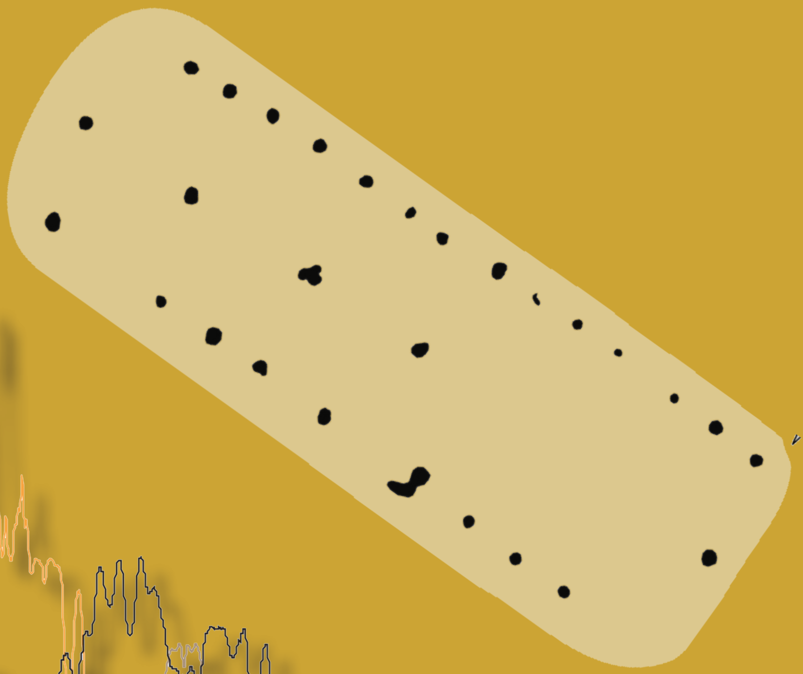
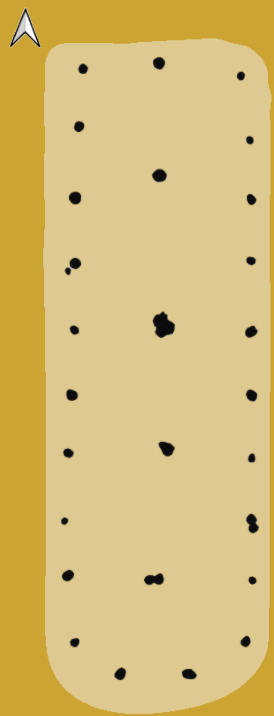
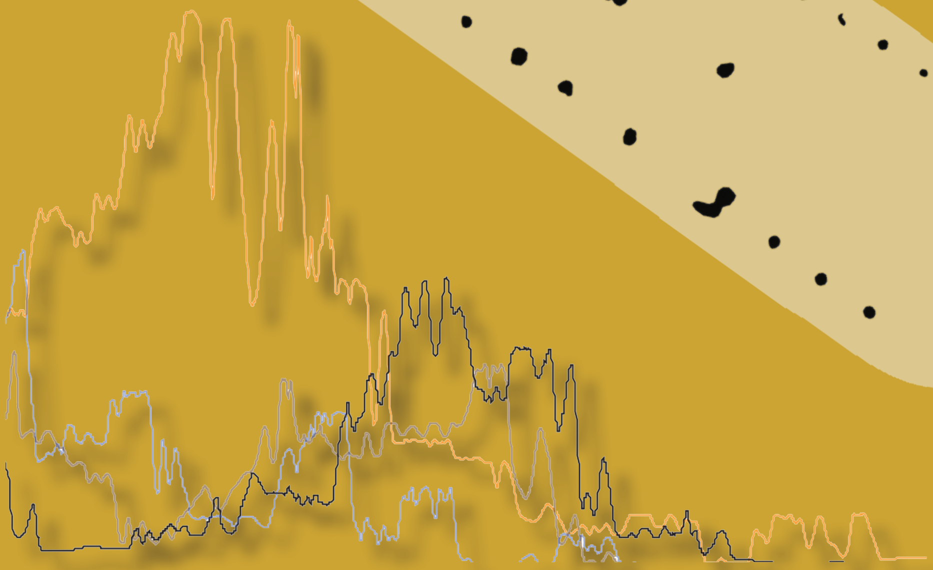


Danish Journal of Archaeology

2023
Volume 12

Danish Journal of Archaeology

This innovative journal is dedicated to the presentation, discussion and interpretation of the archaeological record of southern Scandinavia in its international, regional and local context. Providing a platform for publication and debate for professionals from the museum as well as the university sectors this journal is open for empirical, methodological and theoretical contributions covering all time periods and all kinds of archaeology with relevance for the Scandinavian, Baltic, and North Atlantic regions. In addition, the journal may publish articles of wider theoretical, discursive or global reach.

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The advisory board of the Danish Journal of Archaeology is tasked with following the journal and advising on scientific issues including keeping up with papers within the designated field of expertise of each individual member of the advisory board. The board consists of eight members, who are internationally recognised experts within each of the chronological periods designated below.

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Cover: Selection of data and groundplans from the Oslo Fjord area (Collage: K. Atzbach, article from Anette Sand-Eriksen and Axel Mjærum).

Contents

Editorial

Rune Iversen, Thomas Grane, Helene Agerskov Rose, Sarah Croix, Lasse Vilien Sørensen and Xenia Pauli Jensen

2022 was an eventful year as we welcomed two new members to the editorial board, Sarah Croix and Helene Agerskov Rose, along with a new and engaged advisory board. However, 2023 has also brought changes, as Mette Svart Kristiansen, Associate Professor at Aarhus University, decided to leave the editorial board after many years. Mette was part of the team that oversaw the important change in the journal, when it went from Taylor & Francis to the Open Access platform of tidsskrift.dk. In more recent years, Mette also functioned as our de facto principal editor. We are very grateful to Mette for the time and effort that she has put into ensuring the well-being of Danish Journal of Archaeology. It has been the goal of the editorial board to secure a wide spectrum of expertise among our editors, and for that reason, we welcome the newest member of our board, Xenia Pauli Jensen, Senior Researcher at Moesgaard Museum. She is a world leading scholar in weapons and warfare in the Iron Age, and also excels in numerous other fields relating to the Iron Age societies of Northern Europe. We are very happy that she is now part of the team.

In 2022, we were pleased to announce admission to the Directory of Open Access Journals (DOAJ). This year, we can announce that we have completed the next step, which was to register all published articles within the DOAJ platform. This means that our entire catalogue can now be found via the search engine of DOAJ, something that will greatly broaden our visibility as a scientific journal.

For five years now, Danish Journal of Archaeology has been a full open access journal hosted by the Royal Danish Library at tidsskrift.dk. Generous support from Independent Research Fund Denmark, Farumgaard Fonden and Elisabeth Munksgaard Fonden allowed us to acquire the rights to the back issues of the journal from the previous publisher and to continue the high-quality layout and language control that the journal offers. Continuous funding is, however, necessary to keep the journal running and we are therefore happy to announce that, thanks to renewed support from Independent Research Fund Denmark, we have financing for the next three years, until 2027.

This year's volume contains eleven strong research articles, spanning the period from the Stone Age to the 18th century AD, presented below in chronological order. The chronological span of the articles is therefore wide and covers most of the cultural-historical periods, including the Mesolithic, Neolithic, Bronze Age, Viking Age, Middle Ages and recent historical periods. In terms of methodology, the articles presented in this volume are wide ranging, including a number of scientific approaches, such as the acid etch peptide-based method to determine the sex of human individuals, stable isotope analysis (carbon, nitrogen and sulphur), chemical composition analyses of artefacts, strontium isotope analyses, pollen analyses, ^{14}C dating and ground-penetrating radar analysis. They involve fields such as burial, settlement and landscape archaeology, garbology and conservation/preservation of monuments. In geographical terms, the presented studies deal with various regions within Scandinavia and the Baltic countries, and we are very pleased that the authors are from a range of different countries, including Canada, Denmark, England, France, Ireland, Lithuania, Norway and Sweden.

The article 'Sex Determination and Stable Isotope Analysis of the Nivåfjord Mesolithic Burials, Zealand, Denmark' with Kurt J. Gron as main author, along with an interdisciplinary team of researchers, presents several new results using a range of innovative methods. The acid etch peptide-based method is used to determine the sex of eight individuals from Nivå 10, as well as that of the Nivågård child. Most of the sex determinations confirm the osteological analysis already undertaken on the skeletal remains. One surprise, however, is that the Nivågård child originally identified as possibly a boy, is now identified as a girl based on the recent acid etch peptide-based method. Moreover, the article re-examines the usefulness of stable isotope analysis of carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$) and sulphur ($\delta^{34}S$) in human tissues to reconstruct the life histories and diets of the 10 individuals from Nivå 10, as well as the girl from Nivågård. This indicates there was diversified subsistence exploitation of local resources.

Lone Claudi-Hansen and Arne Anderson Stamne's article 'Re-evaluating 'Denmark's Stonehenge'' presents the results of investigations of possible concentric circles of features and large stone holes, interpreted as a large Neolithic stone- or woodhenge surrounding the large hill of Overdrevsbakken, near Kalundborg, West Zealand. The recent excavation and ground-penetrating radar survey in 2019 to 2021 did not reveal any circular structures, which could support the interpretations of a Neolithic stone- or woodhenge. Instead, the recent results documented clusters of Bronze Age fire pits located at the side of Overdrevsbakken, thus associating continuous, communal, diachronic activities involving fire and heating near a large hilltop with neighbouring burial mounds.

In the article 'Maglehøj', Torben Dehn and Poul Klenz Larsen present their studies of the Maglehøj passage grave 100 years after the monument was first opened up. Maglehøj is one of the few Danish passage graves, with birch bark incorporated into the construction, that are still preserved today. Investigations undertaken in 1996 revealed that the birch bark was relatively well preserved and that there had been a break-in at one end of the chamber late in prehistoric times. Follow-up investigations in 2013 and 2018 were undertaken to clarify the preservation conditions of the birch bark and control the climatic conditions inside the chamber, in order to establish optimal conditions for the future preservation.

Jens Winther's article 'The Late Neolithic Expansion in Denmark' highlights agricultural intensification as a significant aspect of the Late Neolithic in southern Scandinavia, *c.*2350-1700 BC, and proposes that these changes in subsistence led to a population increase, which formed the basis for the spread of agriculture and a new Bell Beaker-influenced Late Neolithic culture from Jutland across Scandinavia. Furthermore, the old cultural differences between West and East Denmark resulted in a delay in the introduction of the Late Neolithic in East Denmark and scarcity of Bell Beaker-related artefacts in the region.

Anette Sand-Eriksen's and Axel Mjærum's article on 'Late Neolithic and Early Bronze Age settlements and agro-pastoral developments in the Oslo Fjord area, southeastern Norway' fits thematically and chronologically with Winter's article on Late Neolithic Denmark. Compared to western Norway, the Oslo Fjord area is generally characterised by a more fragmented archaeological record, without Neolithic longhouses and direct empirical evidence of the introduction of farming. However, based on radiocarbon-dated buildings, cereals and cultivated soils, Sand-Eriksen and Mjærum can demonstrate a general delay in the establishment of longhouses, from 2200-2100 BC, and a stepwise intensification in crop farming from *c.*2100 BC. They interpret this as a more gradual and adaptive development of farming in this part of southern Norway, contradicting the idea that a comprehensive 'Neolithic package' was introduced at the onset of the Late Neolithic.

With 'Tales from Ginderup Mound in Thisted County, Denmark' we are back in southern Scandinavia and in chronological terms in the Early Nordic Bronze Age, *c.*1700-1100 BC. Here, Samantha S. Reiter et al. conducted strontium isotope provenancing and osteological analyses on several individuals from an Early Bronze Age mound at Ginderup. The results suggest that one of the individuals, a female interred with a possible corded skirt, was probably of local origin, but that she was also repeatedly mobile during her lifetime. The authors link this mobility pattern to possible fosterage practices, a somewhat understudied cause of female mobility during this period. The study supports the notion that the Nordic Bronze Age was a period which was characterised by complex socio-dynamics.

The article 'Where water wells up' by Malene R. Beck, Lise Frost and Renée Enevold revisits a forgotten deposition tradition from the Late Bronze Age on Funen, Denmark. The authors aim to improve the understanding of the Bronze Age depositional practices in relation to flowing water, and suggest that offerings in and around springs are an overlooked component of the Bronze Age depositional tradition. The article presents a detailed archaeological and scientific study of a new multi-type spring deposition at Hedegyden, which included three hanging vessels and a belt ornament dating to the Late Nordic Bronze Age Period V. A *chaîne opératoire* is proposed for the various sub-elements and phases of the depositional act, and non-pollen Palynomorph (NPP) analysis of organic materials from the hanging vessels indicates the presence of bee hairs. This suggests that honey or beeswax were included in the deposition, and the authors propose that the former may have had a medicinal role, whereas the latter may have been related to bronze casting.

Torben Sode, Mads Dengsø Jessen and Bernard Gratuze present in 'Viking Age Windows' a ground-breaking study of windowpane fragments from selected Viking Age centres in Scandinavia. This group of finds, they argue, are contemporary with the activities at the sites where they were found, and not considerably later, as the research tradition has previously assumed. This raises questions concerning procurement networks, as well as in relation to symbolic architecture. Windowpanes are indeed remarkably associated with aristocratic residences, which combined political, economic, social and religious functions. Adopting an interdisciplinary approach, integrating archaeological analysis with chemical composition analysis (via LA-ICP-MS), the authors are able to confirm the Viking Age date of the finds and suggest two possible routes for importation of the raw materials. They discuss the symbolic connotations associated with the use of glass in buildings and the possible magical significance of this material.

In 'Sukow Ware at Vester Egesborg, Denmark?', Jens M. Ulriksen and Torbjörn Brorsson investigate whether a group of finds resembling Sukow Ware, an Early Slavic pottery type, found at the Late Germanic Iron Age/Viking Age landing site of Vester Egesborg in southern Zealand, can definitely be identified as Slavic imports. In terms of shape and fabric, Sukow Ware is not easily distinguishable from contemporary South Scandinavia pottery, with rim forms its most diagnostic trait. The authors used ICP-MA/ES analyses to identify the provenance of the clays used to make the presumed Early Slavic pottery and South Scandinavian pottery found at the site. The results indicated that most of both groups were made of local clay from various different sources in the vicinity. Only three samples pointed to a non-local origin: two of South Scandinavian type (possibly the Hedeby area and the Ystad area) and one of Early Slavic type (a decorated Feldberg sherd, possibly from a vessel made in the Roskilde area). The difficulties in disentangling the different pottery traditions attest to the high degree of integration in the western Baltic region.

The archaeological evidence from the medieval castle at Boringholm (1369-early 15th century) is examined by Rainer Atzbach in the article 'The Garbage, the Castle, its Lord and the Queen'. Atzbach uses Boringholm as a case study to embark on a methodological discussion of how archaeologists should deal with apparently paradoxical material evidence: on the one hand, a broad range of artefacts, signalling modes of consumption associated with the elite and a courtly lifestyle; on the other hand, a more modest architecture, resembling more a farmstead than a castle. The author puts forward the principles of garbology, as developed by William Rathje, as a methodological framework to explain why 'elite' waste may to a greater extent reflect a desire to achieve elite status than the pre-existing possession of that status. Considering both finds and contexts, he therefore proposes that the castle at Boringholm was home to the household of a parvenu.

The article dealing with subject matter of most recent date is by Rūta Karaliūtė and colleagues, who present a historic case study from the Old Town of Vilnius, Lithuania. In the article 'The Dietary Stories of One Household: Multi-proxy Study of Food Remains at Dominikonų St. 11 in Vilnius Between 15th-18th Century', they present new results of archaeological, zooarchaeological and archaeobotanical investigations, and combine these with historical written sources to investigate the dietary stories of the residents of a land plot in Vilnius. The residents themselves are not analysed (through stable isotope analysis), but instead their material remains, surroundings and available food sources. This approach enables the authors to discuss long-term dietary changes in relation to, for example, the spatial distribution and architectural developments of the buildings at the site. Specifically, they establish that buckwheat, which historically has been assumed to be a food source of the poor, was instead a reliable food source for all social classes, thus successfully demonstrating the advantage of multi-proxy studies.

We hope you will enjoy this volume!
The editorial team

Sex Determination and Stable Isotope Analysis of the Nivåfjord Mesolithic Burials, Zealand, Denmark

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ABSTRACT

Since 1992 the prehistoric Nivåfjord in northeast Zealand, Denmark, has yielded an appreciable number of inhumation burials and cremations dating to the Mesolithic, especially the sites of Nivå 10 and Nivågård. Unfortunately, the micro-region is characterised by poor organic preservation, restricting the successful application of biomolecular techniques to human remains, including large-scale radiocarbon dating programmes as well as both stable isotope and ancient DNA analyses. Here, we apply an alternative technique, an acid etch peptide-based method, to determine the sex of eight individuals from Nivå 10 as well as the Nivågård child. Moreover, we revisit the utility of stable carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$) and sulfur ($\delta^{34}S$) isotope analysis of human tissues to reconstruct the life histories and diets of 10 individuals from Nivå 10 as well as the Nivågård child. To contextualise further, we sampled 14 *Capreolus capreolus* and three *Sus scrofa* from the Nivågård site for stable isotope analysis. We demonstrate that sex can successfully be determined from contexts susceptible to poor organic preservation, and show that the Nivågård child spent a proportion of its life outside a sea spray-influenced environment, and consumed significant quantities of marine protein as demonstrated by its $\delta^{13}C$ and $\delta^{34}S$ values. By applying novel analytical methods, a wealth of information can both be gleaned from older collections as well as from sites with poorer conditions for organic preservation.

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Introduction

The prehistoric Nivåfjord is located *c*.30 km north of present-day Copenhagen (Figure 1). Here *c*.24 archaeological sites dating to the Stone Age have been recorded in a now-infilled inlet (see Lass Jensen 2001, 2003, 2009, 2016). Of these, two are central to this study, Nivå 10 and Nivågård. These date from the Middle Mesolithic Kongemose (*c*.6400-5400 cal BC) to the Late Mesolithic Ertebølle (*c*.5400-4000 cal BC) cultures, and were likely used for short-term occupations sporadically over this period (see Absolute Dating). Less than 10 km north of the world-famous Vedbæk complex of sites with their multiple Mesolithic burials (see Brinch Petersen 2015), the Nivåfjord sites have also yielded an appreciable number of inhumation burials and cremations (Lass Jensen 2016).

At Nivå 10, a total of 15 individuals have been discovered, represented by nine inhumation burials and three cremations. Added to this are 'a few loose human bones from two or three individuals' (Lass Jensen 2016, 98). All are characterised by poor organic preservation or were cremated, and previous attempts utilising biomolecular techniques, such as radiocarbon dating, stable isotope and ancient DNA (hereafter aDNA) analyses, have largely been unsuccessful (though see Rasmussen et al. 2009; Table 1). In comparison, the single Nivågård burial has much better organic preservation. Since the two sites are separated by *c*.100 m and broadly date to the same period,

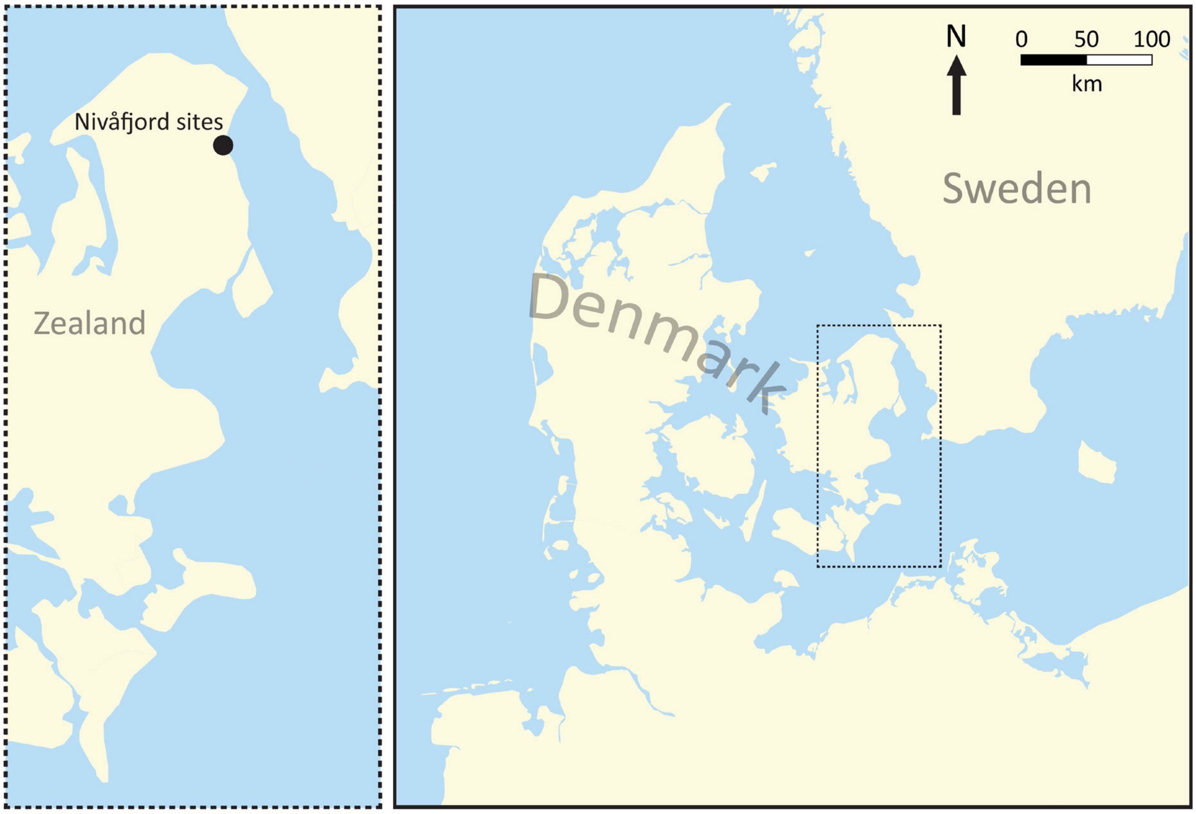

Figure 1. The locations of the Nivåfjord sites (Nivå 10 and Nivågård) on Zealand, Denmark (made with Natural Earth, provider of free vector and raster map data at naturalearthdata.com).

a combined analytical approach was undertaken to reconstruct Mesolithic life and death around prehistoric Nivåfjord.

We undertook a biomolecular study, including stable isotope and proteomic analyses of the human remains from Nivå 10 as well as human and faunal remains from Nivågård. The purpose of these analyses was multi-fold. Firstly, we aimed to determine the sex of as many of the individuals as possible, and in particular the non-adult individuals for which morphology-based sex determination is seldom reliable. Secondly, we aimed to obtain both dentine and bone collagen stable isotope data from as many of the human burials as possible in order to investigate the individuals' life histories as well as diet and other aspects of their lives. Finally, we aimed to contextualise the above data through the bone collagen stable isotope analysis of faunal remains in order to investigate the local environment, mobility, and other factors.

