression of continuous and even overlapping occupations for different groups, as in the case of Cueva de la Cocina, Spain, which has challenged the interpretation of the Neolithic transition in eastern Iberia (Cortell-Nicolau *et al.* 2020; Pardo-Gordó *et al.* 2018).

This, added to different post-depositional effects such as pedogenic movements, has indeed constituted one of the major fronts of discussion in the Neolithisation of the western Mediterranean. In this regard, debates for example between João Zilhão and Alfonso Alday (Alday 2007; 2011; Zilhão 2011) regarding the validity of the record of northern Iberian sites have all been based on the potential biasing factors of pedogenic disturbance.

Post-occupational activity

The specific location of a site and the successive post-occupational events that have occurred in that area might have an effect on its preservation patterns. These events can be natural or environmental, but they are also and often due to human activity. For example, the disappearance of a large amount of the Palaeolithic, as well as Mesolithic record due to post-glacial bathymetric increase is a well-known fact (Astrup *et al.* 2021; Benjamin *et al.* 2017; Conneller 2021). Focusing on the Neolithic, a large problem comes from the fact that fertile agricultural land is valuable both to early farming societies and their successors. If these areas are still occupied today, as is the case in most of the coastal valleys of the Mediterranean shores, this severely hinders (if not renders impossible) potential survey projects and finding new sites is dependent on local development in archaeologically protected areas, according to the different national laws. This, along with the exposure of open-air sites, which might lead to their disappearance even when they have not been successively re-occupied, may result in biased interpretations of occupational spatial patterns. This is the case, for example, for the Iberian Cardial Neolithic, mainly associated with cave sites, but where several valleys potentially suitable for occupation (and surrounded by cave sites) cannot be properly explored due to current urban/agricultural developments.

Additionally, the re-use of archaeological material can pose problems for the interpretation of original structures. This is particularly damaging for megalithic structures, where several of the stones of the original megalith could be later re-used for other construction projects or where the site itself could be re-used according to intentions and practices that are not necessarily aligned with the original ones (Aranda Jiménez *et al.* 2022; Cazzella and Recchia 2012; Scarre 2010). In this regard, and just to cite some examples, Catriona Gibson (2016) refers to how the Chalcolithic re-use of Neolithic megaliths altered their original architecture and depositional assemblages in several European areas, while Magnus Andersson and colleagues (2022) focus on how the constant re-use and re-arrangement of megalithic monuments in Scania hinders the effort to produce accurate chronologies. For its part, Andy Burnham's guide to British megaliths (2018) contains several examples of re-use, from converting megalithic sites and barrows to Iron Age hill forts, to the re-use of stones within the same environment as markers or standing stones, or even for modern windmills.

One last element to take into account in this regard is the intentional (often unauthorised) destruction of archaeological sites, either for economic or personal reasons. Just as an example of a situation that occurs all over Europe, the complete destruction of Cueva de Chaves (Spain), one of the most important sites for the Early Neolithic in the Iberian Peninsula, stands out. This was undertaken by a local entrepreneur with the intention to use it as a hunting trough and, although the process did have severe legal consequences for the perpetrator, the damage could not be undone (e.g. Escario Pómez 2016). This, of course, might have been the fate of countless known and unknown sites throughout history until the present.

Proxy-specific biases

Most archaeological materials have their own loss patterns and processes affecting their preservation. It is impossible to name them all here, but every specialist should be aware of how their own material of interest reacts to the different long-term effects on its preservation. For example, bones and collagen are very sensitive to different soil conditions, such as pH and humidity (Gallo *et al.* 2021; Kendall *et al.* 2018; López-Costas *et al.* 2016; Sullivan and Keenan 2022), and these play a key role in understanding human and archaeozoological assemblages. In the same vein, other perishable materials, such as wood, strings etc., very susceptible to the passage of time, are seldom preserved unless in very specific conditions, such as waterlogged environments (e.g. Bailey *et al.* 2020), as the paradigmatic cases of La Draga in Spain (Romero-Brugués *et al.* 2021) or La Marmotta in Italy (Mazzucco *et al.* 2022) show. These offer a clear contrast to surrounding sites. Waterlogged environments are more common and have proven particularly fruitful in some northern and central European areas, such as the United Kingdom, with several sites ranging from the Neolithic to the Bronze Age (e.g. Ward *et al.* 1996; Yates and Bradley 2010). In these areas, differential preservation between dry and waterlogged environments is noticeable.

Conversely, other proxies such as lithic industry or pottery have more successful survival rates, and this is in part what has made them some of the key vectors for the study of different Neolithisation trends. It is not only their embedded cultural meaning, but also their ubiquity which allows comparison between different groups.