The Sites

Nivå 10 and Nivågård are just two of *c*.24 Stone Age sites located around what was formerly a multi-branched inlet on the northeast coast of Zealand, Denmark (Lass Jensen 2003), *c*.30 km north of present-day central Copenhagen. The inlet was formed by rising sea levels during the Atlantic chronozone (e.g. Christensen 1995), and would have been an economically productive environment for coastal hunter-gatherer-fishers (e.g. Paludan-Müller 1978). Due to the heightened sea level during the Stone Age, settlements were placed on higher ground within the landscape, a landscape that is and has since been threatened by modern agricultural practices (Lass Jensen 2003). Consequently, excavations were initiated in the 1990s, continuing into the 2000s, to investigate the character of the Stone Age settlements along the palaeoinlet before evidence of prehistoric activity was lost (Lass Jensen 2016).

Nivå 10 appears to have been located on a small island on the southernmost margin of the mouth

Figure 2. Several of the individuals sampled in this study. A: The Nivågård child (Photo: by Povl Merløe). B: The Nivågård child at exhibition (Photo: Museum Nordsjælland). C: Inhumation burial (Grave No. A161) at Nivå 10, including the remains of an adolescent/young adult female (Individual M) (Photo: Museum Nordsjælland). D: Inhumation burial (Grave No. A122) at Nivå 10, including the remains of a young middle/old middle adult (Individual L) (Photo: Museum Nordsjælland). E: Inhumation burial (Grave No. A124) at Nivå 10, including the remains of a young/young middle adult male (Individual K) (Photo: Museum Nordsjælland). F: Double inhumation burial (Grave No. A129) at Nivå 10, including the remains of a young/young middle adult male (Individual H) and a child (Individual O) (Photo: Arnold Mikkelsen). G: Double inhumation burial (Grave No. A151) at Nivå 10, including the remains of a young/young middle adult male (Individual F) and a young middle/old middle adult female (Individual G) (Photo: Arnold Mikkelsen). H: Inhumation burial (Grave No. A162) at Nivå 10, including the remains of an old middle/mature adult (Individual N) (Photo: Museum Nordsjælland).

of the inlet (Lass Jensen 2016). The site was in use from 6000 until *c.*4800 cal BC (see Absolute Dating), corresponding to the earliest (Blak phase) Kongemose to the early (Trylleskov phase) Ertebølle (Sørensen 2017; Vang Petersen 1984). Nivå 10 was a settlement, evidenced by four dwellings, two dated to the Kongemose and two to the Ertebølle (Lass Jensen 2003, 2009, 2016). Excavations have yielded one of the more convincing examples of an Ertebølle dwelling throughout southern Scandinavia, a sunken feature with clearly defined activity areas (Lass Jensen 2001). Within the settlement area, 12 burials containing 15 individuals were discovered, including three cremations (Lass Jensen 2016). Since the burials were associated with the dwellings, and were located within the settlement, they probably do not represent a formal burial ground, very similar to the pattern at Vedbæk-Bøgebakken (see e.g. Meiklejohn et al. 1998). Their placement also likely indicates that they are not contemporaneous, but instead reflects the duration of occupation represented by the dwellings. Moreover, there is some evidence for the deliberate disturbance of one of the inhumation burials in prehistory, while the placement of human remains within one dwelling potentially served a ritual purpose (Lass Jensen 2009). Three of the inhumation burials contained more than one individual (e.g. Figure 2). A summary of the inhumation burials and cremations is provided in Table 1 (see Supplementary Material).

The second site, Nivågård, is *c.*100 m to the west of Nivå 10 (Lass Jensen 2001; Rasmussen et al. 2009), and is one of the very few Mesolithic sites from eastern Denmark with deposits of marine shells. Despite this, it is not regarded as a kitchen midden *sensu stricto* (Lass Jensen and Møller Hansen 1998). The site is considerably larger than Nivå 10 (Rasmussen et al. 2009). The preservation of organic remains on sites with depositions of shells is typically excellent, likely because the shells act as a buffer against acidic soils (e.g. Gron et al. 2015). During the course of excavations, an inhumation burial containing a single well-preserved skeleton of a 5 to 8 year-old child was discovered (Alexandersen et al. 1998; Lass Jensen and Møller Hansen 1998).

Comment is needed on the Nivågård child and its identification, especially related to the two initial descriptions of the find (Alexandersen et al. 1998; Lass Jensen and Møller Hansen 1998). The second of these provides an overview of the cultural context and associated archaeology, the first a limited description of the find, focusing most clearly on the teeth and sex of the child. Lass Jensen and Møller Hansen (1998) briefly mention a 5-year-old male child with a stature of *c.*95 cm, and imply that both dental and postcranial data support this conclusion, though with the caveat that the gender is difficult to determine. Alexandersen et al. (1998) focus more tightly on the skeletal material, though primary focus is on the teeth. Identification of the child as male is described as possible. Determination of the age as 5 years old is clearly framed in understanding that 'teeth are generally more sensitive age indicators than bones' (Alexandersen et al. 1998, 27; 'tænder generelt er mere følsome aldersindikatorer end knogler'). However, it is also made clear that osteological markers involving fusion of the skull, the vertebrae and the ischial and pubic bones of the pelvis give an age range of 6 to 7, while unpublished analysis undertaken since identified an ossified navicular bone of the left hand, with full ossification seldom occurring before the age of 8. The mix therefore suggests an age range of 5 to 8 years, with closer accuracy being problematic. It also needs to be noted that the sex suggested by Lass Jensen and Møller Hansen (1998) assumes the accuracy of the age determination of 5. If the older assessment is correct, it becomes quite possible that the child is small for its age. There is no simple solution for this conundrum.

Additional comment is required on identifying the child's remains as male, and the broader issue of the accuracy of determining the sex of sub-adult individuals from the analysis of skeletal remains alone. The answer seems to be that though differences can be detected if large sample sizes are studied, the accuracy of assessment for individual skeletons remains low, with the probability of a successful assessment generally < 70 %, consistently less than half the probability of accurate assessment in adult material (Byers 2008). In addition, there are differences in accuracy dependent on the population under study. Applied to the issue of assessing sex in Mesolithic Danish children, the low number of well-preserved remains makes any comparisons of minimal value. Current opinion suggests that the only markers of value are those involving pelvic details, the auricular surface of the ilium and depth of the sciatic notch (Byers 2008). In the case of the Nivågård child the initial assessment as male was based on more general features, not accepted under present standards. Though not considered in the initial 1998 publications, the final identification of the sex of the child (see below) affirms the degree that osteological identification of sub-adult age is problematic.

Finally, we wish to clarify use of the term child in identifying the Nivågård sub-adult. We do so since the terms juvenile and adolescent have also been used by some for individuals in the age range of the sub-adult, 5 to 8 years of age. In this study we follow a slightly modified version of the standards of Buikstra and Ubelaker (1994), with children identified as aged 1 to 12 years, older than infants (0-1 year) and younger than adolescents

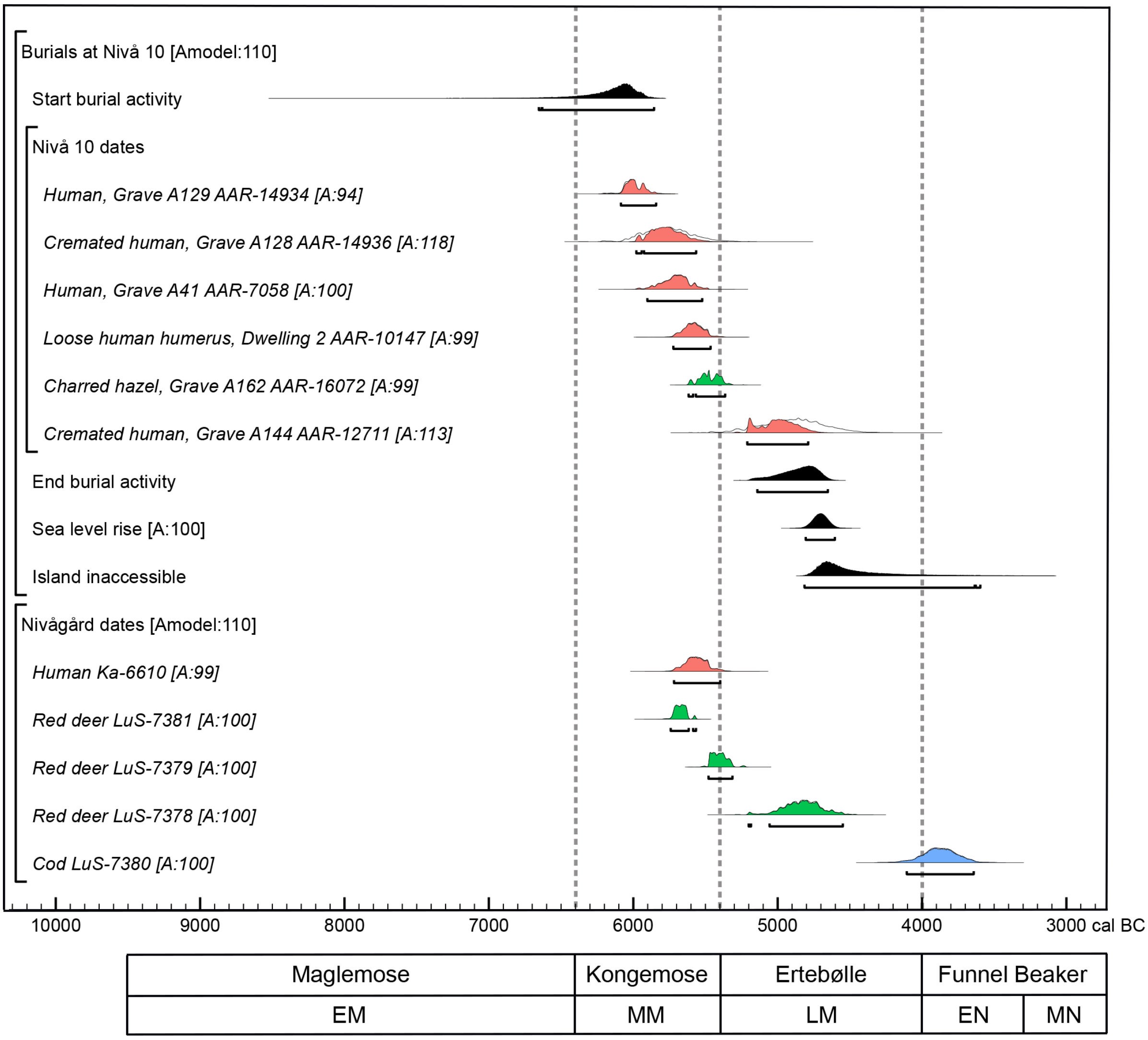

Figure 3. OxCal model output of ^{14}C dates from both Nivå 10 and Nivågård, as shown in Table 2. The chronological order of individual samples is sorted by estimated calendar date (full OxCal CQL code is provided in the Supplementary Material). Legend: red – use of a mixed calibration curve, including a ΔR value of -234±61 ^{14}C years (Fischer and Olsen 2021; see text); green – use of the IntCal20.14c calibration curve (Reimer et al. 2020); blue – use of the Marine20.14c curve (Heaton et al. 2020), including a ΔR value of -234±61 ^{14}C years (Fischer and Olsen 2021); EM – Early Mesolithic; MM – Middle Mesolithic; LM – Late Mesolithic; EN – Early Neolithic; MN – Middle Neolithic.

(12 to 18 years); the term juvenile is not used by Buikstra and Ubelaker (1994). These ranges and descriptive terms are also similar to that given by Lewis (2011) and were also used by Gron et al. (2022) in identifying children's remains at the Late Mesolithic mass burial site of Strøby Egede, Zealand, Denmark.

Absolute Dating

To refine the sites' chronologies, a total of 11 legacy radiocarbon ^{14}C dates (Enghoff 2011; Lass Jensen 2009, 2016; Rasmussen 1998) were modelled in OxCal (Figure 3). The six dates from Nivå 10 were obtained from five human remains and a piece of charred wood (*Corylus* sp.), which was recovered from between the femurs of Individual N in Grave No. A162, while the five from Nivågård were obtained from the inhumation burial as well as the remains of three red deer (*Cervus elaphus*) and one Atlantic cod (*Gadus morhua*) from settlement layers (see Table 2 in the Supplementary Material for further information).

OxCal v.4.4.4. was used to implement the model (Bronk Ramsey 2009). The ^{14}C ages of the human remains were calibrated using OxCal's Mix_Curves function (i.e. IntCal20.14c and Marine20.14c (Heaton et al. 2020; Reimer et al. 2020)), including a ΔR value of -234 ± 61 ^{14}C years (Fischer and Olsen 2021), taking into consideration the measured $\delta^{13}C$ values (when present) for specifying the proportion of each curve. The $\delta^{13}C$ values were used to determine the proportion of marine protein in the diets of the humans by applying the linear $\delta^{13}C$ model described by Arneborg et al. (1999) and applied by Fischer et al. (2007). We used a $\delta^{13}C$ value of -10.1‰ for a 100% marine diet and -21.7‰ for an entirely terrestrial diet. Cremations were calibrated using a mixture of the IntCal20.14c and Marine20.14c curves in an unknown ratio. In contrast, the ^{14}C ages of the charred wood and red deer were calibrated using the Northern Hemisphere atmospheric calibration curve, IntCal20.14c (Reimer et al. 2020), while the ^{14}C age of the Atlantic cod bone was calibrated using the same function and ΔR value as given above for the human remains. All reported calibrated date ranges have been rounded up or down to the nearest 10; for details of the OxCal model definition, see the Supplementary Material.

The modelled data are all reported at 95.4% confidence. The earliest inhumation burial at Nivå 10 dates from the Blak to Villingebæk phases of the Kongemose (Grave No. A129; Individual H; AAR-14934; 7265 ± 38 BP; 6080-5840 cal BC). Then, the cremation burial (Grave No. A128; AAR-14936; 7035 ± 35 BP; 5980-5560 cal BC) as well as deposition of Individual A (Grave No. A41; AAR-7058; 6900 ± 60 BP; 5900-5520 cal BC) and the loose humerus from within Dwelling 2 (AAR-10147; 6868 ± 46 BP; 5720-5460 cal BC) took place during the Villingebæk to Vedbæk phases of the Kongemose. A charred piece of hazel wood recovered from Grave No. A162 dates Individual N to the boundary between the Vedbæk phase of the Kongemose and the Trylleskov phase of the Ertebølle (AAR-16072; 6518 ± 60 BP; 5620-5360 cal BC). After an apparent hiatus of at least a century, a further cremation took place during the Trylleskov phase of the Ertebølle (Grave No. A144; AAR-12711; 6154 ± 45 BP; 5210-4790 cal BC). The calibrated date range for this sample has been constrained in our model by sea level rise, which would have made the island inaccessible from *c.*4700 cal BC onwards. Corroborating this is a lack of archaeological evidence, for instance flake axes or ceramics, demonstrating occupation during the Stationsvej or Ålekistebro phases of the Ertebølle, and it seems likely the settlement was abandoned prior to *c.*4700 cal BC.

At Nivågård, the child (Ka-6610; 6845 ± 65 BP) was buried between 5720-5400 cal BC, overlapping with several of the Nivå 10 inhumation and cremation burials on the boundary between the Villingebæk and Vedbæk phases of the Kongemose. The site, however, appears to have been sporadically used, probably for short-term occupations, as demonstrated by three red deer bones recovered from settlement layers that date to 5740-5570 cal BC (LuS-7381; 6770 ± 50 BP), 5480-5310 cal BC (LuS-7379; 6435 ± 50 BP) and 5200-4550 cal BC (LuS-7378; 5940 ± 100 BP), the Villingebæk-Vedbæk boundary of the Kongemose, the Kongemose-Ertebølle boundary and the Trylleskov-Stationsvej boundary of the Ertebølle respectively. Based on the date obtained from an Atlantic cod bone (LuS-7380; 5400 ± 50 BP; 4100-3640 cal BC), Nivågård was visited around the time of the Neolithic transition.

Sex Identification from Skeletal Remains – some comments

Before proceeding to peptide sex determination, comment is needed on why and whether such approaches can take precedence over direct observation of skeletal remains. We focus here on determining sex in adults and on southern Scandinavian Mesolithic human remains. Determination of sex in sub-adults from simple observation is much less accurate. Determining sex in adults is primarily based on growth patterns in later adolescence and early adulthood, features that are not clearly developed in sub-adults, especially children, and especially in the pelvis, the most accurate region of the skeleton for sex identification.

Determining sex in reasonably complete adult skeletal material is often seen as straightforward, and in many cases is just that. However, this cannot always be assumed, as patterns seen in material from one region do not always apply equally to other regions, including sexual dimorphism. As well, some individuals show non-diagnostic patterns and identifying individuals falling into such categories is not always obvious. Errors in sex identification in reasonably complete skeletons range between five and 15 percent in samples of significant size, in part reflecting sexual dimorphism or its absence. Presence of reasonably complete pelves is critical, as differences in this region are largely sex dependent, whereas differences in other regions reflect both sex and size. An example is seen in Figures 2A and 2B, of the Nivågård child, which show no features that are sex as opposed to age related. Figures 2D through 2H are of Nivå adults, with Figures 2D and 2E (Grave Nos. A122 and A124) showing individuals with little to no visible morphological features. Figures 2F, 2G and 2H (Grave Nos. A129, A151 and A162) are in various states of completion and preservation and all three show pelvic remains, though in poor (Figure 2H) and medium condition (Figures 2F and 2G). As shown in Figure 2, none are sufficiently preserved to allow accurate sex determination with strong confidence. That this is not site specific can be seen in two cases from the Vedbæk-Bøgebakken Mesolithic series, with 16 individuals that are fully adult. Of these, four or a quarter of the total number of adults, have sex identifications marked with a question. The type of problems that occur can be seen in two of the better-known burials, 19 and 22. The simpler is burial 22, one of the best preserved at Bøgebakken, a 40- to 60-year-old female. Diagnosis from the pelvis is clear, with all regular features scoreable and providing an overall score of -1.94 out of a maximum possible of -2.0. However, if the pelvis was absent the other clearest diagnostic would be cranial, with a score of +0.47/+2.0, almost fully in the expected male range. A more complex case is the triple burial 19, with two adults, 19A and 19C, and a child, 19B. Widely described in the literature as a male, a female and their child, the original description (Albrethsen and Brinch Petersen 1976, 14) states that '… sex of the skeletons … cannot be established on anthropological criteria with any certainty', though both adults are reasonably complete. However, both adults have incomplete pelves, with sex primarily based on secondary features, 19A, largely identified as male, in part due to a bone point lodged in the thoracic vertebrae, while 19C, identified as female has associated grave goods compatible with such a diagnosis. However, closer examination shows several discrepancies. Besides being younger, 19A is at the lower end of stature for males at the site, and the cranial composite score is -1.11/2.0 with all markers in the female range. The composite score for 19C is -0.45 with one feature at +3, a robust glabella, usually seen as a male marker. 19C, despite the associated grave goods, is the more robust, and 19A is apparently female, despite possibly being murdered. As suggested by Meiklejohn et al. (2000, 228; see also Tilley 1996, 39) it is '… conceivable that the burial consists of two females, if both the gendered identification and the normative pattern of robusticity are correct'. Clearly, identification of sex using simple observation and association with non-biological features has potential for error.

Peptide Sex Determination

Determination of sex of human remains can be performed on the basis of morphology, metrics, and aDNA. However, it is not always possible to apply these methods, and the latter relies on sufficient organic preservation, is destructive, and can be time consuming and expensive (Stewart et al. 2017). Fortunately, an acid etch peptide-based method for determination of sex on the basis of sexually-dimorphic chromosomally-linked amelogenin peptides in tooth enamel can accurately determine sex in a less-destructive way and one that works despite poor organic preservation and on sub-adult remains (Gowland et al. 2021; Stewart et al. 2017).

In order to determine the sex of the individuals from Nivå 10 we applied the method described by Stewart et al. (2017). Given the poor preservation, including the presence of cremations, it was not possible to sample every individual, while some were not available for analysis as they were on museum display. In total, eight individuals from Nivå 10 were sampled (Table 1, see Supplementary Material). Furthermore, we sampled the permanent mandibular central (R) incisor of the

Nivågård child. Upon inspection under a microscope it was discovered that a consolidant had been applied to the tooth (unbeknown to the curator), which was subsequently removed using an acetone-soaked cotton swab.

Stable Isotope Analysis

Nivå 10

Not all skeletal remains from Nivå 10 were available, accessible, and appropriate for stable isotope analysis. In total, nine bone and dentine samples were chosen, deriving from six individuals (see Supplementary Material, Table 3). For three individuals, both a tooth and a bone sample were selected in order to determine life-history differences between early life and the period preceding their deaths. Although radiocarbon dating had previously demonstrated that collagen preservation was poor (i.e. insufficient quantities of collagen for measurement, see Table 1; Lass Jensen 2009), the analyses were undertaken since tooth dentine is denser than bone collagen. Elsewhere, collagen has been successfully extracted from tooth dentine when bone collagen extraction has failed. The initial goal was to sample tooth dentine sequentially for the determination of a sequence through a restricted period in several individuals' lives (e.g. Beaumont et al. 2013). However, during demineralisation (see Results) the dentine samples lost their structural integrity and essentially 'melted' into sludge. The decision was therefore made to treat this sludge as a sample.

The bone and tooth samples were first cleaned of obvious surface contamination using a high-speed tungsten-tipped dental drill. For the teeth, where practicable, the remaining enamel was removed from the crown using a diamond-tipped dental saw. Peptide etching took place prior to stable isotope analysis and the results were confirmed before demineralisation. Samples were prepared using a modified Longin (1971) method (Ambrose and DeNiro 1986; O'Connell and Hedges 1999; DeNiro 1985) in the Stable Isotope Laboratory within the Department of Archaeology at Durham University. Once extracted, dissolved collagen was freeze-dried and measured by Iso-Analytical Ltd. (Crewe, Cheshire, UK) for their carbon, nitrogen and sulfur isotope ratios. The samples were analysed using a Europa Scientific EA coupled to a Europa Scientific 20-20 IRMS. Due to the generally larger quantities of collagen required for sulfur measurements, only samples with sufficient collagen yields and acceptable atomic C:N ratios were measured.

Nivågård

To contextualise further, 17 faunal remains from Nivågård were selected for stable isotope analysis. These are listed in Table 4 (see Supplementary Material) and included 14 roe deer (*Capreolus capreolus*) and three wild boar (*Sus scrofa*) bones. Each specimen derived from a different individual. An MNI (Minimum Number of Individuals) based sampling strategy was undertaken using a manual overlap method. A total of 14 roe deer left distal humeri, and three wild boar right calcanei were selected. The samples were prepared and analysed in the same manner as the human samples from Nivå 10.

Results: Nivå 10

Tooth Etch Sex Determination

The teeth from Nivå 10 were very poorly preserved and, in addition, in some cases only a very thin sliver (< 1 mm) of crown enamel remained with the majority of the occlusal chewing surface worn down through attrition. In comparison, the tooth from the Nivågård child was in excellent condition. In total, nine individuals from the two sites were etched to determine their sex. Of these, two etches produced no signal but clear interpretable spectra were obtained for seven: three females and four males were identified (Table 5, see Supplementary Material).

Stable Isotope Analysis

In total, nine bone collagen and dentine samples from Nivå 10 were subjected to stable carbon and nitrogen isotope analysis. Sample and collagen weights, collagen yields, and stable isotope data, including atomic C:N ratios are provided in Table 6

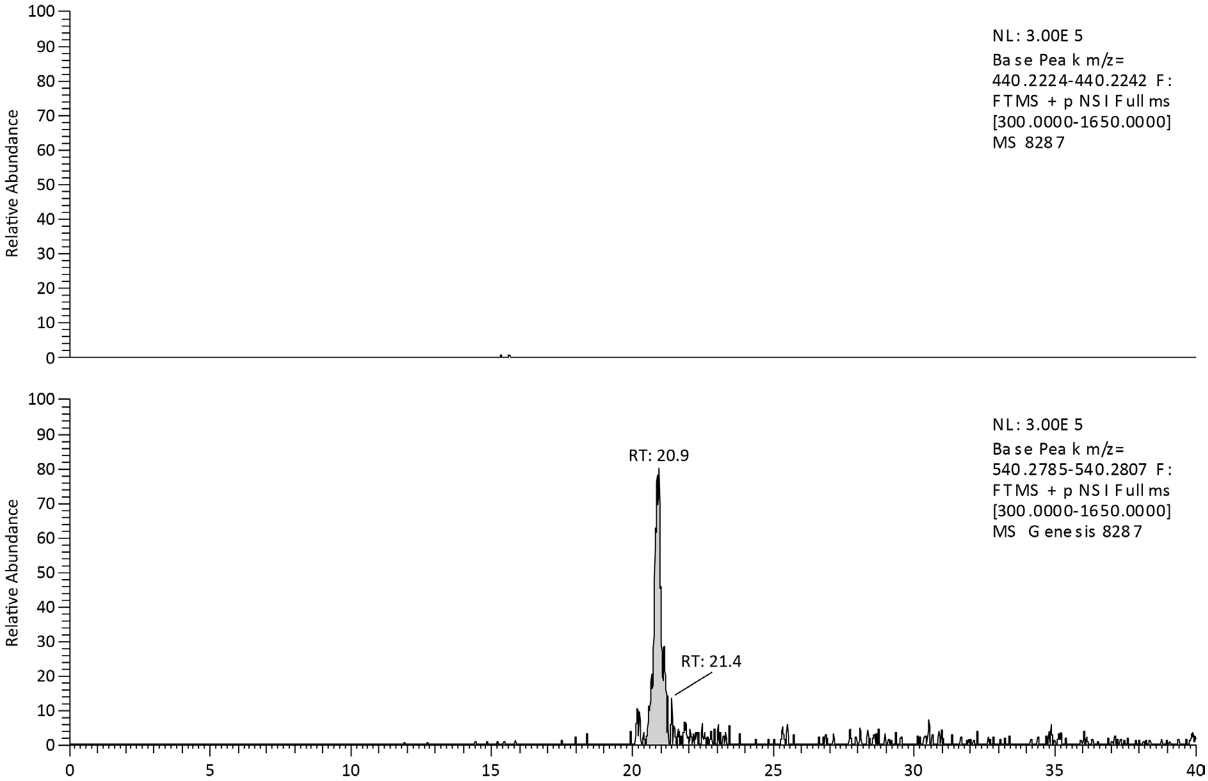

Figure 4. Reconstructed ion chromatograms at 10 ppm mass accuracy for the *m/z* of 440.2224 and 540.2785 for the peptides SM(ox)IRPPY ([M+2H]$^{+2}$, AmelY) (top) and SIRPPYPSY ([M+2H]$^{+2}$, AmelX) (bottom) respectively from the Nivågård child (Sample No. 8287). Since the AmelX isoform was only present, it is deduced that the individual's sex was female.

(see Supplementary Material). The collagen proved to be of low quality, indicating a higher likelihood of diagenesis. Collagen yields were either too low for measurement or the atomic C:N ratios were unacceptable according to the criteria set out by DeNiro (1985), i.e. outside of the range of 2.9-3.6. With one exception (Sample 1160/22), the samples also had insufficient quantities of nitrogen (% N) to permit nitrogen measurements. For these reasons, no acceptable stable isotope data was obtained from the samples from Nivå 10. Consequently, these results will not be discussed further.

Results: The Nivågård Child and Fauna

Tooth Etch Sex Determination

Previous assessments of the Nivågård child's sex, discussed above, assigned it as male (in Danish *dreng*, boy) (Alexandersen et al. 1998). Although peptide recovery was problematic for this sample, on the fifth attempt sufficient peptides were recovered for sex identification of female (Figure 4).

Stable Isotope Analysis

Stable carbon, nitrogen and sulfur isotope analysis was undertaken on a small fragment of cranium from the Nivågård child in addition to the faunal samples from the site. Sample information and stable isotope data are provided in Table 7 (see Supplementary Material). Analytical error for $\delta^{13}C$ and $\delta^{15}N$ was less than ± 0.2 ‰ and less than or equal to ± 0.2 ‰ respectively. For $\delta^{34}S$, analytical error was less than ± 0.3 ‰. The explicit goal of the analysis of the Nivågård child was to obtain a $\delta^{34}S$ value, which can yield information concerning residency when compared with faunal $\delta^{34}S$ compositions. A single 480.72 mg sample produced 40.13 mg of collagen, and a collagen yield of 8.3 %. Atomic C:N, C:S, and N:S ratios were all within the acceptable ranges of 2.9-3.6 (atomic C:N ratio), 600 ± 300 (atomic C:S ratio) and 200 ± 100 (atomic N:S ratio) proposed by DeNiro (1985) and Nehlich and Richards (2009), indicating no sign of diagenesis. Eleven of the roe deer specimens yielded sufficient quantities of collagen for stable carbon and nitrogen isotope analysis (Table 7, see Supplementary Material) and of those, four were analysed for their $\delta^{34}S$ ratios. Two of the three wild boar specimens had unacceptable atomic C:N ratios (DeNiro 1985; Table 7) and are not considered further, while the remaining wild boar sample yielded enough collagen to measure all three isotope ratios. The 11 roe deer specimens had mean $\delta^{13}C$ and $\delta^{15}N$ values of -22.7‰ (SD = 0.89‰) and 4.0‰ (SD = 0.92‰) respectively, while the four roe deer specimens had a mean $\delta^{34}S$ value of 9.0‰ (SD = 2.48‰).

Discussion

The sex of seven individuals from Nivå 10 and Nivågård was determined. In all cases with previous determinations on a morphological basis, these agreed with the enamel peptide determination (Table 5). Two individuals that previously did not have securely assigned sex, Individual L (Grave No. A122) from Nivå 10 and the Nivågård child, were both identified as female based on enamel peptides.

The $\delta^{13}C$ values of the Nivågård herbivores indicated residency in both open and closed environments (e.g. Gron and Rowley-Conwy 2017; Figures 5A and 5B), and were likely hunted from a range of habitats. The wild boar has the highest $\delta^{13}C$ value among the terrestrial fauna, probably representing an individual living in an open environment with a partly omnivorous diet (Masseti 2007). For all taxa, the $\delta^{15}N$ values are typical for southern Scandinavian Mesolithic fauna (Gron and Rowley-Conwy 2017).

In comparison, fewer $\delta^{34}S$ values were obtained (Figure 5B; Table 7). Despite the broad range (+5.8‰ to +11.7‰), the $\delta^{34}S$ values reflect terrestrial diets (below *c.*+12‰) according to Nehlich (2015). However, the roe deer $\delta^{34}S$ values (+5.8‰ to +11.7‰) likely indicate that they resided in a number of locations, ranging from areas likely affected by sea spray and marine precipitation (marine sulfates) to saltmarshes (sulfide-derived) (Guiry et al. 2021a; Lamb et al. 2023; McArdle et al. 1998). Similarly, the wild boar probably used saltmarshes based on its $\delta^{34}S$ value of +7.2‰. In comparison, the Nivågård child is likely to have consumed animals that were sulfide-derived (Guiry et al. 2021a), such as fish that live in seagrass meadows (Guiry et al. 2021b).

Given the slow collagen turnover rates in cranial bones (Fahy et al. 2017), the isotope values of the Nivågård girl should encompass the entirety of her life. Her $\delta^{13}C$ value of -13.8‰ (Figure 5A) indicates consumption of marine-derived protein, reflecting the absence of C_4 plants in Mesolithic Northern Europe (see Fischer et al. 2007). Moreover, the $\delta^{13}C$ value is similar to one obtained previously (-13.5‰, Rasmussen 1998). Indeed, the consumption of large quantities of marine protein was commonplace during the Late Mesolithic of southern Scandinavia. When compared with contemporary individuals from the region (Fischer et al. 2007), the Nivågård girl seems to have enjoyed a similar diet.

Although the $\delta^{34}S$ value of 6.9‰ of the Nivågård child (Figure 5B) is somewhat at odds with the high marine protein diet demonstrated by the $\delta^{13}C$ and $\delta^{15}N$ values, it likely indicates the consumption of sulfide-derived resources (Guiry et al. 2021a; Guiry et al. 2021b). Further stable sulfur isotope analysis of human and faunal remains from throughout the region is required to identify the drivers behind higher $\delta^{13}C$ and $\delta^{15}N$ values and lower $\delta^{34}S$ values.

Conclusions

A primary goal of archaeological research is to investigate past life-ways. The development of new methods allows even poorly preserved archaeological remains the potential to yield new lines of evidence, enriching our understanding of ancient economic and social systems. Nivå 10 falls into this category. Despite the lack of sufficiently well preserved bone collagen, our proteomic investigations of the human remains have confirmed the sex of several of the individuals and assigned to the same to a further individual, which had not previously been assigned a sex.

At nearby Nivågård, better-preserved bone collagen of both the inhumation burial of the child and the faunal remains has yielded crucial stable isotopic data. The presence of fauna, probably

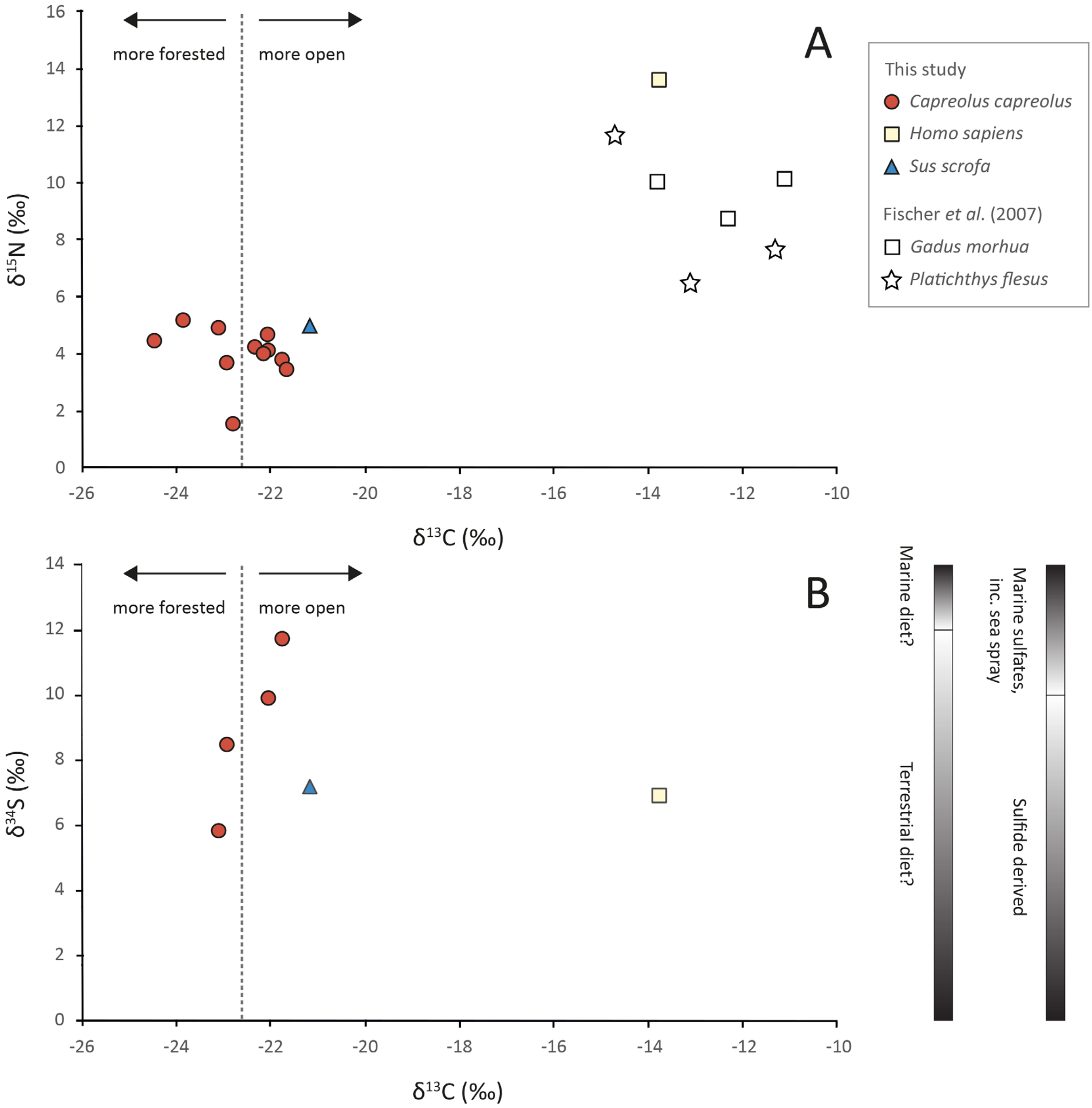

Figure 5. Bone collagen isotope data from Nivågård. $\delta^{13}C$ and $\delta^{15}N$ data obtained from Atlantic cod and European flounder bone collagen are also included for comparison (see Fischer et al. 2007; Table 7, Supplementary Material). A: Plot of $\delta^{13}C$ and $\delta^{15}N$ values. B: Plot of $\delta^{13}C$ and $\delta^{34}S$ values.

originating from several places and a range of environments, speaks to the richness of the local resource base, while the $\delta^{34}S$ values illustrate that they were exploited from both sea spray-affected areas and saltmarshes. The disconnect between a high marine protein diet, demonstrated by the $\delta^{13}C$ and $\delta^{15}N$ values, but absence of a marine $\delta^{34}S$ value, often cited as being derived from consumed protein, warrants further investigation. In determining the sex of the Nivågård child we hope to have returned even a small part of her identity to them and demonstrated the utility and value of revisiting older collections with novel analytical methods.

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Supplementary Material

Supplementary Material see also .xlsx- and .doc-attachment

Table captions:

Table 1. The Nivå 10 and Nivågård inhumation burials and cremations. Note that the loose human bones are not listed, though see Table 2. Those assigned an 'Etch Lab #' were subjected to an acid etch peptide-based method for determination of biological sex, while those assigned a 'Collagen Lab #' were subjected to stable isotope analysis. Note that when 'Age at Death' data were provided, the 'Age Classes' were standardised following Buikstra and Ubelaker (1994) and Lewis (2011) with alterations (Malin Holst personal communication).

Table 2. Radiocarbon dates from Nivå 10 and Nivågård, sorted by estimated calendar date. The calibrated dates of samples were obtained by the OxCal v.4.4.4. model provided in the Supplementary Material, as described in the text. The estimated % marine diet indicated was based on a linear $\delta^{13}C$ model (see Arneborg et al. 1999; Fischer et al. 2007), while their Bayesian updated values used in calculating the calibrated age range are in parentheses.

Table 3. Sample information for the Nivå 10 inhumation burials.

Table 4. Sample information for the Nivågård fauna.

Table 5. Nivå 10 and Nivågård tooth etch-based peptide sex determination results. Note that the osteological sex determinations are given for comparison. UND denotes undetermined due to a lack of peptide recovery.

Table 6. Nivå 10 stable isotope data. Key: struck through – sample yielding an atomic C:N ratio outside the acceptable range of 2.9-3.6 (DeNiro 1985).

Table 7. Stable isotope data from the Nivågård child and fauna, including previously published data obtained from Atlantic cod (*Gadus morhua*) and European flounder (*Platichthys flesus*) bone collagen (Fischer et al. 2007). Note that sulfur was not run in duplicate due to the amount of collagen required for analysis. Key: struck through – sample yielding an atomic C:N ratio outside the acceptable range of 2.9-3.6 (DeNiro 1985).

Re-evaluating 'Denmark's Stonehenge'

Bronze Age communal activities in a distinctive landscape setting

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ABSTRACT

In 1965, an aerial photograph from eastern Denmark revealed three concentric circles surrounding a large hill. In the following years, the National Museum conducted two small excavations, which seemed to confirm that these circular marks reflected concentric circles of features and large stone holes, but the reports were never completed. The site was later classified as a 'stone- or woodhenge'.

In this paper we assess the interpretation of the aerial photograph and archaeological features around the prominent hill based on a re-excavation and ground-penetrating radar survey of a part of the site. While no circular structures can be identified, we argue that clusters of fire pits at the side of the steep hill represent communal activities from the Bronze Age, which combines the transformative elements of fire with the distinctive landscape of the large hill and the surrounding burial monuments. The site thereby serves as an example that links prominent hilltops surrounded by burial mounds, with the event of establishing fire pits in clusters.

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Introduction

In the spring of 1965, an aerial photograph taken near Kalundborg in western Zealand by the Danish Geodetic Institute, revealed three large concentric circles of crop marks surrounding the large hill Overdrevsbakken. The outer circle is approximately 320 m in diameter and the inner circle 220 m (Figure 1). At the centre is a protected Late Neolithic tomb and scattered by the sides and foot of the hill are several Bronze Age burial mounds and Neolithic dolmens, reflecting a high degree of prehistoric activity in the area (Figure 2). The photograph was presented to archaeologist and Curator at the National Museum of Denmark Thorkild Ramskou in 1967. Two years later, he initiated the first of two small excavations at the site, drawn by the hypothesis that the circular crop marks could reflect holes and foundations of now missing stones (Ramskou 1970, 61).

While Ramskou published two articles to the public about the site, he never completed reports of the excavations. In the articles, Ramskou concluded that the excavations confirmed his interpretation of the site as consisting of three concentric circles of features and large stone holes, mainly corresponding to the aerial photograph (Ramskou 1970, 64, 1972, 17). Consequently, the site was later classified as a Cultural Heritage Site of National Importance, described as a 'stone- or woodhenge'. Given the rarity of this interpretation, the site has continually attracted the attention of amateur archaeologists and the local public. Correspondingly, the area has been avoided in planning new roadworks, assuming it would entail a substantial expense to contract archaeology.

Ramskous interpretations were limited by the methodological challenges that were prevalent at this early point of modern archaeology. As such, the experimental removal of the topsoil was uneven, which might have affected the recording of features (Ramskou 1972, 16). The excavation trench was of limited size compared to the

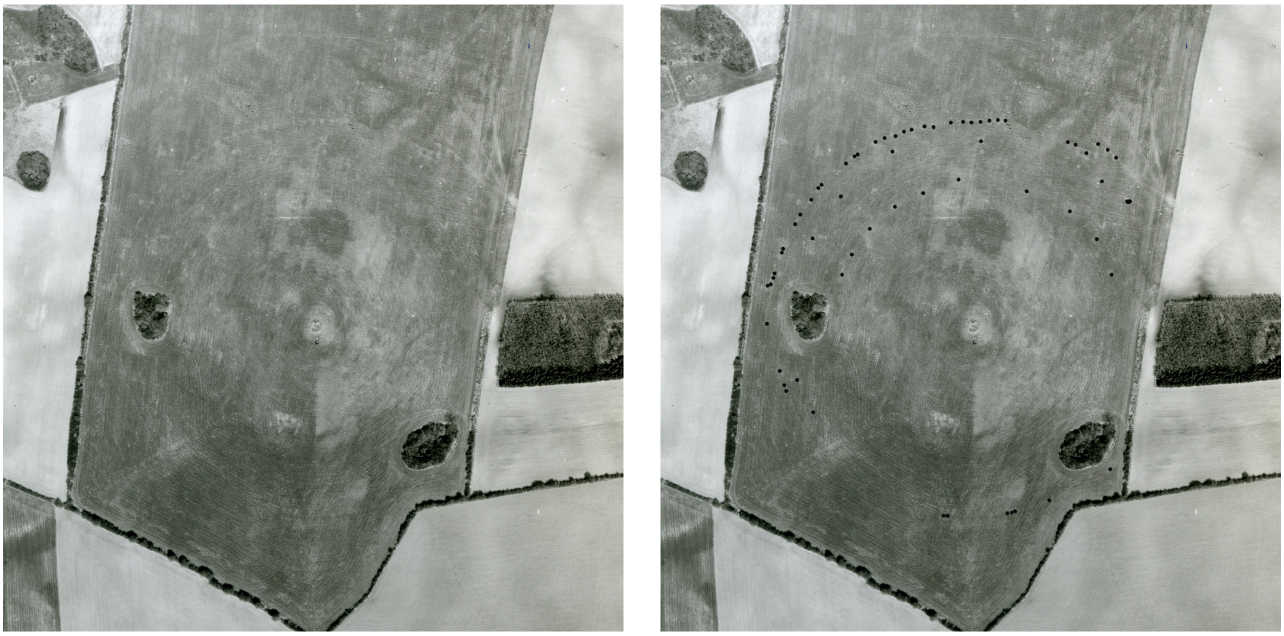

Figure 1. Aerial photograph from 1965 (left) reproduced with the circle structures highlighted by Thorkild Ramskou 1970, 60 (right) (Photo: SDFE).

standards of archaeological excavations today, and the orientation of the trench followed the presumed orientation of the stone holes, making it difficult to assess if there are equivalent features on the outer- or inner side of the circle structure.