Research bias

So far, it has been mentioned how archaeological data are generated and then lost through time, but archaeological data must also be found in order to be available for analysis, and how data are found is conditioned by several potentially biasing factors. To start with, not all archaeological data come from well-planned and research-driven survey projects and excavations. Anecdotes involving the discovery of caves with archaeological remains are widely known, but even more important is how different recent urban/agricultural development processes, and their regulation by national and regional laws, affect the discovery of new sites. A paradigmatic case is Japan, where an intense development during the second half of the twentieth century, coupled with good practice and appropriate regulations, left one of the most complete archaeological datasets in the world (Takata and Yanase 2021). In Europe, because laws are different not only at a national level, but often also at regional levels, the rate of archaeological discoveries due to urban development can be unequal. However, there are some prime cases on this continent as well, for example Sweden, where particularly well-conducted contract archaeology has provided a large and useful set of radiocarbon dates (Friman and Lagerås 2023).

In any case, even focusing on research-driven work there might be differences in how we collect our data. Differential access to funding is one, for which the simple exercise of comparing the amounts of radiocarbon dates recovered per continent can give a good idea (Bird *et al.* 2022). Other common factors are listed below.

Research interest

Some archaeological processes attract more attention than others and, as anything else, they are subject to the trends of their time. Unavoidably, this can result in an overrepresentation of some periods, while others might be not sufficiently acknowledged. For example, a demographic boom and boost pattern observed for the Early Neolithic by Stephen Shennan and colleagues (2013) is currently widely accepted within the archaeological community. However, it is also true that archaeologists tend to date more often the very early stages of the farming expansion in search of its initial trajectory. While the boom and boost process seems consistent, is there any influence of archaeological practices in the large amount of Early Neolithic dates? This same concept applies to the dating of single sites, where some of them present large date series, while others with similarly long sequences are much less well dated.

Taxonomic biases

Since the beginning of the discipline, archaeologists have built analytical units which, in turn, have given place to the cultural complexes as we know them today. Abusing Natasha Reynolds and Felix Riede's house of cards metaphor (2019), this has created a situation where every inference is based on previous layers of assumptions (e.g. the frequencies or shapes of specific materials will configure one cultural complex, which in turn will allow different interpretations), but the analytical process to determine such assumptions is rarely justified further from personal experience or knowledge. In other words, archaeologists build artefact types which configure cultural complexes, but neither the ontology of those types and/or complexes, nor their meaning or even their existence as a distinct unit *per se* within the cultural group they belonged to are sufficiently addressed. Additionally, the existence itself of archaeological types forces archaeologists to divide their record into pre-specified categories, creating several problems. First, they reduce the overall variation of the full assemblage, second, they assimilate units of different contexts which might have had different evolutionary paths and cultural meaning, and third, they create specific ideological units, or target types, which then become the research objective rather than the research instrument, potentially enhancing what has been called the collector bias (Ragan and Buchanan 2018). Finally, once a specific artefact or monument is assigned a type, it becomes a number to be passed on to further studies, thus passing onto these studies the potential biases that each researcher might carry, based on their school and experience. In an era where cumulative research of large (and often under-assessed) datasets is becoming more and more common, this represents an increasing problem, since it is always rarer for global archaeologists to properly assess the specificities of the datasets they are analysing.

Although awareness of the concept of taxonomic construction has increased (Beck and Jones 1989; Dunnell 1971; O'Brien and Lyman 2003) and is being raised again lately (Edinborough *et al.* 2015; Lycett and Cramon-Taubadel 2015; Reynolds and Riede 2019), the concept has not been fully embraced across the archaeological community as a whole. This may be because types are indeed useful for archaeologists to 'speak the same language' (or something similar to a same language). Nonetheless, overreliance on such types must always be taken into consideration in order not to reproduce self-fulfilling prophecies.

Legacy datasets

This type of bias is actually related to the above. Legacy datasets retain large amounts of information and are crucial for the configuration of our archaeological knowledge. However, archaeological practice has evolved over time, and some elements that are considered relevant may not have been so in the past. For example, the recovery of small lithic debris is more thorough on current excavations, and this might have an impact when frequencies matter in our current studies (Cortell-Nicolau *et al.* 2019). In general, when assessing legacy datasets, and the further we go back in time, there is a risk of bias against artefacts traditionally considered less significant which, nonetheless, could prove to be very useful for current archaeological practice.