The site's categorisation as a stonehenge is spectacular in the context of prehistoric Southern Scandinavia, where no comparable sites are known. In that respect, as the extent of Ramskous excavations was limited, the professional archaeological viewpoint has been sceptical overall. The interpretation of the site as a stonehenge has been reproduced, mainly online, by popular science-, historical and ancient-astronomy internet sites, as well as the description of the site as a stone- or woodhenge in the National Register of prehistoric sites in Denmark[1]. Together with Ramskous two popular articles, these descriptions have initiated discussions and queries about why such an important site is not

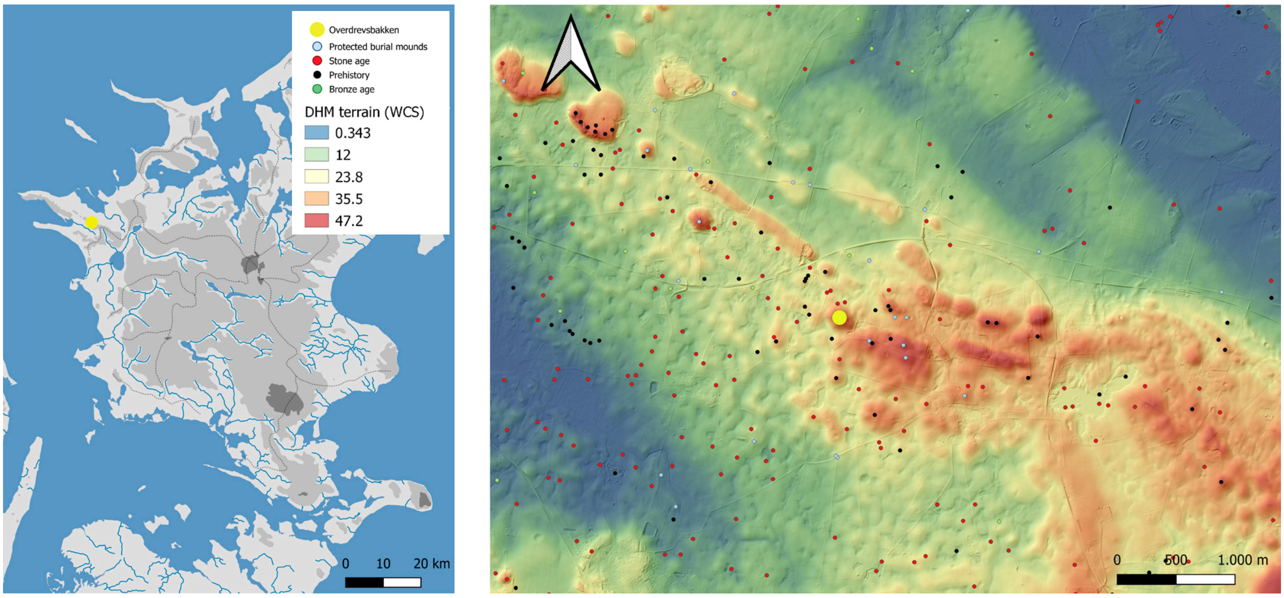

Figure 2. The location of Overdrevsbakken (yellow dot) and surrounding registered prehistoric sites. The hill is situated near Kalundborg on a ridge between Saltbæk Vig and the former Kalundborg Inner Inlet (Graphics: SDFE and digitalised map by Claus Dam).

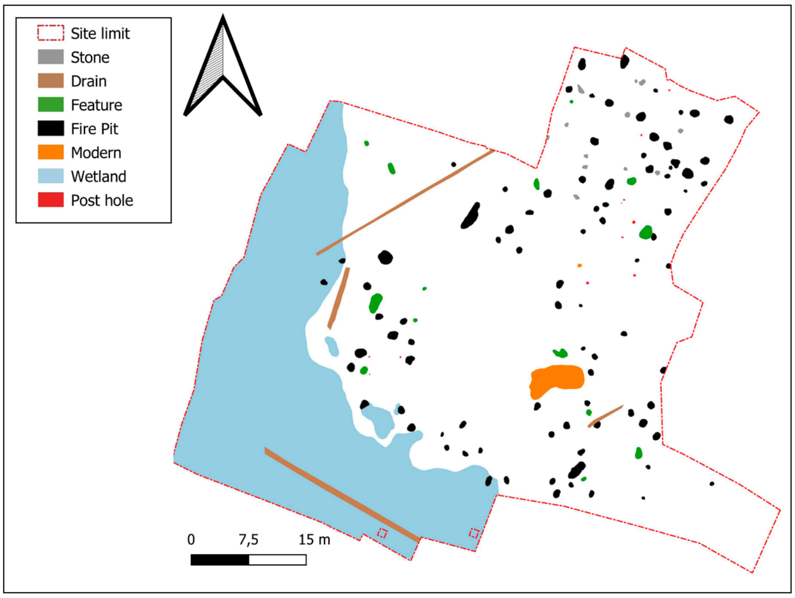

Figure 3. The interpreted excavation site.

properly excavated and made accessible to the public. Therefore, this paper aims to assess the interpretation of the site as a henge-monument based on new information from re-excavation and a ground-penetrating radar survey and suggest possible re-interpretations of the function and role of the site.

The re-excavation of the site

In 2019 the possibility arose for Museum Vestsjælland to conduct a small trial excavation north of the hill. The excavation exposed postholes and features, including stone holes and a few fire pits. Only a thin layer of plough soil covered these, and agriculture strongly affected the preservation conditions of the site.

In order to clarify if the features were arranged in circles around the hill or if they just represented a high degree of prehistoric occupation, it was necessary to examine a larger area. With the financial support of The Danish Agency for Culture[2], this was pursued in the summer of 2021, undertaken as an archaeological excavation of *c.*3000 square m northwest of the hill, combined with a non-destructive geophysical survey of *c.*17.000 square m using a ground-penetrating radar.

The circular structures from the 1965 aerial photograph were georeferenced and marked in the landscape northwest of the hill. The topsoil was removed in an area of *c.*25 x 25 m to expose both sides of the outer and middle circle structure. It became apparent that a dark-soiled wetland area covered one-third of the excavation site. Besides this dark wetland area, 88 fire pits, 12 small postholes and 14 features were uncovered. The features had a light sandy fill, and some might reflect natural rather than cultural events. Similarly, some of the postholes were questionable, and no structures could be recognised in their internal layout. On the contrary, the fire pits were of a solid appearance, generally one m in diameter, 40-50 cm deep with a rounded bottom, containing charcoal and packed with fire-cracked stones. The fire pits were distributed on a large part of the hillside, mainly along the edge of the former wetland area and on the foot of the steep slope by the hill's western side (Figure 3).

As fire pits are the dominant feature at the excavation site, it was necessary to examine if their distribution could have caused the circular structures identified in the 1965 photograph. No obvious circle structure was apparent in the layout of the pits, so it was explored if the depth and fill of fire pits located near the georeferenced marks differed from the other fire pits. This was not the case, as pits of similar size, depth and fill were scattered across the site (Claudi-Hansen 2021a, 11-12). Furthermore, no traces of fire pits or other features were present in the wetland area, where at least three marks should have been located, according to the photograph. Conversely, the wetland area would be expected to appear darker than its surroundings in the aerial photograph if marks of features beneath the soil did, but this was not the case.

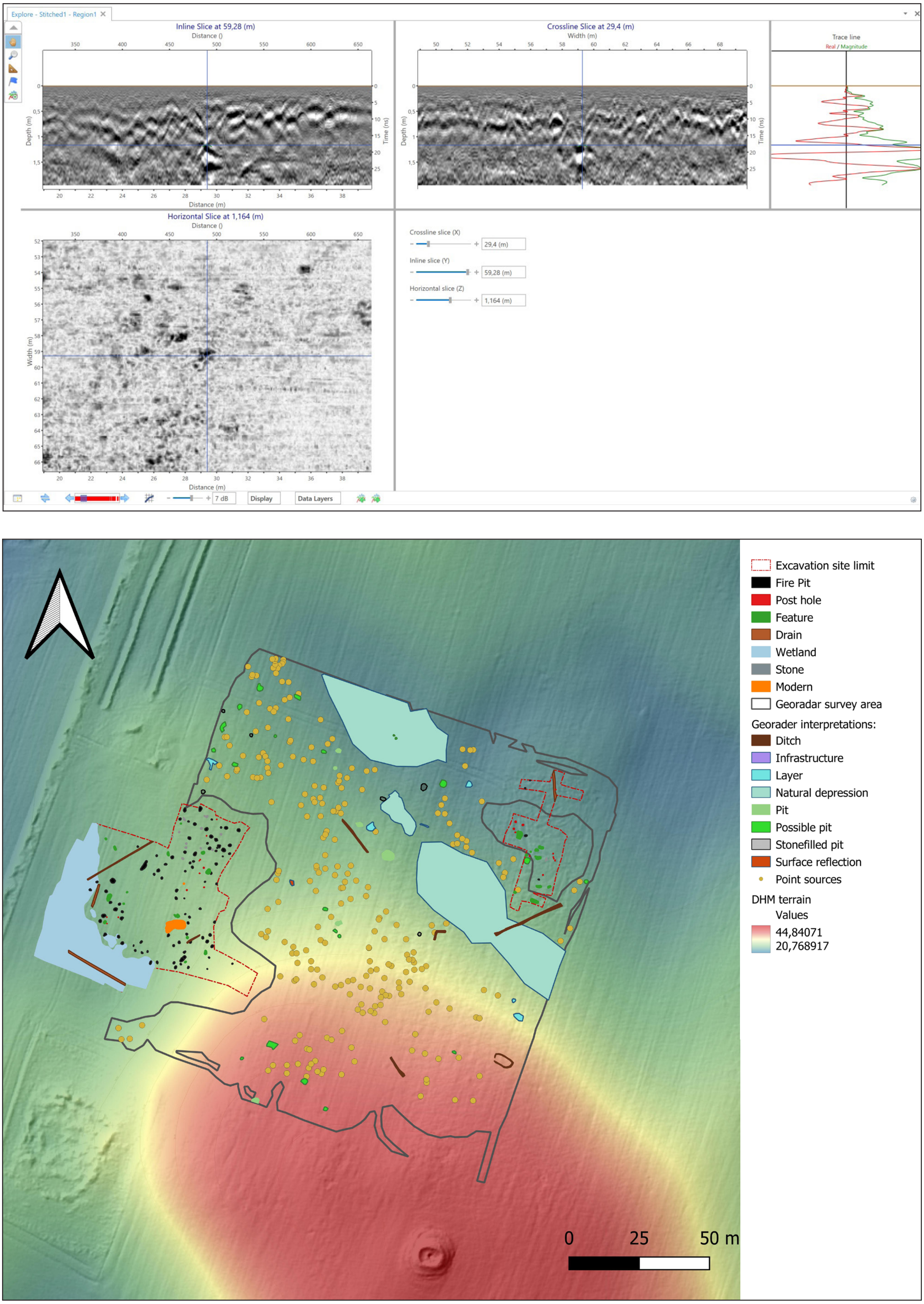

Figure 4. The 2019 and 2021 excavation sites shown with the results of the geophysical mapping and example of anomalies in the geophysical data interpreted as „point sources“, probably containing stones as viewed in both plan and section view above (after Stamnes 2021). Such responses are seen in the map as brown dots. Contains maps from SDFE.

Figure 5. Photograph from Thorkild Ramskou's excavation, illustrating cultivation in circle structures around the hill (Photo: The National Museum of Denmark, Thorkild Ramskou).

The geophysical mapping

A ground-penetrating radar survey investigated a larger area of about 1.73 hectares directly east of the excavation trench, mapping areas and features with an apparent electrical conductivity contrast to its immediate surroundings (Stamnes 2021) (Figure 4). A total of 48 anomalies and 280 point sources were identified and interpreted from this dataset. The anomalies were classified and interpreted based on their geophysical contrast, response, placement, and visual appearance.

The point sources, interpreted as singular natural occurrent rocks, were plentiful. Few of them had a location that coincided with the crop marks observed in the 1967 aerial photo. The same is valid for the anomalies interpreted as pits, stone-filled pits or similar. There were fewer stone-filled pits (interpreted as fire pits) visible in the dataset than expected based on the results from the nearby excavations undertaken simultaneously. Likewise, only a few fire pits were identified in the small trial excavation from 2019 north of the hill. This emphasises that the cluster of fire pits identified in the excavation is restricted to a limited area northwest of the hill. The survey results do not give additional strength in interpreting this site as a circular henge-monument. The geophysical observations are still of archaeological interest, as the interpretation of a pit and a layer close to the possible location of a dolmen or a passage tomb reveals new knowledge about the area and its cultural-historical constituents (Stamnes 2021, 4-23).

Modern-day cultivation marks

The excavation and geophysical mapping results demonstrate that no circular structures can be positively identified. So, what did the 1965 aerial photograph display, and what did Ramskou find? Recently, a box with photographs from Ramskou's excavations was located at the National Museum archives. From the photos, it appears that Ramskous site II is located in the wetland area of the 2021 site, which was partly characterised by concentrations of smaller stones, corresponding to the irregular stone paving described by Ramskou (Ramskou 1970, 64; Claudi-Hansen 2021a, 15-17). Consequently, the described features in this area seem to reflect natural variations and stones in the dark wetland soil.

Among the documents was a sequence of aerial photographs taken during the excavation in 1970 (Figure 5). These illustrate that the field was cultivated in circle structures around the hill and orientated north-south to the north, in the flat part of the field (Ramskou 1970, 60). Prior to the introduction of heavy machinery, this kept the tractor from repeatedly crossing the steep hillside[3]. The reciprocal orientated cultivation of the newly prepared field in the spring of 1965 is likely to have created the observed spots in the photograph.

Clusters of Bronze Age fire pits

While no circular structures could be identified in the excavation or geophysical survey, the cluster of firepits on the steep hillside reflects communal activities that took place in close connection to the many burial mounds on and around the distinctive hill. Nine of the fire pits distributed in different parts of the excavation site have been ^{14}C-dated on identified suitable charcoal (Table 1). The dates from eight fire pits correspond closely and lie between *c.*1200-900 BC (period III-IV of the Bronze Age), while a large flat fire pit of a different character than the others is younger (*c.*795-540 BC/ period V-VI). All of the dates are carried out on charcoal, which might give a slightly older date, depending on the age of the used wood.

Clusters and rows of fire pits are a phenomenon found mainly on prominent hills or close to water in Northern Europe. Their exact function is unknown, but generally, the clusters and linear assemblies of fires are thought to represent social and ritual events in connection to either collective cooking and feasting activities or ceremonial performances involving fire, heat, and steam (Henriksen 2005, 96-99; Kristensen 2008, Martens 2005). Fire is a sensuous element with a highly transformative power in rituals and communal activities (Flohr Sørensen and Bille 2008). The concentration of fire pits is generally detached from the domestic sphere. While clusters are often situated on prominent hills or close to water, the fire pit lines can be seen as axes in the landscape, guiding movement and connecting landscape markers and monuments (Løvschal and Fontijn 2019, 150-153; Kristensen 2008; Schaefer-Di Maida 2022, 476-479).

Overdrevsbakken is situated on a ridge together with other prominent hills, of which several are scattered with prehistoric burial mounds. As the extent of archaeological excavations in the area is low, we know little about what activities that took place in connection to the specific landscape elements and monuments. In the small town of Boeslunde near the coastline *c.*40 km to the south, the distinctive hill Borgbjerg Banke formed the centre of a unique concentration of votive offerings from the Late Bronze Age and rich grave finds from the Early Bronze Age (Jensen 2002, 411-416). Sporadic archaeological excavations in this area have repeatedly exposed the presence of fire pits in both lines pointing towards graves situated on hilltops, and in clusters as the only trace of activities in immediate connection to the impressive votive offerings (Henriksen 2005, 87-88; Claudi-Hansen 2021b, 15-20).

In that light, the clusters of Bronze Age fire pits on the steep north-western hillside of Overdrevsbakken, can be seen as an example of communal activities combining the transformative elements of fire and heat with the atmosphere of the place. This emphasises a spatial conception of – and engagement with – the distinctive landscape of the large hill and the surrounding burial monuments. While several of the burial mounds at the foot of the hill most likely originate from the Bronze Age, the two monuments closest to the cluster of fire pits is re-

Laboratory number	Character	Material	Radiocarbon age BP	Calibrated age 1σ	Calibrated age 2σ
LuS 17744	Fire pit, A90	Charcoal, fagus	2525±35 BP	780-565 BC	795-540 BC
LuS 17745	Fire pit, A163	Charcoal, maloideae	2840±35 BP	1050-925 BC	1115-905 BC
LuS 17746	Fire pit, A191	Charcoal, ulmus, sp.	2790±45 BP	1010-850 BC	1050-820 BC
LuS 17747	Fire pit, A180	Charcoal, corylus sp.	2960±35 BP	1255-1115 BC	1285-1045 BC
LuS 17748	Fire pit, A188	Charcoal, maloideae	2880±35 BP	1120-1005 BC	1200-925 BC
LuS 17749	Fire pit, A122	Charcoal, alnus sp.	2920±35 BP	1200-1045 BC	1225-1005 BC
LuS 17750	Feature, A70	Charcoal, fagus sp.	630±30 BP	1295-1395 AD	1290-1400 AD
LuS 17751	Fire pit, A184	Charcoal, alnus sp.	2890±35 BP	1125-1010 BC	1210-935 BC
LuS 17752	Fire pit, A71	Charcoal, corylus sp.	2860±40 BP	1110-935 BC	1195-910 BC
LuS 17753	Fire pit, A222	Charcoal, corylus sp.	2840±35 BP	1050-925 BC	1115-905 BC

Wood identification: Dendro.dk

^{14}C-dates: Lunds University, Laboratoriet för ^{14}C-datering

Table 1. AMS radiocarbon ages from MVE03541-2 Overdrevsbakken.

spectively from the Early and Late Neolithic, stressing that the events of creating fire pits could relate to spatial markers across a wide range of time.

Concluding remarks

Henges have attracted massive public interest, and an interpretation of Overdrevsbakken as a large henge-monument in an area without any parallels makes this interpretation spectacular. However, without access and insight into excavation results and an understanding of the formation process behind crop marks, it is hard for the public to critically evaluate how sound such an interpretation is. The legend of Overdrevsbakken as a henge has, therefore, continued.

Based on the excavation and the results of the geophysical mapping, however, no circular structures can be identified in the investigated area. The observed marks on the 1965 aerial photograph appear to reflect structures from the field's contemporary cultivation, conducted immediately before the photograph was taken, and not to reflect traces of prehistoric activities preserved underneath the soil. Instead, concentrations of fire pits reveal that communal activities took place on the hillside in the Bronze Age, combining fire and heat with the atmosphere of the distinctive hill and the burial monuments erected on and around it.

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The Danish Agency for Culture is thanked for funding the surveys as part of the resources for documenting archaeological sites prone to cultivation and erosion. The authors are very grateful for the helpful comments from Rune Iversen, Lasse Sørensen, Poul Otto Nielsen and Niels H. Andersen during the excavation process and the collaboration with Kalundborg Arkæologiforening, Camielsa Prévost and the engaged first-year archaeology students from the University of Copenhagen. We would also like to thank The National Museum of Denmark for providing access to Ramskous' material in their archives.

Declaration of interest

The authors declare no conflict of interests.

Notes

1) For example: Videnskab.dk: https://videnskab.dk/kultur-samfund/det-danske-stonehenge-var-et-imponerende-soltempel (2015); Historisk atlas: https://historiskatlas.dk/@55.6639810,11.1953610,16z; Ancient Astronomy.dk: http://www.ancient-astronomy.dk/majmag99.htm.
2) The excavation was funded by The Danish Agency for Culture's resources for the documentation of archaeological sites prone to cultivation and erosion. The full report of the excavation is accessible at Fund & Fortidsminder 030610-123.
3) Jens Kristian Nielsen is thanked for drawing the attention to this.

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Løvschal, M. and Fontijn, D., 2019. Directionality and axiality in the Bronze Age: Cross-regional landscape perspectives on ´fire pit lines´and other pitted connections. *World Archaeology*, 51:1. 140-156. https://doi.org/10.1080/00438243.2018.1488609

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Maglehøj – preservation of birch bark in a passage grave with evidence of forced entry in prehistory

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ABSTRACT

Maglehøj is a Danish passage grave which has birch bark incorporated into its construction. An account of the opening of the monument in 1823 reports the discovery of an earth-free chamber and describes constructional details, including the use of birch bark. An investigation undertaken in 1996, prompted by the information given in this account, revealed that the birch bark was relatively well preserved and that there had been a break-in through one gable of the chamber later in prehistory. This article gives several examples of similar intrusions, which were a more common phenomenon than previously appreciated. The results of the climatic conditions inside Maglehøj's chamber, aimed at optimising preservation of the birch bark, are also presented. The investigation included measurements of air change and humidity carried out under different conditions. The outcome was a recommendation that the entrance to the chamber be closed with an air-tight seal.

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Introduction

Of the many passage grave chambers that, especially in the 18th and 19th centuries, were opened for the first time since prehistory, some were found to be empty of earth, precisely as when they were used and then closed for a final time more than 4000 years ago. Numerous megalithic tombs have been opened in modern times some by farmers and stone masons, others by the landed gentry, clergymen and others with an interest in the past. A few descriptions exist of how these earth-free chambers appeared and were laid out when they were entered. This was, as a rule, through the roof or through the stone layer between the orthostats and capstones. Probably the most detailed and comprehensive account of such an entry into an earth-free passage grave chamber relates to Maglehøj on Stevns, southeastern Zealand. Moreover, out of a total of 14 passage graves where birch bark is present, Maglehøj is the tomb in which the bark is best preserved. An investigation undertaken in 1996 had aims which included clarification of the preservation criteria for the birch bark. This investigation was followed up between 2013 and 2018 by an investigation of the climatic conditions in the chamber directed at establishing optimal conditions for preservation of the bark.

The opening of the passage grave in 1823

The passage grave was opened by the user of the plot of land on which the monument stood, smallholder Lars Rosted, who began to dig away at the mound in April 1823 to gain new cultivable land. In the process, he struck a burial chamber which the vicar in the nearby village of Hellested, Peter Holm (1766-1831), immediately became aware of and was greatly interested in. He followed the work of exposing and entering the chamber, and he submitted two accounts to *Den kongelige Commission til Oldsagers Opbevaring* (i.e. the Antiquities Commission). This was set up in 1807 and its aims included acting to preserve prehistoric monuments. Already in his first report to the commission, Pastor Holm mentions that the chamber in Maglehøj resembled that in Julianehøj near Jægerspris, which was excavated in 1776 (report of 24 April 1823 in the archive of the Danish Agency for Culture and Palaces).

The Antiquities Commission addressed Pastor Holm's first letter at its meeting on 16 May 1823 (Jakobsen 2007, 279) and in their letter of reply included a request to Count Moltke to schedule (i.e. protect) the monument. Lars Rosted continued exposure of the passage grave under Pastor Holm's supervision, and in his next report Pastor Holm gave a thorough description of both the passage grave's earth-free interior and of the monument's construction outside the chamber (report of 16 May 1823). Other contemporary accounts about the opening of passage graves focus especially on the artefact inventory and the skeletal material. What makes Pastor Holm's description unusual and significant is his archaeological observations of the monument's layout and construction. Maglehøj's contents were, however, very modest in comparison to other passage graves.

Together with his report about the opening of Maglehøj, Pastor Holm also submitted the artefacts that had been found. These were incorporated into *Det Kongelige Museum for de Nordiske Oldsager* (i.e. the Royal Museum of Antiquities) with the accession numbers DCCCLXXXVI-DCCCXCIV (i.e. 886-894). The artefacts comprised two flint axes, two flint daggers, six roughouts for arrowheads, some potsherds, samples of birch bark, samples of the white coating on the orthostats and of the reddish soil by the skeletons. Finally, there were also parts of three skulls and some human bones (Thomsen and Thorlacius 1827, 260-262).

Pastor Holm's reports about Maglehøj did not leave their mark in the later archaeological literature – with one notable exception: V. Boye refers to Maglehøj in a note: 'As in Maglehøj in Hellested parish (Stevns hundred, Præstø county), where birch bark was packed between the slabs that filled out the gaps between the chamber's orthostats' (Boye 1862, 339). It was established in 1995 that the birch bark in Maglehøj was still in a relatively intact state. The only other known occurrence of birch bark in a passage grave at that time was in Jordhøj near Mariager, where it was found by V. Boye on opening this monument in 1890 (Dehn and Hansen 2006, 29-31). The rediscovery of relatively well-preserved birch bark in Maglehøj prompted efforts to ensure its optimal preservation. An investigation of the monument was therefore launched in 1996, and Pastor Holm's description of the opening of the passage grave again acquired relevance.

Pastor Holm's report to the Antiquities Commission

It is evident from Pastor Holm's report that smallholder Lars Rosted had dug on the spot for some time 'to gain arable land', before the clergyman heard of the activity. Pastor Holm was, however, apparently given an account of what had happened prior to his involvement. The digging began at the edge of the mound, where skeletons were encountered. Rosted also struck kerbstones and therefore presumed that there could be a 'place of burial' in the mound, so he began to dig in the top of the mound. Here, too, he found skeletons – some of them in 'a stone-built box'. It was first below this that he encountered one of the chamber's capstones and by removing a smaller stone, he was able to look directly into the earth-free chamber. Here, he saw bones lying on a floor covered with small round stones.

Pastor Holm then gives an account of what happened in April in connection with Lars Rosted's digging in the top of the mound and opening of the chamber through the roof:

At a depth of more than 3 alen [1.9 m]*, he encountered stones and found there, in a box built of small stones, approximately 3 quarter* [0.5 m] *square, a skull that on the least contact crumbled away; otherwise, there was only earth in the box. Immediately below this he encountered a very large boulder beside which a smaller flat stone was taken up, whereby there came an opening into the grave chamber from above, through which opening he clearly enough could glimpse the white human bones and the neat, smooth stone layer of small round beach pebbles, on which the bones lay.*

When Rosted entered the chamber, he gathered the best-preserved bones, while others crumbled completely at the slightest touch. He took the intact bones out from the chamber and buried them in a sand pit in the vicinity. He also found two flint daggers and an empty pottery vessel in the dry sand of the chamber floor, but the pot disintegrated completely. He then dug through the floor with a spade but found no further artefacts.

When Pastor Holm himself gained access to the chamber, he described it as follows:

In between these dry-walling slabs a kind of bark has been placed, of which follows a small sample in no. 1. The man who has excavated the mound says that it is birch bark, which he, as a Norwegian, professes to know well. Around by the sides of this wall was a fine, white material of which follows a sample no. 2; presumably it is saltpetre or lime.

Pastor Holm further explains that there has been a platform in the middle of the floor bearing the remains of the individuals interred here – raised above the rest of the floor and apparently with a kerb of stones placed on edge:

Within this oval room is another oval, 4 alen and 3 quarter [3 m] long and in the middle almost 2 alen [1.3 m] wide, but like the form of the outer broader in the southeastern and narrower in the northwestern end. The floor in this room is a good quarter [15.7 cm] *higher than the floor in the rest of the burial chamber, laid with beach pebbles, surrounded by roundish, not very large boulders, which stand up a few inches* [of 2.5 cm] *above the floor.*

Pastor Holm argues that there must have been a break-in uppermost in one of the gables:

There are major grounds to presume that the grave in the earliest times has been opened and plundered; because when Rosted first entered the burial chamber, he found at the southeastern end loose, blackish topsoil that had slipped down from above, as there was otherwise in the grave only sand and stones, on which the corpses, without any form of covering or clothing were placed. Furthermore, the wall or stone wall was not constructed of slabs, which is why the earth has slipped, as otherwise around and between the upright stones, but simply covered with a couple of large slabs set on edge with their surface in towards the grave. This less sealed walling-up has caused a limited degree of damp in the burial chamber at the southeastern end, where the stones are covered with saltpetre, which is not to be found in the northwestern end. Finally, the mound has externally in places been less rounded and somewhat indented directly over this place where the opening can be traced.

Pastor Holm describes the original closure of the passage, as seen described for other passage graves, that is a flat stone as a door, sealed from the outside with stones:

The outermost part of the entrance passage was covered or packed with quite large boulders of varying form; within these directly by the opening was a fine, flat stone erected.

The outer part of the passage, presumably outside the door slab, was damp:

The earth here was damp and very compact, and the bones brittle and fragile, although the teeth in one jawbone were particularly fresh and still shiny. Of a kind of reddish soil, of which there was only a little here, follows a sample no. 3, as this appeared to be heavier than ordinary soil or clay. The bones lay in bare earth, without sand; it was difficult to extract them from the compact soil.

The inner part of the passage was dry:

The inner part of the passage was dry, filled with small stones, earth and bones; but nothing else was found. In the outer part of the passage, I discovered charcoal yesterday, but only a few small speckles.

Pastor Holm also describes the stratigraphy above the capstones, presumably as he observed it in Lars Rosted's excavation in the top of the mound. The stratigraphy corresponds fully to modern observations – he did not, however, see that the stone slabs were probably overlapping:

It is remarkable the care with which efforts have been made to ensure that the burial place is preserved from the penetration of water and damp. Immediately on top of the capstones a layer of flint has been laid approximately 1 quarter [15.7 cm] *in thickness; on top of this a layer of white clay or lime marl of the same thickness; over this again a layer of red clay of the same thickness; on top of this stone slabs, and then again a layer of red clay also approximately 1 quarter thick, and on top of this ordinary topsoil to the roof of the mound.*

Pastor Holm estimates the height of the mound to be just less than 6.3 m; today it is 4-5 m high. This concurs roughly with Lars Rosted first encountering the capstones 1.9 m below the surface. Together with skeletal remains found outside the chamber, this indicates that the megalithic mound had been extended with at least one mound phase; a relatively common occurrence. It is also possible that there has been a Bronze Age mound outermost:

Figure 1. During the investigation at Maglehøj in 1996, five dry-walling slabs with preserved birch bark in between were extracted and fixed as a block for museum storage (Photo: T. Dehn).

The entire mound is constructed on a level bank that, despite its height has not been large and hardly 10 alen [6.3 m] *from the base of the burial chamber, has made it appear more conspicuous than if it had been placed on lower ground.*

The investigation of Maglehøj in 1996

The investigation of Maglehøj in 1996 was planned based on information contained in Pastor Holm's reports of 1823. Its aims were:

1) to record the birch bark in the passage grave's dry-walling,

2) to extract a block sample containing birch bark in collaboration with the National Museum of Denmark for storage in the museum's storage facilities (Figure 1),

3) to attempt to establish the significance of the monument's construction for the preservation of the bark and

4) to attempt to find an explanation for the unusual construction of one gable of the chamber which, on the face of it, resembled a modern restoration.

In addition to recording the birch bark that was immediately visible from inside the chamber, a 2-m-wide excavation trench was dug into the mound by the southeast gable, where the birch bark is chiefly found and where some of the mound has already been removed, presumably by Lars Rosted in 1823. This trench exposed the rear of the chamber's gable, together with the construction of the mound, with its packing of crushed flint and clay (Figure 2 and 3). It was also possible here to remove a block sample containing four dry-walling slabs and the folded birch bark between them. It also became apparent that parts of the original construction of both the overlying mound and the chamber had been disturbed and then re-established following a break-in uppermost in the chamber's gable later in prehistory. Given that flint daggers were found in the chamber in 1823, it seems likely that this intrusion took place in Late Neolithic times (*c*.2350-1700 BC).

The birch bark in Maglehøj is dated to 4440 ± 50 (KA 6975), calibrated (Stuiver et al. 1998) ± 1 st. dev.: 3330-2920 BC (Dehn and Hansen 2006, 26). This dating is consistent with the dating of seven other passage graves with birch bark, whose dating is within the period 3350-2850 BC (Paulsson 2010, 1010-1012).

Pastor Holm's observations and the 1996 investigation

Pastor Holm's observations, combined with the results of the investigation in 1996, give a valuable picture of the layout and construction of the Maglehøj passage grave. It is intriguing that no traces whatever have been recorded today of the mound's latest phase. Already when digging at the edge of the mound, Lars Rosted encountered skeletons. It must be presumed that these originate from graves outside the original passage grave mound, because it is apparent that the mound has been almost 2 m higher than today and must, thereby, have had a significantly greater diameter than now.

In conjunction with the skeletons at the edge of the monument, Lars Rosted also found a ring

Figure 2. Maglehøj 1996. Section showing the intact construction of the mound outside the southwestern end of the chamber. Immediately adjacent to the orthostat and intermediary layer lies a packing of crushed flint, held in place by a structure of stones and mound fill. It is evident that the latter was added in three operations (1-3) (Drawing: T. Dehn, L. Holten and M. Nissen).

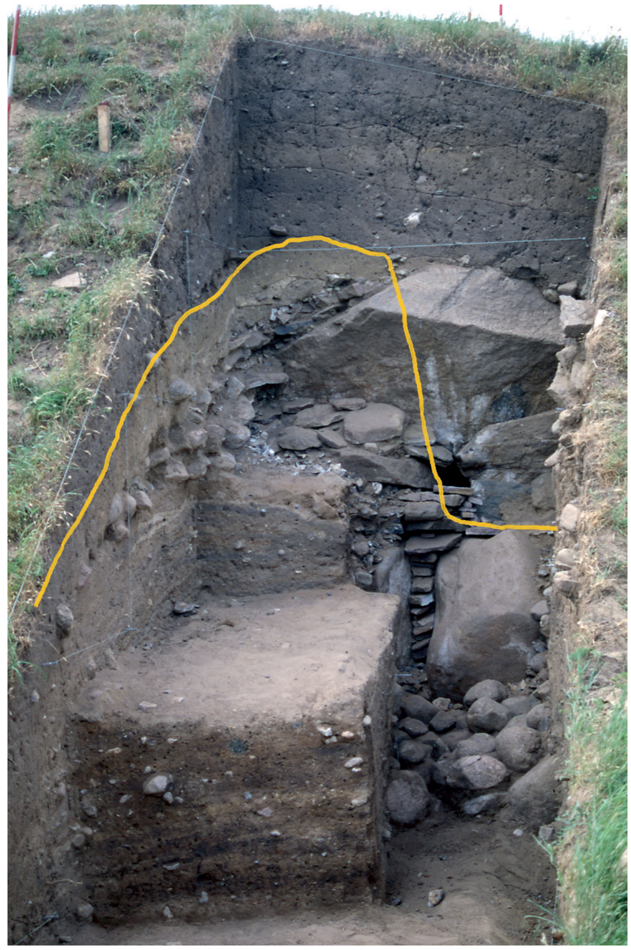

Figure 3. The excavation trench at Maglehøj in 1996 and the southwestern gable of the chamber. The area below the yellow line is the intact structure of the passage grave. The area above the line was altered later in prehistory, probably during the Late Neolithic (Photo and drawing: T. Dehn).

of kerbstones and he presumed that there could be more graves farther in. He therefore began to dig in the top of the mound and found skeletons of several individuals here, too. One of them lay in a stone-lined grave at a depth of about 2 m below the surface. The striking increase in the height of the passage grave mound could have taken place in both the Bronze Age and Iron Age. One example of massive expansion of a megalithic mound in the Bronze Age is provided by the passage grave at Sulkendrup Mølle, which was investigated in 1919 and underwent restoration in 2013-14. A stone-built Bronze Age grave was established above the passage grave chamber here, and the mound was extended so the passage of the passage grave lay 5 m within a new kerbstone ring (Rosenberg 1929, 206).[1] It is possible that there was further expansion later, as there were also Iron Age graves in the top of the mound.

Immediately beneath the Bronze Age grave in the top of Maglehøj, Lars Rosted encountered the upper surface of one of the chamber's capstones. He removed a smaller, flat stone at the edge of the latter and was then able to look directly down into the earth-free passage grave chamber.

Looking at the chamber from the inside today, there is only one place where it is possible to penetrate the roof without moving capstones, and this is between capstones 30 and 31 (Figure 4). Pastor Holm mentions in his first report of 24 April 1823 that the gap between the capstones is so narrow that he was only able to pass through with difficulty and without his outer garments. He then briefly describes the passage grave from inside. He notices

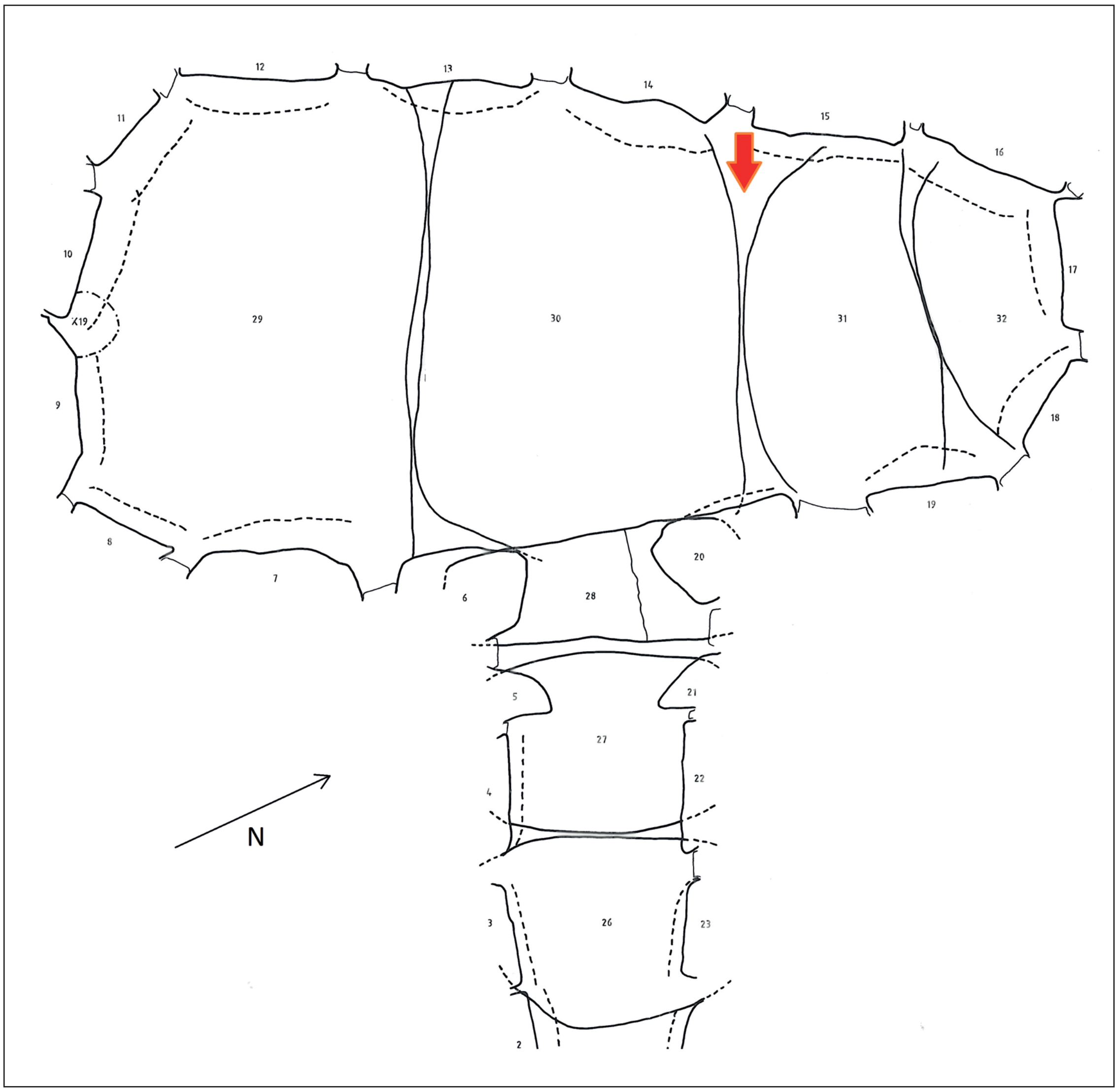

Figure 4. Ground plan of the Maglehøj passage grave. The red arrow marks where the chamber was entered between the capstones when the monument was opened in 1823. The chamber is 5.6 m long (Drawing: L. Holten and M. Nissen).

that the passage is blocked, so he asks Lars Rosted to empty it to provide easier access. From his second report of 16 May 1823, it is apparent that he has been in the chamber again but has now entered via the passage. This new description is extremely thorough and detailed and is presumably combined with what Lars Rosted has told him about his first visit to the chamber. Not only are the chamber's orthostats and dry-walling with birch bark precisely described, but also the floor, which, according to the first description, is said to have been dug up by Lars Rosted.

The chamber's ground plan is stated as being oval, but broader at the southeastern end. The chamber is 5.6 m long and 2.5 m wide in the middle. Within this oval room there is a 15-16 cm high raised platform on the floor, 3 m long and almost 1.3 m wide in the middle, and of the same oval form as the chamber's ground plan. This is laid with small, loose beach pebbles, and around the edge stand some 'roundish, not very large boulders', which extend 'a few inches' above the floor. Over the chamber are three large capstones and a lesser one. This arrangement of the chamber floor is quite unusual. Normally, chamber floors are covered to varying degrees by cobblestones or flagstones, to which can be added various examples with clay, sand and fire-shattered flint (Ebbesen 2011, 276-278). The situation on the chamber floor can vary considerably when initially described. It has often been disturbed in conjunction with the discovery of the passage grave and perhaps the first steps in

Figure 5. The southwestern gable of the chamber in Maglehøj seen from the inside. The flagstone set on edge associated with the secondary closure is the light stone in the upper left (Photo: T. Dehn).

demolition. Moreover, many passage graves have been reused and altered during later periods of prehistory and, in conjunction with this, several layers of graves have been laid one on top of the other. Intrusions and alterations have resulted in the chambers becoming gradually filled with settled and subsided mound fill. Only rarely is there information about the chamber being entirely earth-free when it was discovered and opened. But one of these instances is, of course, Maglehøj.

With reference to Lars Rosted's description, Pastor Holm then reports that the skeletons of four individuals – two adults and two children – lay on this platform. The skeletons were disarticulated, and the bones were mixed and scattered. Pastor Holm explains this in terms of the passage grave having been plundered already in prehistory. When Lars Rosted entered the chamber for the first time, he noticed a heap of black topsoil, which had fallen from above, at the southeastern end of the chamber. The materials were exclusively sand and stones in the remainder of the chamber, so this heap obviously stood out clearly. Pastor Holm notes that the construction of the chamber differs above the heap of topsoil in that the wall between the orthostats and the capstones is not constructed of horizontally laid slabs, as in the rest of the chamber, but merely closed with a couple of vertical flagstones (Figure 5). Due to a covering of saltpetre on the surface of the stones at this end of the chamber, Pastor Holm concludes that there has been some leakage here. His conclusion is supported by the surface of the mound here always having been less rounded and 'rather depressed'.

Pastor Holm's interpretation was fully confirmed during the investigation in 1996. The reverse of one of the vertical slabs between the orthostats and capstones was visible in the excavation trench which exposed the rear of one gable. It was clear that the mound construction in the part behind this slab was not the original. Instead of meticulous sealing with flint packing and clearly stratified mound fill, in this area there was unstructured fill containing topsoil mixed with stones of all sizes. This was interpreted as backfill in a large pit dug behind the uppermost part of the chamber's gable (Figure 6). In this backfilling, some of the material has penetrated the poorly sealed rebuilding of the gap between orthostats and capstones, where access was gained to the chamber, which is why Lars Rosted noticed a heap of soil here. Subsequent settlement of material in the backfilled pit resulted in the 'depressed' mound surface that was described in the 1820s.

The fact that passage graves have been reused during later prehistoric periods has been known since archaeology's infancy. This conclusion was based on discoveries of artefacts that, in addition to representing the inventory of the time when the monuments were built, often reflected activities in the Late Neolithic and Bronze Age. The best-known example is the twin passage grave of Klekkendehøj, which was opened in 1799 (Dehn, Hansen and Kaul 2000, 12-56).

Prehistoric intrusions into and alterations of passage graves

In some cases, indications of intrusions into or alterations of passage graves later in prehistory can be

Figure 6. Section showing the intrusion into the intact Maglehøj passage grave. To the left is the edge of one of the chamber's capstones and below this the flagstone set on edge associated with the secondary closure. Outside these is the back-filled pit from the intrusion (layer 3) (Drawing: L. Holten and M. Nissen).

observed from inside the chamber and passage. But acquiring evidence of an unusual constructional detail not being a part of the original construction requires an intervention into the surrounding mound fill with exposure of the external surfaces of the chamber. This gives the opportunity to observe the construction of the earthen mound, as well as changes in the original stone packing around the exterior of the orthostats and capstones.

One example is the Bigum passage grave. Already on being opened in 1914, it was realised that a large gable stone at one end of the chamber leaned outwards and that the dry-walling was missing on both sides. During a restoration in 1990, a trench was dug into the mound behind the leaning orthostat, and it could be seen that the gable stone had been tilted further outwards so there was access between the upper surface of the gable stone and the capstone (Dehn, Hansen and Kaul 2000, 235-254). The gable stone was subsequently not completely returned to its original position, so the horizontal gap between the gable stone and capstone had been closed with large, rectangular slabs set on edge (Figure 7). It was also apparent that the kerbstone ring had been rebuilt at least twice. During the investigation in 1914, it became evident that the passage lacked capstones. Instead, a Late Bronze Age urn grave stood on one of the orthostats and a stone bearing rock art lay in front of the entrance to the passage. The chamber had two clearly distinct burial layers: The lower layer contained skeletal remains and amber artefacts, while the upper layer had contents that included flint daggers and a bell beaker, indicating that extensive alterations took place in both the Late Neolithic and the Bronze Age.

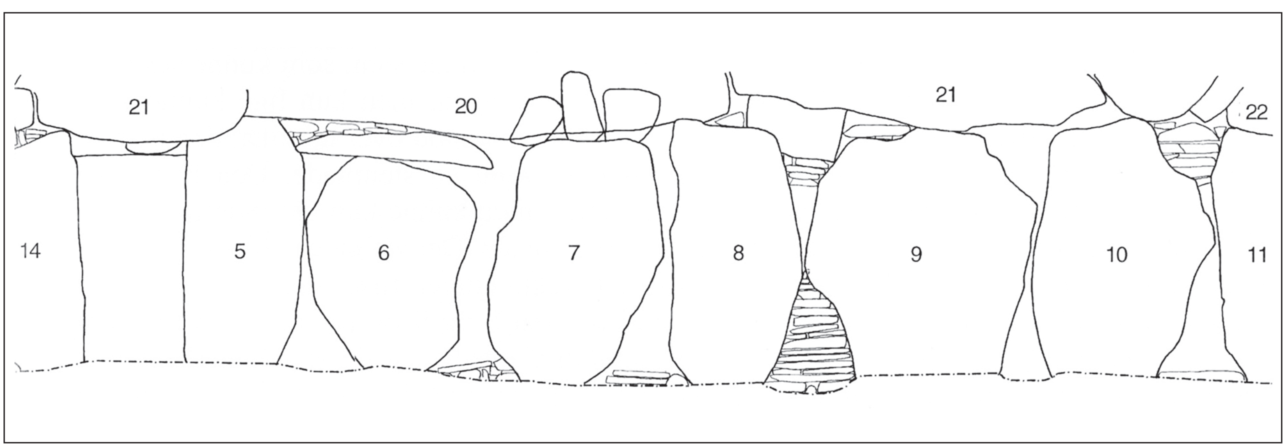

Figure 7. The chamber of the Bigum passage grave was also broken into later in prehistory. On this elevation showing part of the chamber three slabs set on edge cover the gap between orthostat 7 and capstone 20 externally. To the right of this is another slab set on edge between orthostat 8 and 9 (Drawing: T. Dehn).