Multidisciplinary bias

Archaeology is, by definition, multidisciplinary. In this sense, it greatly relies on fruitful collaboration with other scientific disciplines and sub-disciplines, from mathematical or computational modelling to aDNA analysis, chemistry, physics, forensics and many others. While this collaboration often results in outstanding results, it also has a downside. Occasionally, experts from other fields rely on pure analysis of the data without further (or enough) archaeological assessment. As a result, it is increasingly common to find works with stunning results, but which would not survive strong scrutiny of the data which they are based upon. This occasionally results in exaggerated claims which may be supported by one single (and probably underdetermined) proxy, but that systematically ignore or misread and sometimes even contradict broader analysis of full archaeological assemblages. While multidisciplinary collaboration between different scientific branches is necessary, fluent communication among all of them is needed, in this case with archaeology at the centre (see Johannsen *et al.* 2017).

Shall we stop doing Archaeology then?

The situation portrayed above may certainly look discouraging. Archaeological practice rests, indeed, on very problematic datasets that do limit our inferential power. The upside, however, is that archaeologists are, for the most part, well aware of the problem. As a matter of fact, new solutions and proposals have appeared in the last few years, trying to account for this. Perreault, in his aforementioned 2019 work, proposes a switch in the scope of archaeological research questions to focus on macroscale tendencies, and warns against ambitious questions as drivers for methodological development on the grounds that methods are in general borrowed by archaeologists and not developed *ad hoc* (Perreault 2023). Other views advocate for the resolution of specific problems, which might increase the quality of our dataset. While some of the problems exposed above might have no short-term solution, others can be addressed. For instance, in several works Michael O'Brien and colleagues (e.g. O'Brien and Lyman 2003; O'Brien *et al.* 2010; 2014) have extended Robert Dunnell's (1971) concept of paradigmatic classes to frame typological construction, put to use by Kevan Edinborough and colleagues (2015) in their study of French Neolithic arrowheads and discussed by Alfredo Cortell-Nicolau and colleagues (2021) in their model for origins and routes of expansion of the Iberian Neolithic, where they ended up focusing on morphometric classification instead.

Another clear example of how new inferential tools can be used to solve shortages in archaeological data during the European Neolithic is related to the treatment of radiocarbon chronologies. As stated before, a typical effect of taphonomic bias occurs when archaeological artefacts are displaced vertically along the sequence due to post-depositional processes. This can lead to radiocarbon samples dating layers where they were not originally found. If the displacement is severe, archaeologists can usually acknowledge the fact and dismiss the date, but if it is not, and the date would still be plausible (although extreme) given the material culture in the layer, it can be a source for interpretative problems regarding the chronological understanding of a specific period. This can impact broader debates. For example, if a date is labelled as Neolithic by the regional expert, further experts doing macro-analysis on an area, with more dates and significantly less region-specific knowledge, will probably not challenge the original definition of the date and will just include it in their studies as it is. If the affiliation of the date was not completely reliable to start with, this will have an effect on higher-level studies.

Bayesian chronological modelling (Buck *et al.* 1994) has been a great and widely used tool to deal with this problem of chronological uncertainty. In essence, these models construct posterior probabilities for the estimated chronology of a site, based on the prior probabilities assumed for such a chronology. In other words, the researcher might assume no previous knowledge (in which case the dates themselves are the only elements informing the final output) or may consider specific distributions for the dates of the site (which would condition the outcome). From this, the model gives an estimated probability range for the chronology of the site, with or without previous information for the dates obtained; this can take into account potential outliers and offset derived from post-depositional and taphonomic effects (Ramsey 2009). Indeed, Bayesian models are currently of common use for understanding European Neolithisation, with scholars such as Oreto Garcia-Puchol and colleagues (2018; 2023) building chronologies for legacy excavations at Cueva de la Cocina, one of the key sites for the Mesolithic–Neolithic transition in Iberia or, at a broader scale, Bettina Schulz Paulsson (2019) assessing the essentially maritime megalithic expansion in Europe.

Ultimately, if there is one requirement to account for and fight against the problems posed by biases in archaeological data, it is a proper updating of theorists and methodologists in order not to repeat misinterpretations already solved. Let us, for example, continue with radiocarbon dates and the case of the sums of probability distributions of 14^{C} dates (SPDs). SPDs are based on John Rick's (1987) dates-as-data approach, and they rest on the basic rationale that more radiocarbon dates would mean more people; therefore, they have been used widely for the interpretation of past demographic trends. They are, at the same time, one of the star and more polemic methods to understand demographic dynamics in Neolithic Europe (Bevan *et al.* 2017; Collard *et al.* 2010; Kondor *et al.* 2023; Pardo-Gordó and Carvalho 2020; Shennan *et al.* 2013; Vatsvåg Nielsen *et al.* 2019).