Vasagård on Bornholm provides a similar example of drastic alterations. A dolmen chamber and a passage grave lie about 20 m apart at each end of a long barrow, 34 m in length. The dolmen chamber was investigated and the passage grave discovered in 1894. Investigation of the latter in 1938 revealed signs of a break-in, as two capstones had partially slipped and the opening between the chamber and the passage had been closed with a stone slab, which stood 40 cm above floor level. In the chamber were traces of a burial from the Late Bronze Age. During a restoration in 2008, it was discovered that capstones and some of the passage's orthostats had been removed. By the outer part of the passage there was a raised horizontal platform laid with slates. A ground-penetrating radar (GPR) scan suggests that this plateau forms part of a terrace which runs around the entire long barrow. The finds include Middle Neolithic pottery and amber beads, as well as half a boat-shaped battle axe from the Battle Axe culture. It is impossible to determine when the passage grave was first subjected to a forced entry, but the long barrow with its terracing can be ascribed to the Bronze Age (Hansen 2014, 48-56).

A third example is evident in the passage grave of Stuehøj near Ølstykke in northern Zealand[2]. This was opened in 1834 by the landowner, who found flint daggers, urns and bronze artefacts, among other things, in the chamber. For many years, the chamber's capstones lay exposed at the base of a large pit, and in 2006 a restoration was initiated. One end of the chamber consisted of a large pile of fieldstones, which was found to represent secondary closure of the chamber after a large orthostat in the gable had been completely removed to give access (Figure 8). A stone socket, together with remains of dry-walling, showed that an orthostat had once stood there (Figure 9).

The stone socket contained flint which had been part of the packing behind the orthostat that was removed from the chamber. The flint had fallen into the gap left when the stone was pulled outwards. The earthen fill that has also fallen into the gap had a high charcoal content, and in the area behind the stone socket there was a 5-10 cm thick layer of charcoal (Figure 9). A likely explanation for this is that fire was used to make the stone brittle so it could more easily be broken into pieces and removed.

Figure 8. The chamber in Stuehøj lacks an orthostat at one gable. This has been replaced by a heap of stones, which includes larger packing stones and a partially toppled orthostat, seen on the lower left of the picture, where the upper part of the stone heap has been removed (Photo: T. Dehn).

Figure 9. The pit dug down to reach the subsequently removed orthostat lay under the stone heap at the gable of Stuehøj's chamber. Remains of dry-walling can just be glimpsed on the left, and the base of the flint packing which has formed part of the structure around the orthostat is visible behind the pit. To the right, this packing is preserved to a greater height. The actual stone socket has a charcoal-rich fill containing a quantity of crushed flint from the packing outside the stone. Immediately above the preserved base of the flint packing is a 5-10-cm-thick charcoal-rich layer. There is therefore much to suggest that fire was used to make the large stone brittle and ease the process of its removal (Photo: T. Dehn).

A similar situation applies in the case of a fourth example – the passage grave Holmshøj near Vojens in southern Jutland.[3] There has been no forced entry into the chamber here but there have been drastic alterations to the passage grave and the entire mound, which was modified and extended on several occasions during the Bronze Age. The chamber was opened in 1884, when it was established that the capstones of the passage were completely

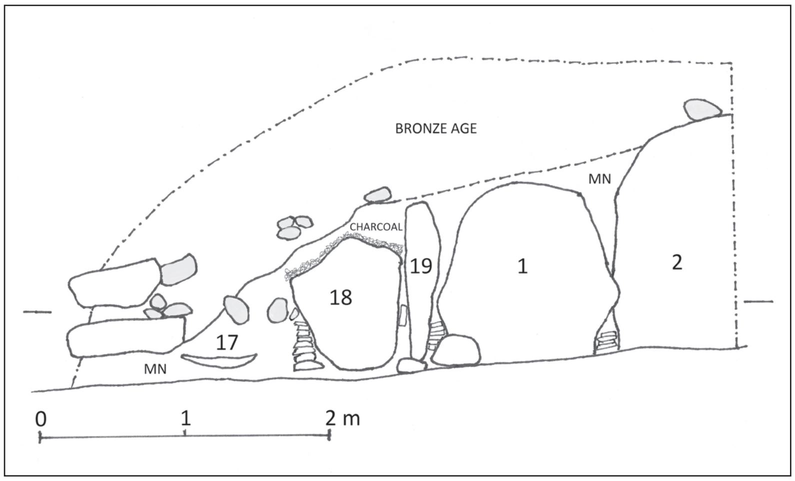

Figure 10. In the Holmshøj passage grave, the outermost part of the passage was reduced in height during alterations to the mound. On this elevation, stones 1, 2 and 19 are still seen in situ, while stone 17 has been removed, although its base remains in a 'rotten' state. The upper part of stone 18 has been hacked off after being rendered brittle by fire. The two horizontal stones on the left form part of the altered kerbstone construction (Drawing: S.I. Hansen and T. Dehn).

Figure 11. The penultimate orthostat in Holmhøj's passage (no. 18 on Fig. 10) has been reduced in height by hacking away its upper part. Large quantities of charcoal and red-burnt mound fill show that a fire has been lit outside the stone to aid the process (Photo: T. Dehn).

absent. During a restoration in 1887, the orthostats at one side of the passage were broken up to enable a completely new passage to be built which provided better access for visitors. One of the aims of another restoration in 2021 was to remove the latter and, as far as possible, re-establish the original passage. During this process, the preserved side of the passage again became visible (Figure 10).

The outermost part proved to have been reduced in height, presumably so as not to be visible in the surface of the new mound, which at this side was lower than that of the original megalithic mound. This modification had been achieved by removing the capstones over the passage and the outermost orthostat in the passage, as well as by taking the top off the passage's penultimate orthostat. This was achieved by exposing the uppermost part of the stone and then lighting a fire behind it. The fire rendered the stone brittle, thereby making it easier to hack the top off it (Figure 11).

Whether the same actions were undertaken on the opposite side of the passage is not known, as this was removed in 1887. But the kerbstone construction was partially removed on both sides of the entrance to the passage, and partially destroyed, so it too was reduced in height.

As a final example of a possible intrusion into a chamber, mention can be made of the passage grave in the megalithic complex at Tustrup on Djursland. In both 1887 and 1891 this was described as a passage grave in a collapsed state, and it was excavated and restored in 1954 (Eriksen, Dehn and Hansen in press). The orthostat in one gable and a broken capstone together provides a basis for an interpretation that an intrusion into the chamber took place in prehistory. The gable orthostat is tipped outwards and lies at an angle of at least 45 degrees. The capstone is broken into two parts, which lie directly beside the orthostat on the floor of the chamber (Figure 12). It seems

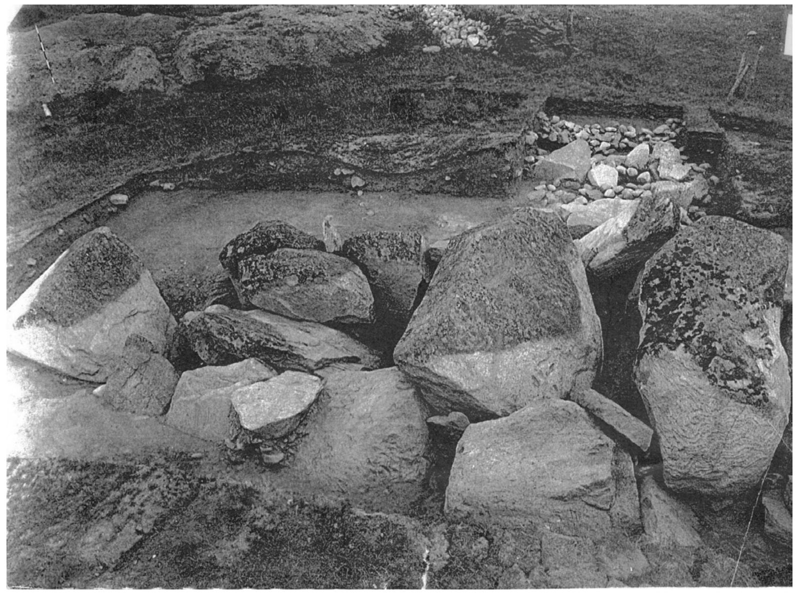

Figure 12. The collapsed and exposed chamber of the Tustrup passage grave in 1954, prior to investigation and restoration. Even back then, the possibility was considered that the collapsed end of the chamber on the left of the picture was caused by an intrusion later in prehistory (after Eriksen, Dehn and Hansen in press).

likely that the breaking of the capstone was caused by the gable orthostat being toppled. Extensive preparatory work was required prior to toppling the large orthostat outwards, as it was necessary to dig a pit measuring *c.*2 x 2 x 2 m from the surface of the mound, part of which had to be cut through some of the solid stone packing which encloses the entire construction.

During the investigation of the passage grave, Funnel Beaker culture artefacts were encountered but there were no finds from other periods, and once again there were no indications of when the mound over the chamber was removed. It is therefore only the collapsed part of the chamber which suggests that a secondary intrusion may have taken place. Similarly, the poor state of preservation of the passage grave prior to restoration excluded the possibility of finding traces of secondary closure.

In addition to these five examples, numerous others can be mentioned where an intrusion and/or alterations must have taken place, but where it is not possible to explain the situation in more detail. A twin passage grave at Årby near Kalundborg completely lacked capstones when it was investigated in 1879. In addition, remains of a Bronze Age burial were found on top of the common orthostat between the two chambers, and in another place a Bronze Age urn stood uppermost in the grave fill. This suggests that at least some of the capstones had been removed in the Bronze Age at the latest (Dehn, Hansen and Kaul 2000, 145-156). When it was opened in 1890, the Nissehøj passage grave near Vellerup in Zealand was found to contain an oak coffin burial from the Bronze Age. During a restoration in 1992 it could be established that the outer part of the passage had been altered, presumably to make it possible for the oak coffin to be manoeuvred into the chamber. The passage was then closed with a stone slab, which stood upright in a Late Neolithic burial layer (Dehn, Hansen and Kaul 2000, fig. 5.26).

Common to Maglehøj and the other examples of forced entry into and alterations of passage graves is that these activities cannot be securely dated. The only possible exceptions are Stuehøj and Holmshøj, where charcoal can be dated, but this has not yet been undertaken. Nevertheless, the artefacts found in the chambers provide some indications of likely dates, typically in the form of information from Late Neolithic flint daggers and Bronze Age artefacts in the chambers. Rock art on the stones is also suggestive of activities in the Bronze Age – at least when the motifs take the form of figures, as seen on the stone found in front of the entrance to the passage and included in the new ring of kerbstones around the Bigum passage grave (Dehn, Hansen and Kaul 2000, figs. 14.4 and 14.6). Cupmarks, on the other hand, commonly occur on the capstones and orthostats of both dolmens and passage graves. In some cases, this is undoubtedly because the surfaces of these stones were accessible in the Bronze Age, but it also seems likely that some of them were carved already in the Middle Neolithic. Two stones bearing cupmarks were found in a Middle Neolithic context in one of Vasagård's palisade ditches, but an

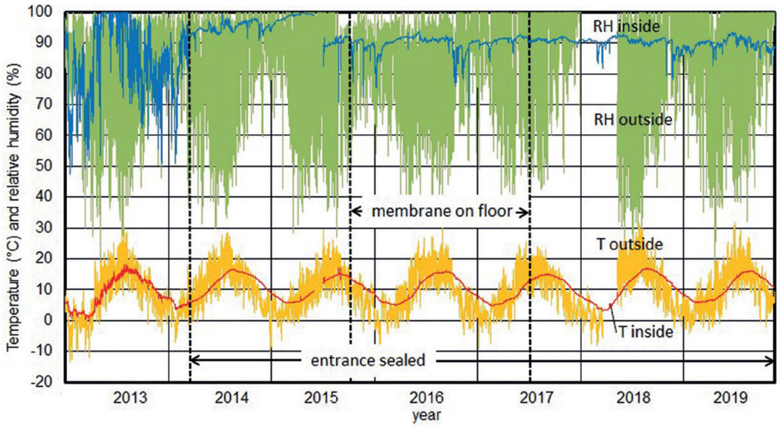

Figure 13. Measurements of temperature and relative humidity inside and outside the Maglehøj chamber in the period 2013-19.

earlier date is also possibly (Iversen, Thorsen and Andresen 2022, 163). Moreover, in the presentation of a major project encompassing an evaluation of dolmens in northern Europe, it is proposed that the stones which were included in megalithic graves were selected and carved with cupmarks before they were incorporated into the monument (Cummings and Richards 2021, 63-92).

The passage graves' birch bark and its preservation

Following the rediscovery of the occurrence of birch bark in Maglehøj, increased awareness of this phenomenon has resulted in the finding of this material in several passage graves. In 2006, eight occurrences were known (Dehn and Hansen 2006), and since then the presence of birch bark has been confirmed in a further four passage graves, two of which lie in Scania, Sweden[4] (Hansen 2016, 104). The birch bark between the dry-walling slabs is normally poorly preserved and, in some cases, only recognisable as small fragments. Maglehøj is therefore the only known passage grave to date where the bark is preserved to any greater extent so that it is clearly visible and illustrates how this material was generally used.

A common feature of the passage graves with preserved birch bark is that the chambers were partially or completely earth-free until they were opened in modern times. A further characteristic is that behind the dry-walling with birch bark there is a solid packing of crushed flint. This held the rear of the dry-walling free of the earth of the mound fill and permitted a certain degree of desiccation.

Preservation conditions for birch bark

In the period 2013-19, the Danish National Museum's Department for Environmental Archaeology and Materials Science undertook an investigation of the preservation conditions for birch bark in the Maglehøj passage grave (Larsen et al. 2017). There was a suspicion that the bark was undergoing degradation, even though it was judged to be reasonably intact in 1995 The aim was to clarify how the reopening of the chamber in 1823 had influenced the internal climate. There was a particular awareness that condensation, which was observed on both orthostats and capstones, could be damaging to the birch bark. In addition, samples of the birch bark were taken to be investigated for signs of decay.

During the first year of the investigation the passage leading into the chamber was open, while in the subsequent 5 years it was closed with a sealed door. Temperature and relative humidity were measured both inside and out with the aid of electronic sensors attached to a central data logger (Figure 13). The measurements showed that the internal temperature follows the average external temperature with a delay of about a month. The annual fluctuations in temperature are damped inside the chamber so the maximum lies some degrees lower and the minimum some degrees higher than the corresponding averages for the external temperature. This is due to the thermal inertia constituted by both the stones and earthen fill, as well as the earth below the floor. There is only a marginal difference in the fluctuation from summer to winter between the open and the closed passage. The thermal stability is far from adequate to level out annual variations

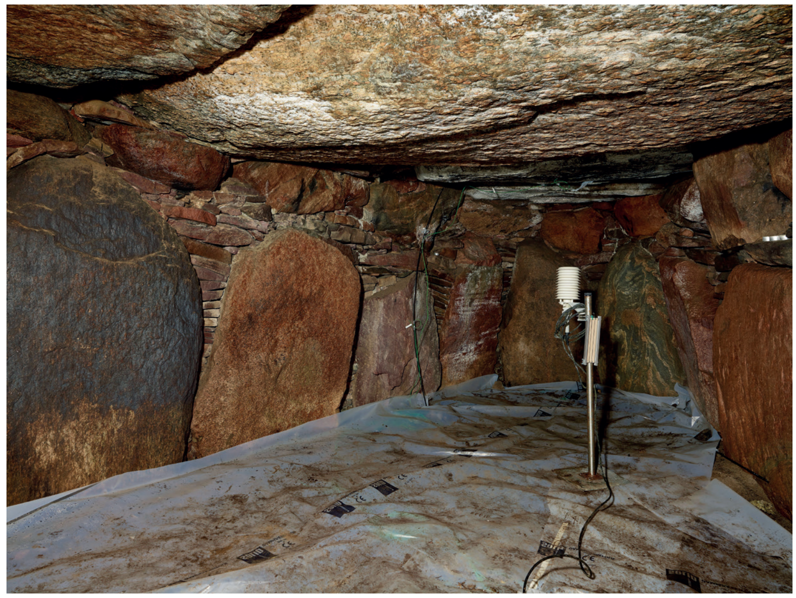

Figure 14. The Maglehøj chamber seen looking north, with a damp-proof membrane on the floor. The internal climate sensors can be seen on the right (Photo: R. Fortuna, Danish National Museum).

in temperature, regardless of whether the chamber is open or not.

The closing of the chamber had a much greater influence on air humidity than on temperature. In the open chamber, air humidity varies between 50 % and 100 % RH according to the season and external climate. There are frequent episodes with condensation on the internal surfaces in the period between April and September. This is because the external air during this period is warmer than the chamber and contains a relatively large amount of water vapour. When this warm, damp air meets the cold surface of the stones, the water vapour condenses. In the closed chamber, the relative humidity is high and constant, around 90 % RH all-year round. Even so, condensation is a rare occurrence. This is because the temperature of the air is almost the same as the surface temperature of the stones. Even though the relative air humidity is high, the dewpoint is rarely exceeded. The closed situation has presumably prevailed during most of the monument's existence up until the opening of the chamber two centuries ago. There has therefore been a stable, damp climate *without condensation* for much longer than a variable climate with alternating periods of desiccation and condensation (Figure 14).

In addition to the climate measurements undertaken in the actual chamber, the moisture content of the earth in the floor below the chamber and in the fill above it was also measured. The earth was generally damp down to a depth of about a metre all-year round, but in the open chamber the surface dried out in winter, when the relative air humidity was low. This is due to evaporation from the upper layer of the floor into the air. As the climate was very wet during the first year after the chamber was closed, the floor was experimentally covered with a damp-proof membrane. Subsequently, the air humidity stabilised at 90 % RH, which apparently confirmed the influence of the damp floor on the climate in the chamber. But the membrane was removed for the final 2 years, without any noticeable effect on air humidity. Evaporation from the damp earthen layer of the floor is therefore of less significance for condensation than first assumed.

The earthen fill over the chamber was saturated by moisture during winter and dried out in summer. The precipitation was evenly distributed through the year, so the earth's moisture content was essentially determined by the evaporation. There was no connection between the moisture content of the earthen fill and periods with condensation inside the chamber. The influx of moisture from the earthen fill into the chamber is therefore judged to be insignificant. It is assumed that the original clay packing over the chamber is intact. There is consequently no need to establish a new moisture barrier over the chamber.

The natural air change was measured through two 3-week periods in February and August 2016 in collaboration with the Danish Building Research Institute (SBI) by the perfluorocarbon tracer method (PFT). The closed chamber had an average air change of 0.34 h^{-1} in February and 0.16 h^{-1} in August. This means that between 16 and 34 % of

Figure 15. The folded birch bark between the sandstone slabs in the dry-walling in Maglehøj (Photo: L. Aa. Jensen, Danish National Museum).

the air in the chamber was renewed each hour. This is a surprisingly high rate, which corresponds to a normal leaky house with windows and doors. In June 2016, an attempt was made to localise leaks in the chamber with the aid of cold smoke. A ventilator was installed in the door to give slight positive pressure. A small amount of smoke escaped through the passage over the door, but no smoke was observed through mouseholes or other parts of the mound.

It is therefore assumed that the relatively large air change takes place evenly distributed through the porous earth and the flint packing around the outer surface of the orthostats. From here, the air penetrates through the cracks between the individual sandstone slabs in the dry-walling as well as other gaps between the orthostats. In this way, the dry-walling forms part of a rather effective ventilation system, which is driven by small pressure differences caused by wind or temperature gradients. If all the gaps in the dry-walling were sealed with birch bark, the air change would probably be significantly lower. We cannot know whether this effect was intended by chamber's builders.

Due to the high natural air change, it is unlikely that the chamber has been deficient in atmospheric oxygen (O_2). But oxygen also occurs in the form of ozone (O_3), which is much more reactive and is therefore a significantly more powerful degradation factor. The ozone concentration in the closed chamber was investigated by several independent methods in spring 2016. The measurements demonstrated unanimously that the ozone level in the closed chamber is virtually zero, even though the natural air change is quite considerable. During the air's passage through the earthen mantle, the ozone reacts with organic components and a conversion takes place. Consequently, the earth functions as an effective ozone filter, and probably also as a filter for other reactive components in the air.

The influx of ozone into the chamber was then investigated with an open passage. Over the course of two sunny days in June 2016, the ozone level was measured inside and outside the chamber through a period of 48 hours. The ozone level in the middle of the open chamber was 8 ppb (average) but varied between day and night (<1-15 ppb). But the ratio of inside to outside concentration was, however, largely a constant 0.25. Spot measurements undertaken directly in front of the dry-walling showed a slightly lower inside to outside ratio of *c.*0.2. In the open chamber there is, accordingly, free access for ozone, with the birch bark also being exposed. In the two centuries that have elapsed since the Maglehøj chamber was reopened, the birch bark has been influenced by ozone corresponding to a millennium of open air. This has probably contributed to degradation of the bark by oxidation (Figure 15).

Several studies have been undertaken of the degradation and conservation of birch bark (Orsini et al. 2015). There is general agreement that the material is exposed to 'natural ageing', resulting in it becoming brittle and stiff. Natural ageing is due to oxidation and hydrolysis, where-

Figure 16. Maglehøj seen from the south with the entrance to the right. The external climate sensors can be seen in the centre (Photo: L. Aa. Jensen, Danish National Museum).

by the material's components are broken down by chemical reactions with oxygen and water. The cell structure of birch bark differs substantially from that of an ordinary wood cell, both physically and chemically. In chemical terms, suberin rather than cellulose constitutes the greatest component of the cell wall (*c*.45 %), and it is suberin that gives birch bark its strength and flexibility. The second largest component is betulin (*c*.34 %), which is antiseptic and hydrophobic and gives birch bark its pale appearance. Analyses of the birch bark from Maglehøj have confirmed that the bark's components are affected by chemical changes. Conversely, there are no indications of microbial degradation of the bark's structure.

Birch bark absorbs only *c*.5 % water at 100 % RH, which is much less than birch wood. On drying out, the various layers of the bark are affected by varying tensile stress, causing an unrestrained piece of bark to curl up. Birch bark preserves best in a stable, damp climate.

Conclusion

The investigation of Maglehøj is an example of how a careful review of an archival source can be of significant importance for the outcome of an archaeological investigation in a well-preserved monument. Pastor Holm's description of the passage grave is of exceptionally high quality, but it has also proved invaluable in other projects to closely read older descriptions as part of the preparation for an investigation. Maglehøj is also an example that drastic changes to the construction of both chamber and passage may have been made during later prehistoric use of passage graves. This observation has been of great importance for the analysis of other passage graves.

Based on the results of the investigations of the preservation conditions for birch bark, it is recommended that a permanent, air-tight closure of the door is established to stabilise the internal climate and keep the chamber free of ozone. Access for visitors is already hindered by a locked airtight metal door, so accessibility will not be further impeded. There are many other well-preserved burial chambers without birch bark which can better tolerate the wear that people and animals inflict on the remains of the 5000-year-old bark (Figure 16).

Acknowledgements

The investigation of Maglehøj in 1996 was – like the other investigations mentioned here – planned and executed in collaboration with Svend Illum Hansen. Lars Holten and Mette Nissen participated as students in the fieldwork. The Danish National Museum's Conservation Department, represented by Ion Meyer, took the block sample with dry-walling and birch bark. Pastor Holm's reports from 1823 were transcribed in Danish by Ingrid Nielsen, English translations by Anne Bloch and David Earle Robinson. Jørgen Westphal and Lars Bjarke Christensen, of the Danish Agency for Culture and Palaces, undertook the collaboration with the Danish National Museum's Department for Environmental Archaeology and Materials Science about the climate monitoring. Lars Aasbjerg Jensen, National Museum of Denmark, Morten Ryhl-Svendsen, School of Conservation at the Royal Danish Academy, and Tim Padfield participated in the climate monitoring.

Translation of manuscript from Danish to English: Anne Bloch and David Earle Robinson, Heritage Science and Language Services.

Notes

1) Sulkendrup Mølle, reg.no. 090617-9; report of 2015 in slks.dk/sites-and-monuments.
2) Stuehøj, reg.no. 010607-53, report of 2006 in slks.dk/sites-and-monuments.
3) Holmshøj, reg.no. 200210-157, report of 2021 in slks.dk/sites-and-monuments.
4) Møllehøj, reg.no. 010604-33, Øm passage grave, reg.no. 020402-13, as well as Örenäs and Ljunghög in Scania, Sweden.

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The Late Neolithic Expansion in Denmark

Ancient and new traditions 2350-1700 BC

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ABSTRACT

Although the Scandinavian Late Neolithic today is mainly defined by the introduction of bifacial flint work, particularly daggers, agricultural intensification must also be seen as a part of the Late Neolithic package, which developed under Bell Beaker-influence in Jutland around 2350 BCE. It is argued that the changes in subsistence led to a population increase, which was the background for the spread of the new Late Neolithic culture in Scandinavia. A delay in the introduction of the Late Neolithic in East Denmark is, among other things, reflected in the scarcity of Bell Beaker-related artefacts in the region. It is suggested that this must be understood on the background of old cultural differences between West and East Denmark.

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Introduction

The present paper is an attempt to understand the development of the Late Neolithic (LN, 2350-1700 BCE) in Denmark on the background of migration, changes in subsistence and regional cultural differences.

It is today widely accepted that the transition to the Late Neolithic happened simultaneously throughout Southern Scandinavia (Iversen 2015, 29; Madsen 1978; Müller and Vandkilde 2020) and that the cultural diversity, which reigned in Denmark during the last half of the Middle Neolithic (MNB, 2800-2350 BCE) ended with the beginning of the Late Neolithic (Iversen 2015, 117). This understanding is based on the rapid spread of bifacial flint work, particularly daggers, in most parts of Southern Scandinavia (Apel 2001; Earle 2004; Kristiansen 1987; Lomborg 1973; Madsen 1978; Müller 1902; Sarauw 2007b). The focus on the Late Neolithic flint work is so strong that the period also has been nicknamed 'the Dagger Period' in Denmark. However, the existence of several regional differences within Southern Scandinavia during the Late Neolithic has also long been recognised. Most significant is the variation in burial practices (e.g. Iversen 2015, 123-130; Lomborg 1973, 96-133; Müller and Vandkilde 2020, 37-38). Furthermore, the much-debated Bell Beaker influence mainly affected West Denmark, with additional expansion further north and northeast (Prescott and Glørstad 2015; Sarauw 2007a, 2007c; Vandkilde 2005; Østmo 2012). Not least, numerous settlement excavations in the last twenty years have contributed significantly to this picture of regional differences, especially regarding house types (Sparrevohn, Kastholm and Nielsen 2019). The settlement excavations have also broadened our understanding of Late Neolithic subsistence strategies. It is today widely accepted that the transition to the Late Neolithic in southern and western Norway also represents the Neolithisation, in the economic sense of the word, i.e. when hunting and fishing was succeeded by agro-pastoralism as the primary subsistence base (e.g. Prescott 1996, 2020; Østmo 1988). Recent interdisciplinary studies on the Late Neolithic in Western and Southern Sweden also focus on subsistence (Blank

2021; Tornberg 2018). In Danish research, however, Late Neolithic subsistence strategies are only mentioned in passing (Iversen 2015, 121-122; Jensen 2001, 511-513; Sørensen 2014b: 64-67), probably because changes are blurred by an earlier Neolithisation, which occurred with the introduction of the Funnel Beaker Culture *c.*4000 BCE, around 1700 years before the Late Neolithic period (Sørensen 2014a). However, where the MNB has been characterised as an overall de-Neolithisation of Southern Scandinavia (Hinsch 1955, 104; Iversen 2013; 2015 69-73; Klassen 2005; Nielsen, Persson and Solheim 2019; Østmo 1988, 225-227), the LN must be characterised as a re-Neolithisation, where Southern Scandinavia's favourable conditions for agriculture were exploited to a hitherto unseen extent (Johannsen, in prep-a, in prep-b). In the present paper, it is suggested that increased agricultural production played a significant, nevertheless overlooked, role in the development of Late Neolithic Denmark. Thereby, the beginning of the Late Neolithic is understood as the introduction of a package, which besides the bifacial flint working technique, also included new subsistence strategies and settlement patterns.

Based on a review of regional cultural differences in MNB and LN, recent migration studies, and Late Neolithic subsistence, the present paper thus questions the current orthodoxy of bifacial flint technology as a common cultural denominator in Late Neolithic Denmark.

Methodological and theoretical approaches

In order to understand the cultural development in Southern Scandinavia in the Late Neolithic, the present study discusses Late Neolithic regional differences against a background of regional cultural diversity in the preceding period. The material used in the paper has primarily been found in published studies of various Late Neolithic artefacts and construction types with specific regional distributions. New observations are however also included. These are part of a larger ongoing study of the Scandinavian Late Neolithic subsistence and social development, which is based on a vast amount of previously unpublished material from databases, excavation reports, papers and monographs. This work is ongoing, and revealing its full extent lies beyond the boundaries of the present study. The presented analysis and interpretations must thereby be understood as preliminary.

The paper's premise is that the beginning of the Late Neolithic in Southern Scandinavia began with migrations from the northwest European fringes (Germany and the Netherlands) of the pan-European Bell Beaker phenomenon to the northwestern part of Jutland at the end of MNB (Prescott 2009, 206). The areas which were influenced by the Bell Beaker phenomenon can be described as contact cultures, which Helle Vandkilde has defined as '*geographically extended and fairly confined zones of intense interconnectivity which may have differing backgrounds, but nevertheless display a high frequency of translations of shared ideas*' (Vandkilde 2016, 107-108). As the new ideas were translated to fit with local traditions, the concept of contact cultures implies that the degree to which new cultural habits were accepted varied from region to region in accordance with the existing traditions. This is in line with Rune Iversen's research on cultural development in Southern Scandinavia in the 3rd Millennium BCE (Iversen 2015, 2016). Iversen has described the mix of cultures within the period as a process of creolisation; a concept borrowed from linguistics, which in short describes when two or more languages fuse into a new language (Iversen 2015, 149). In line with Vandkilde's concept of contact cultures, Iversen describes the mix of cultures in the second half of the Middle Neolithic on Zealand as selective adoptions, transformation and use of new cultural elements in a way that resonated with existing Funnel Beaker traditions. In relation to the linguistic term creolisation Iversen concludes that 'the '*grammar*' [in MNB on Zealand], *(rules of usage, or in cultural creolisation the way which material things are made, used and perceived) remained principally Funnel Beaker culture whereas the 'lexicon'/vocabulary (words, or in this case the artefacts) appear to be Single Grave Culture*'. Iversen here extends the Funnel Beaker' grammar' beyond the use of artefacts to social practices such as burial customs and offerings (Iversen 2015, 151 with further references). The way new cultural elements were adopted and the willingness to do so is thereby understood as determined by existing cultural traditions. On this background, it will be proposed that the new Late Neolithic culture was accepted faster in West than in East Denmark.

A tripartite partition of the Late Neolithic period based on typological variation of flint daggers has been suggested by Ebbe Lomborg (1973), but today most scholars follow Helle Vandkilde's division of the Late Neolithic in two periods (1996): LN I (2350-1950 BCE) and LN II (1950-1700 BCE), which is based on metalwork, flint daggers and radiocarbon-dates. Vandkilde's division is also used in the following.

Cultural diversity at the end of the Middle Neolithic

A brief overview of the MNB in Denmark and the southern part of Sweden is necessary to understand the background for the regional cultural variation in this area in the Late Neolithic. While there were regional differences throughout prehistory in South Scandinavia, the cultural differences in MNB are significant. Variations of the Corded Ware Complex (CWC) settled in West Denmark and Southern Sweden. The CWC is in Scandinavia mainly known for its single burials, which represent a profound break with the multiple burials in megalithic tombs of the preceding Funnel Beaker Culture. Only few houses from the MNB have been excavated and mainly from the end phase of the period. The settlements seem to have been small and dispersed, which may indicate they were only inhabited for short periods (Brink 2009, 268-277; Nielsen 2019, 20-24; Sarauw 2019, 283-286). The sandy, nutrient-poor soils of Western Jutland, corresponding to the core area of the Single Grave Culture (Danish CWC), were not suited for plant cultivation but offered good pastures. There is thus reason to believe that animal husbandry, possibly cattle breeding, played an significant role in subsistence here (Müller and Vandkilde 2020, 40). Crops were also cultivated, but evidence of this has mainly been found in the eastern part of the distribution area of the Single Grave Culture and from the end of the period (Andreasen 2009; Klassen, 2005). Several recent DNA studies indicate that the gene pool of the Early European Farmers was, to a large extent, replaced with Steppe-DNA in the areas affected by the Corded Ware Complex (Allentoft et al. 2015; Egfjord et al. 2021; Haak et al. 2015; Malmström et al. 2019; Mittnik et al. 2018). This has been interpreted as indications of massive migrations and violent takeover of land, possibly aided by a pandemic, which opened up Europa for migrations (Kristiansen et al. 2017, for a differing view see Furholt 2021).

While the different Corded Ware groups expanded in the western and eastern part of Southern Scandinavia, the Pitted Ware groups from the Scandinavian Peninsula affected the Kattegat Region. DNA analyses on Pitted Ware burials from the Baltic Sea area show that DNA profiles are best modelled with ancestry of European hunter-gatherers (Mittnik et al. 2018). The subsistence of the Pitted Ware groups in the East Baltic was almost exclusively based on hunting and fishing (Eriksson 2004; Fornander, Eriksson and Lidén 2008). The Pitted Ware influence in the Kattegat region is most profoundly reflected by the ubiquity of large, tanged arrowheads and increased activity along the coasts (Iversen 2010; Klassen 2020). Subsistence here seems to have been based on a mix of hunting/fishing and farming (Andreasen 2020; Makarewicz and Pleuger 2020).

To complicate the picture even further, the older Funnel Beaker traditions continued in Eastern Jutland, on Funen and on Zealand in particular. East Denmark has been called the megalithic heartland as megaliths were constructed here in large numbers during the 4th millennium BCE and used for burials throughout the 3rd millennium BCE (Iversen 2016, 168). Additionally, the construction of causewayed enclosures continued in the shape of palisaded structures on Zealand, Bornholm and in West Scania during the MNB (Brink 2009; Nielsen, Nielsen and Adamsen 2014; Struve 2018). Little is known of subsistence in the area; it may have consisted of a mix of field cultivation and animal husbandry, similar to the economy introduced with the Funnel Beaker Culture 1200 years earlier. There are, however, some indications of a decrease in cultivated land (Iversen 2015, 69-71), while finds of large fishing weirs of MNB-date may reflect that fishing was an important part of the subsistence (Sørensen 2018, 23; Andreas Kallmeyer Bloch, the Viking Ship Museum, pers. comm. 2022). Two human genomes

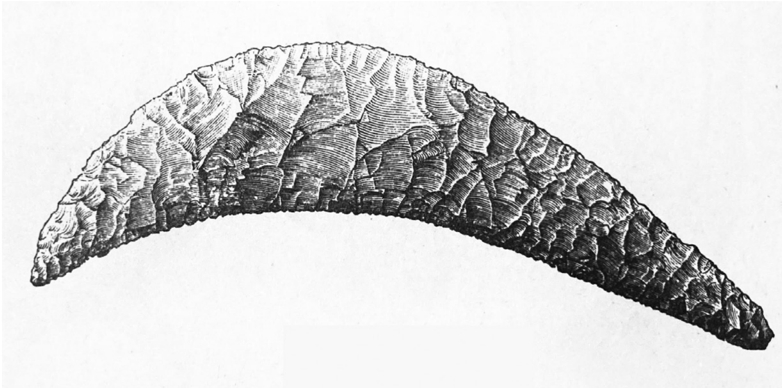

Figure 1. The asymmetrical early Late Neolithic sickle blade from Vallåkra in Kvistofta parish in Scania. Approximate length: 14 centimetres (after Montelius 1917).

from the MNB on Zealand have been published. The first comes from a passage grave in Kyndeløse and has mainly been modelled with ancestry of the Early European farmers and minor influence from European hunter-gatherers and steppe herders (Malmström et al. 2019, 6 and Figure 1). The second individual derives from a megalithic tomb, presumably a passage grave, on the East Danish island of Falster. This individual has been modelled with ancestry from steppe herders (Allentoft et al. 2022, NEO792). Although it is open to discussion whether the Kyndeløse individual is representative of the MNB population of eastern Denmark (Frei et al. 2019, 11), the genomic continuity corresponds well to the described Funnel Beaker continuity of the region, while the presence of a person with Steppe-DNA in a passage grave on Falster is perhaps the best example of the creolisation process described above.

From the Middle Neolithic to the Late Neolithic in Southern Scandinavia

Several changes in the material culture mark the transition to the Late Neolithic. Most evident for us today is the introduction of the bifacial flint working technique, and that the prime symbol of male identity changed from the battle-axe to the flint dagger. Finds of weaving weights, buttons and dress pins show that woven (woollen?) cloths were also introduced (Ebbesen 1995; Grundvad and Poulsen 2014; Lundø and Hansen 2015), while pottery with Bell Beaker inspired shape and decoration indicate the introduction of new social conventions (Prieto-Martínez 2008; Sherratt 1997). However, changes in subsistence were likely the most significant new element to the South Scandinavian population. Although bones from domestic animals are rare, livestock farming's importance to Late Neolithic subsistence is reflected by ard marks preserved under barrows and in the houses' sunken floors, assuming that oxen were used as draught animals (e.g. Borup 2019, 111-115; Johannsen in prep-b; Thrane 1989). Evidence of livestock farming is also reflected in palynological evidence. An example is the settlement Vinge in the northern part of Zealand, where massive clearance of the arboreal wetland vegetation during the second half of the Late Neolithic is most likely related to livestock farming (Johannsen in prep-b). While it is difficult to evaluate the significance of livestock farming to Late Neolithic society, the archaeological evidence is much more clear when it comes to plant cultivation. Changes compared to the MNB are obvious: the very rare blades from harvest knives associated with the MNB were succeeded by the more efficient flint sickles (Figure 1), which were serially produced in different shapes and overwhelming quantities throughout the LN and into the Early Bronze Age (EBA) (Johannsen, 2022; in prep-a; Norling-Christensen 1940). Systematic soil sampling of Late Neolithic houses, macrofossil analyses, radiocarbon-dating and increased awareness of ard marks have shown that a greater variety of cereals was cultivated and that crop rotation, cultivation of former house plots and likely also manuring improved and maintained field fertility (Andreasen 2009; Borup 2019; Gron et al. 2021; Kanstrup et al. 2014; Møbjerg, Jensen and Mikkelsen 2007; Simonsen 2017, 379-393). Agriculture favours sedentism, and the overall change in architecture to solid, permanent houses (Brink 2009, 268-277; Larsson 2009; Nielsen 2019, 20-24; Sarauw 2019, 283-286) may thus be understood as the most significant indication of changes in subsistence strategies from MNB to LN. Scandinavian houses dated to the Late Neolithic must be counted in hundreds (Artursson 2005; Prescott 2020, 385; Sparrevohn, Kastholm and Nielsen 2019). That old houses were replaced repeatedly within relatively small settlement areas (Brink 2013; Sarauw 2006a; Simonsen 2017; Sparrevohn 2019) must reflect an agricultural strategy which was sustainable enough to allow people to stay within the same area for several generations.

Regional differences in Late Neolithic Denmark

Despite similarities in material culture over large parts of Southern Scandinavia, distinct regional differences continued in Denmark in the LNI. One difference between West and East is that finds associated with the earliest part of the Late Neolithic, i.e. the Bell Beaker Culture, have a marked western distribution: Bell Beaker-inspired pottery, which had its core phase at the very end of MNB and during LNI, has been found at several Late Neolithic settlements in Jutland but is very rare on Zealand (Sarauw 2019, Figure 15.1). The characteristic barbed and tanged arrowheads of the Bell Beaker culture have mainly been found in Jutland and on Funen (Ebbesen 1979, Figure 47; Sørensen 2014b, Figure VI. 21). V-perforated amber buttons have their main distribution in northern Jutland (Ebbesen 1995, 236). Late Neolithic wrist guards have in Denmark exclusively been found in Jutland and on Funen (Skov 1970, Figure 5). Archery burials containing elaborate parallel flaked flint daggers and clusters of arrowheads are also a distinct West Danish phenomenon (Sarauw 2007b, 64), and Type IC daggers, which are strongly connected to the South Scandinavian Bell Beaker environment, are entirely lacking on Zealand (Iversen 2015, 100; Lomborg 1973, Figure 14; Sarauw 2006b, 253).

The most frequently mentioned difference between West and East in Late Neolithic Denmark is the variation in burial practices. MNB and LN burial traditions are diverse and complex (Iversen 2015, 73-82; Lomborg 1973, 96-129). However, there seems to have been an overall continuation in burial traditions from MNB and LNI in both West and East Denmark. In the West, graves were in LNI placed in the top of Single Grave Culture mounds (Lomborg 1973, 113-121; Madsen 2020, 53; Müller and Vandkilde 2020, 37), and new small burial mounds were constructed when people settled in areas without Single Grave Culture barrows, exemplified by the site Kvindvad in Central Jutland (Ebbesen 2004, 94). Meanwhile, reburials in the old Funnel Beaker tombs continued in East Denmark, mainly reflected by numerous dagger finds in megaliths in the region (Iversen 2015, Figure 5.28; Lomborg 1973, 124-126).

The distribution of the various dagger types also differs from West to East. Northern Jutland was likely the primary production area of Type I A, B and C daggers. The northwest Danish daggers may have inspired the production of Type ID and II in South East Denmark, while Type III daggers have a more or less even distribution throughout the country (Lomborg 1973, Fig. 22-28; Vandkilde 2005, 17). Asymmetrical bifacial sickle blades dated to LNI are also far more common in West than East Denmark (Ebbesen 2004, 102; Johannsen in prep-a) (Figure 2).

Last but not least, both house types and settlement patterns differ from West to East. Sunken floor houses belong to the end phase of the MNB and were constructed throughout the LN and into the Early Bronze Age (Nielsen 2019, 22-24; Simonsen 2017, Figure 1.1). While hundreds of houses with sunken floors have been excavated in Jutland, only four are known from Zealand, and none of these belongs to the first half of the Late Neolithic (Johannsen 2017, 5; Sparrevohn, Kastholm and Nielsen 2019, cat. no. 12). Settlements with several houses emerged in the early Late Neolithic in West Denmark, with the Myrhøj and Bejsebakken as the most profound examples (Jensen, 1973; Sarauw 2006a), while large early Late Neolithic settlements are not known from Zealand.

Several of the early Late Neolithic Bell Beaker elements, which are rare in East Denmark, but common in Jutland, are found in South and West Norway and along the west coast of Sweden: daggers of Type IC, wrist guards (Figure 3), and the barbed and tanged arrowheads are found in both South and West Norway, and South West Sweden (Apel 2001, Figure 9.2-9.3; Holberg 2000, 205-206; Kaelas 1952; Prescott 2009; Sarauw 2006b,

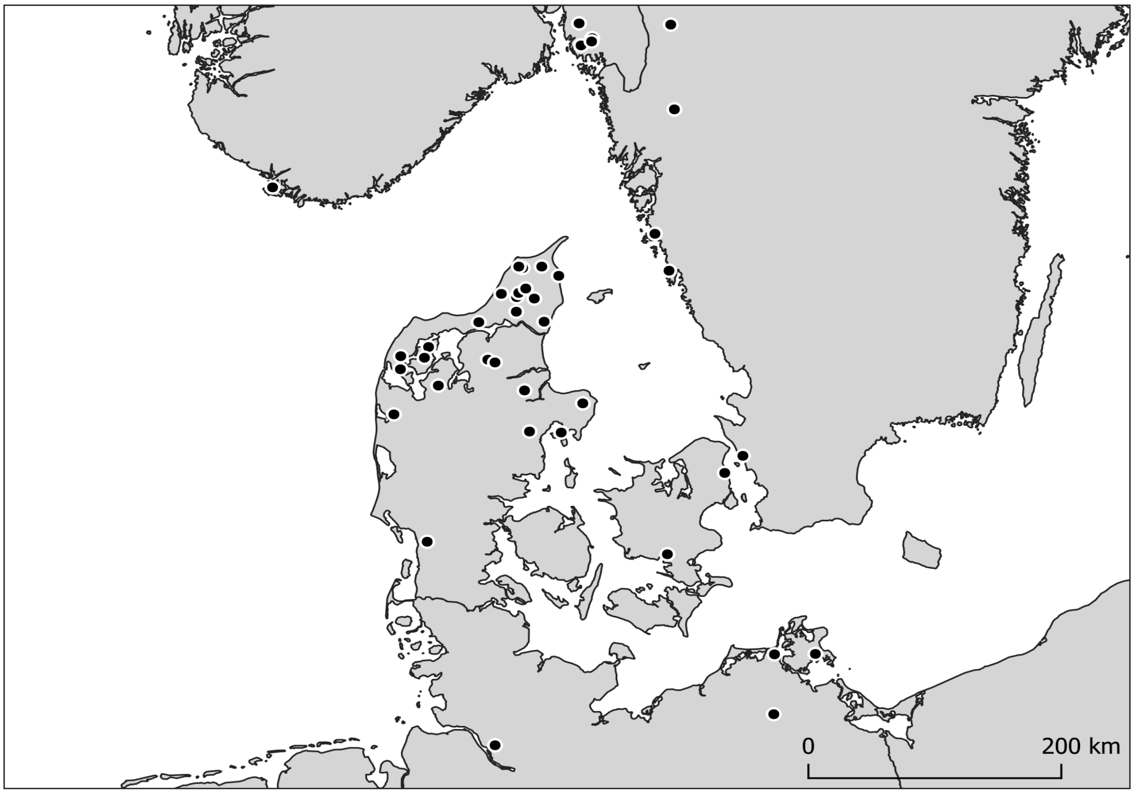

Figure 2. Distribution of asymmetrical sickles in Southern Scandinavia and Northern Germany. The map is based on hoards containing the sickle type (Johannsen in prep-a).