I will not provide an extensive view of misuses and interpretation problems of SPDs, since this has already been provided recently, thoroughly and effectively (Carleton and Groucutt 2021; a broad and updated review of the method can also be found in Crema 2022). Rather, I would like to focus on a different fact. From the beginning, the method was heavily criticised on several grounds, and most of them were actually fair criticisms. In its initial development, the method was sensitive to biases, and these included differential dating of sites due to preservation or research bias, differences in the generative processes and in sampling intensity by region or difficulties in tracking demographic processes given an insufficient number of dates. However, most of these issues have been addressed and solved at least to a certain extent. Enrico Crema and colleagues (2017), for example, have addressed problems of differential regional sampling intensity, while problems of site representativeness have also been successfully addressed through binning/random thinning dates (Crema and Bevan 2021). Additionally, advances in tracking underlying demographic trends have evolved from the previously mentioned null model proposal (Shennan *et al.* 2013) to the introduction of continuous piecewise linear models of population change (Timpson *et al.* 2021). This has helped make this technique one of the main tools for the study of the demographic dynamics of the European Neolithic, both in terms of its relation to previous hunter-gatherers, but also concerning developments throughout the period. Indeed, and with different levels of correction, this has been applied to several case studies. To name just a few, these include population crises in the broader European Early Neolithic (Timpson *et al.* 2014), the relationship between demographic intensity and various monumental feats (Edinborough *et al*. 2021), Portuguese megalithism (Pardo-Gordó and Carvalho 2020) or the relationship between demographic fluctuation and climatic events (e.g. Großmann *et al*. 2023). Particularly interesting is Fabio Silva's (2020) adaptation of SPD's methodological rationale to explore potential orientation patterns between human-made structures and celestial events.

All in all, this methodological tool stills presents problems, as many others do, but as has been shown from its numerous applications, the shocking element is that so many of the criticisms that the method receives are based on issues that have already been solved and are rooted in an outdated understanding of the technique. In a field that evolves so fast, criticisms of this (and any other) tool are useful, since they can lead to an optimisation of the method, but they must come from a constructive, and not destructive perspective and, even more so, they must be rooted in where the methodological development is now, not where it was ten of fifteen years ago.

The present article has intended to bring a short and non-comprehensive guide to the most common biases affecting archaeological research, while also offering some insight into how methodological development can help us overcome such problems. In particular, the specific problems that affect prehistoric data, and specifically early farming societies require dedicated assessment and methods if we want to enlarge our research scope. Fortunately, methods are being developed and archaeologists are more than capable of developing their own tools to face their own challenges (in this case, the bias generated by archaeological data). In this regard, providing solutions for each of the biases mentioned above would greatly exceed the plausible objectives of a single publication. However, a common clause could be that dealing with biases in archaeological data must start from the acknowledgement both of the bias itself and the temporality of our hypotheses, but must continue by active research which, when possible, offers solutions to these problems. Ultimately, we have to work with what we have, but the honesty to recognise that 'what we have' is not enough might help us to keep our mind open to being wrong, to recognise being wrong and, especially, being open to incorporate new techniques that help us transcend our own limitations as researchers and as a field and allow us to build more robust inference.

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THE EARLY NEOLITHIC OF NORTHERN EUROPE

In Britain, Ireland and Southern Scandinavia, the Early Neolithic is characterised by monumental constructions (e.g. causewayed enclosures, dolmens) and by specific traditions of depositional practice. Some aspects of these practices are similar in both regions, for example the shapes and use of monuments, their overall developmental sequences, and the traditions of deposition (kinds of objects and their treatment, locations chosen and so on). In spite of these similarities, however, there has been little explicit comparative work, largely also because of research paradigms that tended to stress local and regional peculiarities over wide-spread similarities.

Given the increasing evidence for group and personal mobility in recent years, this begs the question of whether such similarities are the result of accidental convergence on the basis of a broadly shared "Neolithic" lifeway, or rather the result of contacts, whether direct or as part of a large-scale, but loose network of interaction. The papers in this volume provide initial case studies to address this issue. Regional case studies of Britain, Ireland, southern Scandinavia, northern France and northern Germany form the basis for reflecting on the similarities and differences of sites and materials to those from adjacent areas, and on the forms and rhythms any potential contact might have taken. Authors draw on both archaeological studies of specific material categories or site patterns, as well as on aDNA evidence or modelling of ^{14}C dates. Papers also offer theoretical reflections on the modalities of contacts and connections at this time, defining more directed questions and priorities to further develop this line of research in the future.

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