253; Sørensen 2014b, Figure VI. 21; Østmo 2012, Fig. 6.1, Jan Apel, Stockholm University, pers. comm. 2021). Several two-aisled houses with sunken floors have been excavated in West Sweden (Artursson 2009, 43-44; Nordvall 2019), and also the early asymmetrical, bifacial sickle blades have been found in Norway and West Sweden (Figure 2).

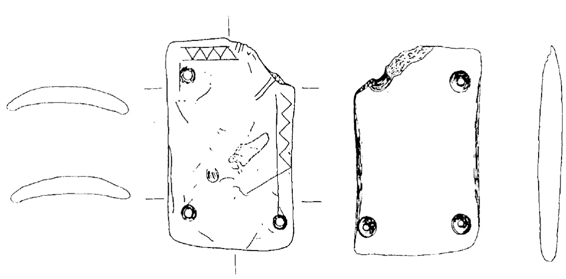

Figure 3. This wrist guard was found in what was likely a sunken floor of an early Late Neolithic house excavated in the southern part of the city Malmö in southwest Scania, Sweden. The wrist-guard is 6.2 centimetres long and 3.65 centimetres wide and made of slate (Salomonsson 1974). Another Swedish wristguard has been found in the Resmo passage grave on the East Swedish island Öland (Malmer 1962, Fig. 80).

As outlined above, finds associated with the early LNI are rare in East Denmark. When it comes to evidence of activity in the second half of the Late Neolithic, the material is, by contrast, overwhelming on Zealand. From around 2100 BCE, several new traits occur: Danish gallery graves have their main distribution in Northern Zealand (Figure 4). The majority of the dagger finds from the graves are of Types III, IV, and V (Lomborg 1973, Figure 75). As recent research shows that Type III daggers likely belong to the middle part of the Late Neolithic (Blank in press, 89), the construction of the Danish gallery graves seems to have started around 2100 BC. This has recently been confirmed by a series of radiocarbon dates made on human bones from Danish gallery graves (Allentoft et al. 2022; Frei et al. 2019, Tab. 1 and 2). While the sunken-floor houses were still the most common house type in Jutland into the Early Bronze Age (Nielsen 2019, 37), the so-called Fosie-houses, which are characterised by their solid construction and a rectangular outline, were constructed on Zealand from around 2100 BCE, and possibly slightly earlier in Scania (Johannsen 2017, Fig. 19; in prep-b).

Figure 4. Distribution of Late Neolithic gallery graves in Denmark. The map is based on Ebbesen 2007, where 119 Late Neolithic gallery graves are included. A review of gallery graves included in the national Danish database of prehistoric sites, Fund og Fortidsminder, added 32 examples to Ebbesen's list.

Settlements with several houses occur on Zealand and in Scania from around 2100 BC (Björhem and Säfvestad 1989; Brink 2013; Johannsen in prep-b; Sparrevohn, Kastholm and Nielsen 2019, cat. no. 41), and finally, new palynological evidence from East Zealand reflects a dramatic opening of the landscape from around 2100 BCE, which is most likely connected to intensified agricultural activities (Johannsen in prep-b, Fig. 7; Mortensen in prep).

Discussion

As outlined above, the strong Bell Beaker influence in Scandinavia at the transition between MNB and LNI left East Denmark more or less untouched, while there are several indications that the overall transition to the Late Neolithic, also in the economic sense, happened somewhat later in East Denmark. The question is what the background for this was.

Recent DNA studies show that the spread of the Bell Beaker phenomenon in Britain from around 2450 BCE was accompanied by rapid replacement of the gene pool (Olalde et al. 2018, 4-5). It therefore seems likely that the Bell Beaker influence, and consequently the beginning of the Late Neolithic in Southern Scandinavia, was also related to migration, although DNA evidence of this is still lacking from the region. The expansion of the Bell Beaker phenomenon in Scandinavia has been suggested to have been propelled by ideals of warriorhood, travelling and learning (Prescott 2012; Sarauw 2007b), while the quest for raw materials – metal and flint – has been suggested as pull factors (Melheim 2012; Sørensen 2014b, 15). The search for arable land may however also have played an essential role in the Bell Beaker expansion since the link between the Bell Beaker influence in Norway and the overall turn to agro-pastoralism as the prime subsistence base shows that farming was an integrated part of the Late Neolithic package (Prescott 1996, 2009, 2020). The increased permanence of the settlements, the development of the bifacial sickle, and the greater variety of cultivated crops also reflect intensification of cereal production in Late Neo-

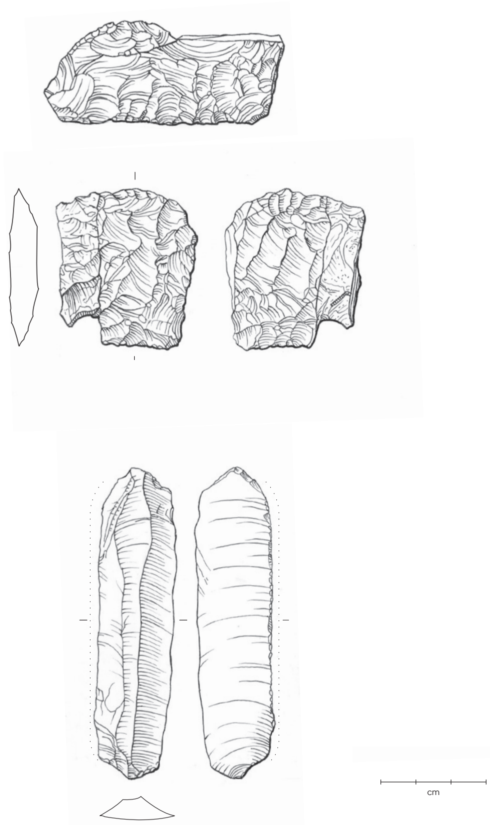

Figure 5. Blade and bifacial sickles from the Myrhøj site. From above find no. 1576-EKL, no. 1576-EJ and no. 1576-AOQ (Drawing: Louise Hilmar).

lithic Denmark, although this is less visible here since the Neolithisation, again in the economic sense of the word, already happened around 1700 years earlier (Sørensen 2014a). That the earliest bifacial sickle blades in Jutland are found in the areas with the strongest Bell Beaker influence (Figure 2) shows that the new sickle Type was developed in the Bell Beaker environment. Furthermore, the Myrhøj site (Jensen 1973), with its evidence of cereal cultivation (ard marks, quern stones, cereal impressions and sickles (Figure 5)) and finds from the earliest part of the Late Neolithic (wrist guard, thick-butted adzes and straight-walled beakers with Bell Beaker ornamentation), demonstrates that the subsistence of the early Scandinavian Bell Beaker tradition was primarily based on agriculture. Although agricultural production already increased in Jutland in the second half of the MNB (Klassen 2005), this strong association between the Danish Bell Beaker environment and agriculture indicates that the overall increase in cereal cultivation during LN in Southern Scandinavia took off with the Bell Beaker influence in Jutland at the transition between MNB and LNI.

It is commonly known that plants convert solar energy into human food much more efficiently than animals do (Pimentel and Pimentel 2003). A smaller area is therefore needed to support people with crops than with livestock, not to mention hunting and gathering (Sabaté and Soret 2014, 478). A landscape's bearing capacity for human population will thus increase significantly with a turn from a diet primarily based on animals to a diet primarily based on plants. The intensification in cereal cultivation during the LN may thereby have led to larger and more stable food production within the society. This formed the basis for decreased infant mortality, in the long run resulting in a population increase. A population boom in Northern Europe in the Late Neolithic is supported by recent population studies (Feeser et al. 2019; Hinz et al. 2012; Johannsen, Laabs and Mortensen in prep; Nielsen, Persson and Solheim 2019) and is further supported by a reduction of primary forest in the same period (Haak et al. in press, Figure 7; Johannsen in prep-b; Regnell and Sjögren 2006, 79).

While the increased food surplus and the derived population increase may have been the fuel for the expansion of the Late Neolithic culture, heritage systems may have been a motor. Recent DNA and strontium isotope analyses on Bell Beaker burials from Central Europe indicate that a male primogeniture and female exogamy system was part of the social structure. It has been suggested that the firstborn son inherited the ancestral land; younger sons had to move away and start their own community, while the daughters of a household established alliances with neighbouring settlements through marriage (Sjögren et al. 2020, Figure 9). The study of social systems through strontium isotopes and DNA analyses is still in its early phase, and there are indeed alternatives to Sjögren et al.'s interpretations (Brück 2021, 7). However, the study is interesting because the presented analyses support long-debated interpretations of kinship structure and social institutions in Copper Age Europe. If a similar inheritance system existed in Southern Scandinavia or was introduced with migrating Bell Beaker groups at the transition to the Late Neolithic, the suggested dynamic of younger sons of a household establishing new settlements could explain the expansion of the Late Neolithic culture.

The Neolithic is traditionally identified as the phase when social and political inequality emerged. The idea is that there is an inherent base for social inequality within the typical Neolithic economic system (e.g. Childe [1936] 1966; Service [1962] 1971). It has, however, been pointed out that this potential for centralisation and stratification was not broadly realised in Europe before several millennia after the Neolithisation and that this may be explained by a balance between top-down exploitation and power consolidation and bottom-up avoidance of elite manoeuvrings. It is suggested that the expansion of agricultural communities into Southeastern and Central Europe was driven by the relatively unsettled land of the European Continent, which made it possible for people to react against top-down attempts to centralise power by simply migrating into a nearby area of unsettled land. The gradual Neolithisation of the European Continent was thereby a product of people's will to make their living beyond the control of leaders (Furholt et al. 2019, 170-176). This model applies well to Late Neolithic Southern Scandinavia, where the expressions of social stratification are vague until the emergence of the monumental houses at the end of the period (Egelund Poulsen 2009; Johannsen 2017). Following Furholt et al.'s interpretation of the Neolithic expansion in Europe as a reaction against social control, an explanation of the seemingly egalitarian Late Neolithic society in Southern Scandinavia is that attempts to centralise power were avoided by resettling and cultivating new land. For instance, in line with Sjögren et al.'s interpretations (2020, Figure 9), when younger sons of a household were forced to find their own way of living if they did not want to work for their father and subsequently, their older brother. A combination of such a heritage system and population increase would have led to expansion.

According to this model, the spread of the new Late Neolithic traits should gradually have covered Southern Scandinavia. However, this is not what happened. The development was not linear but abrupt: as presented above, the distribution of Bell Beaker-related artefacts shows that the new traits rapidly expanded from Jutland into Southwest Norway and West Sweden, while it took longer for new traits to gain a foothold in East Denmark, reflected by the emergence of sturdy houses, large settlements, and gallery graves in the area from around 2100 BCE. Today, the Bell Beaker tradition is described as a phenomenon, not a culture, because of significant regional variations in its material expression. One common element, however, is male graves furnished with bow, arrows, and dagger (Heyd et al. 2018, 3; Sarauw 2007b). The weapons may express a common warrior identity, indicating that violence was an integrated part of the Bell Beaker phenomenon. It is thereby tempting to explain the Bell Beaker expansion in Southern Scandinavia as a violent colonisation, as has been suggested for the expansion of the various Corded Ware groups in Europe (Kristiansen et al. 2017). In this view, the delay from West to East could be understood as the East Danish stronghold of Funnel Beaker-traditions managing to resist colonisation. Competition for farmland is a possible point of conflict in a society like the Late Neolithic, which was almost entirely based on agriculture (Earle 1997). Although osteological analyses made on Late Neolithic human bones show that violence was part of Late Neolithic life (Blank 2021; Tornberg, in press, Tab. 4), it is however questionable if the background for this was territorial conflicts when the pollen diagrams show that, except for Western Jutland, large parts of Southern Scandinavia were still covered by primeval forest at the transition to the Late Neolithic (Haak et al. in press, Figure 7; Regnell and Sjögren 2006, 40-79). Throughout the Late Neolithic, it was thus still possible to find large unoccupied areas which could be transformed into fertile farmland.

Furthermore, replacement of the existing culture must be expected with a violent colonisation. However, the continuity of several cultural elements in Denmark at the transition from MNB to LN shows that the existing culture was not replaced but reformed. This is clearly expressed by male burials, which at the transition to the Late Neolithic in Jutland were equipped with daggers instead of a battle axe, while other Single Grave Culture burial traditions continued. It has been pointed out that Bell Beaker burial rituals were not much different to Corded Ware burial rituals but variations of the same practice (Furholt 2019, 116-117). The Bell Beaker burial rituals thereby resonated with the existing burial traditions in

Jutland around 2350 BCE. It was therefore easy for the existing population in Jutland to adapt the new Bell Beaker traits introduced by migrating people, which may explain the rapid spread of the new Late Neolithic culture in this area. In the same way, the much larger differences between the existing Funnel Beaker-derived culture and the new expanding Late Neolithic culture may explain the unwillingness to adopt the new cultural elements in East Denmark and Zealand in particular. Here, the gallery graves may be a key to understanding the final breakthrough of Late Neolithic culture. The Danish gallery graves are most commonly east-west oriented, up to 3.8 metres long and 1.4 metres wide, constructed by flat stone slabs and covered by a small mound (Ebbesen 2007, 15). The east end of the gallery graves is typically less sturdy, easing the entrance when the graves were opened to successive burials. As many as 19 individuals have been identified in a Danish Late Neolithic gallery grave (Ebbesen, 2007 31). While 151 Late Neolithic gallery graves are registered in Denmark (Figure 4, Ebbesen 2007; Kjær 1910), about 2000 Late Neolithic gallery graves are registered in Sweden (Blank et al. 2021, 64; Blank, Sjögren, and Storå 2020, Figure 5; Johansson 1961, Figure 157). Thereby, it is reasonable to assume the new burial type reached East Denmark from the Scandinavian Peninsula, as also suggested by Ebbesen (2007, 7-10). Some Swedish gallery graves are considerably larger than the Danish examples, and as many as 80 individuals have been identified in a single gallery grave (Lennblad 2015; Retzius 1900). In that sense, the gallery graves are comparable to the ancient megalithic tradition of the Funnel Beaker Culture (Müller and Vandkilde 2020, 39). Around 2800-2350 BCE, when variations of the Corded Ware Complex settled in Southern Scandinavia, the tradition of single burial emerged in West Denmark and the southern part of Sweden. However, the tradition of reburials in megaliths, as mentioned, continued in East Denmark, and continuity thereby characterised the burial traditions here during the second half of the Middle Neolithic period and the Late Neolithic (Iversen 2015, Figure 5.28; Lomborg 1973, Fig. 77). When the new smaller megaliths in the shape of gallery graves were introduced on Zealand from the East in the middle of the Late Neolithic, it thereby resonated with the existing burial practice. It was thus not a break with the existing traditions but an expansion of a still vital megalithic burial practice. This may have been what made the new cultural elements acceptable to the conservative population of Zealand and finally opened up the region for the breakthrough of the Late Neolithic, including improvements in subsistence. The gradual decline of Funnel Beaker traditions on Zealand, as identified by Iversen, was thus not finalised with the MNB. To reuse Iversen's creolisation analogy, the continuation and revival of megalithic traditions in the Late Neolithic on Zealand can be seen as a continuation of the Funnel Beaker 'grammar'. The explanation as to why it was necessary to construct new megalithic monuments in East Denmark after more than 1000 years break may be sought in an increasing demand for new farmland: besides being expressions of the (Late) Neolithic religion and ideas of the afterlife, the revival of the megalithic tradition in East Denmark and Southern Sweden may also be an expression of expansion. Some gallery graves were built close to the shore (Johannsen 2021), but most were constructed on fertile soil inland, likely close to settlements (Figure 6). In a few lucky cases, ard marks have been recorded under Late Neolithic gallery graves, suggesting that they were constructed directly on the cultivated fields (Thrane 1989). The small megaliths with several inhumations could thereby be interpreted as family/kinship plots, which were the visible evidence of property rights to the land of the descendants of the buried, an interpretation which has also been suggested for the megaliths of the Funnel Beaker Culture (Brozio et al. 2019, 1566; Renfrew 1976), and is supported by a recent study of haplogroups of individuals found in gallery graves in Falbygden in Southwest Sweden (Blank et al. 2021, 25). The old megaliths, used for burials over several centuries, were no longer enough since new farmland came under plough with a population increase propelled by the agricultural improvements outlined above. Similar to the example from Kvindvad of Late Neolithic settlers coming into new areas in Central Jutland (Ebbesen 2004), the new settlers in East Denmark had to start from scratch, which included the construction of new megalithic burial monuments.

Figure 6. A gallery grave at Marbäck near Ulricehamn in Sweden. The main part of Denmark is cultivated farmland today. Agrarian reforms during the last 200 years have significantly contributed to this development. But in the less intensively cultivated Sweden, it is still possible to get an impression of the Late Neolithic landscape. It is thus fascinating to see that the Late Neolithic gallery graves, like the one from Marbäck, are found in open areas, cleared of wood and glacial erratics. These areas are often still used for grassing, haymaking and cereal cultivation (Photo: Jens Winther Johannsen).

The next question is whether this Late Neolithic expansion on Zealand was caused by people migrating from the East or the diffusion of cultural traits from the same area. Both suggestions could be the answer. However, it seems unlikely that the introduction of a distinct new house type (the Fosie house), the construction of a new kind of megalith, the introduction of several new tool types and changes in subsistence were only the result of the existing population's contacts on the other side of Øresund. People most likely migrated from East to West during this period. But that the new cultural elements, rooted in the Bell Beaker expansion several hundred years earlier, for the first time gained a foothold on Zealand, were, as argued, also rooted in a congruity between the new cultural elements and the ancient Funnel Beaker traditions. This supports the idea that the Late Neolithic expansion in East Denmark was not a violent takeover of land but a combination of migration from the East and adaptation of new cultural customs by the existing population on Zealand.

Conclusions and implications

The development outlined above is an attempt to understand the expansion of the Late Neolithic culture as more dynamic than in previous studies. Southern Scandinavia did not turn to the Late Neolithic overnight around 2350 BCE and remained so until the Bronze Age's onset 650 years later. The expansion of the Scandinavian Late Neolithic culture was multi-laned and rooted in migrations, changes in subsistence, and possibly a social system motivating people to colonise unsettled land.

Finally, the suggested delay from West to East Denmark in the spread of Late Neolithic culture makes it worth reconsidering the critique of Lomborg's chronological division of the South Scandinavian Late Neolithic. Lomborg interpreted daggers of Type I as the earliest chronologically, followed by Type II, followed by Type III and so on. Based on this, Lomborg divided the Late Neolithic into the three chronological phases A, B and C, where daggers of Type I belong to LN A, Type II and III to LN B, Type IV and V to LN C and Type VI to the Early Bronze Age (Lomborg 1973, 64-80). The marked lower frequency of Type I daggers in East Denmark compared to West Denmark was used as the main argument in a critique of Lomborg's chronological division. The typological differences between Types I, II and III were suggested to be a question of spatial variation. Type I daggers were thought to have been produced and used in West Denmark mainly meanwhile Type II, and III daggers were mainly produced and used in East Denmark (Apel 2001; Madsen 1978; Rasmussen 1990; Vandkilde 1989). The dagger types may not be as chronologically distinct as Lomborg thought; combinations of various dagger types in hoards show that overlaps exist, which was already pointed out by Lomborg himself (1973, 67). However, considering the indications of a delay from West to East in the introduction of Late Neolithic culture, the lower frequency of Type I daggers in East Denmark may be explained by only a small number of flint daggers reaching Zealand in the earliest part of the Late Neolithic. The complete absence of daggers of Type IC on the island supports this interpretation. Late Neolithic culture did not widely reach Zealand before Type I daggers were largely replaced by Type II and III daggers. This interpretation is in line with Iversen's interpretation of the Type K and L battle axes on Zealand, the use of which is suggested to continue to 2250 BCE (Iversen 2015, 29). As the prime symbol of male identity on Zealand, these were succeeded by daggers – of Lomborg's Type II and III. Consequently, it is reasonable to consider the reinstitution of Lomborg's tripartite division of the Late Neolithic Period in Southern Scandinavia.

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Late Neolithic and Early Bronze Age settlements and agro-pastoral developments in the Oslo Fjord area, southeastern Norway

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ABSTRACT

For several decades, there has been a duality in the archaeological research on the character and nature of how people became farmers in southern Norway, with scholars favouring a (swift) introduction of a comprehensive cultural package with the onset of the Late Neolithic (*c*.2350 BCE) on the one hand, and scholars favouring more long-term trajectories and internal dynamics on the other. Due to a generally more fragmented archaeological record from southeastern Norway, where there for long have been a lack of longhouses and direct empirical evidence of the introduction of farming, western Norway has been the focal point of this debate.

Through newly aggregated and different relevant data types, we aim to better the understanding of the agricultural developments and the trajectories of the early (farm-based) settlements in the Oslo Fjord area in southeastern Norway. The results of our study prove a general delay in the establishment of longhouses, which appear from 2200–2100 BCE, and a stepwise intensification in crop farming from *c*.2100 BCE, although certain regional variances were detected. Both these trajectories also contrast some of the more profound material changes evident from around 2350 BCE. We interpret this as a more gradual and adaptive farming development in this part of southern Norway, hence disfavouring the theory of the introduction of a comprehensive package with the onset of the Late Neolithic.

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Introduction

Since the 1990s, there has existed a duality in the archaeological research addressing the character and nature of how people became farmers in southern Norway. This debate has mainly had western Norway as its focal point. A reason for this, is that compared to western Norway, there has for long been a lack of evidence of Late Neolithic (LN, for details see Table 1) and Early Bronze Age (EBA) longhouses and other finds associated with a farming economy, such as cereals and bones from domesticates, as well as tilled fields, from southeastern Norway (Damlien et al. 2021, 131). The overarching aim of this paper is to better the understanding of the agricultural developments and establishment of farm-based societies in the Oslo Fjord area in southeastern Norway (Figure 1), and through this also contribute to the long-lasting and still ongoing debate on the process of how people become farmers in southern Norway.

This debate consists partly of scholars arguing for the introduction and spread of a comprehensive economic, social, and cultural package throughout southern Norway with the onset of the LN (e.g. Melheim 2012; Myhre 2002, 38-75; Prescott 2009, 200; 2020). Among the discussed changes, are the introduction of two-aisled houses and agricultural practices (e.g. Austvoll 2019, 2021; Børsheim 2003, 2004; Løken 1998; Prescott 2005; Soltvedt

Period	Late Neolithic		Early Bronze Age		
Phase	LN I	LN II	EBA I	EBA II	EBA III
BCE	2350-1950	1950-1700	1700-1500	1500-1300	1300-1100

Table 1. Chronology of the period in study (after Vandkilde 1996, From Stone to Bronze).

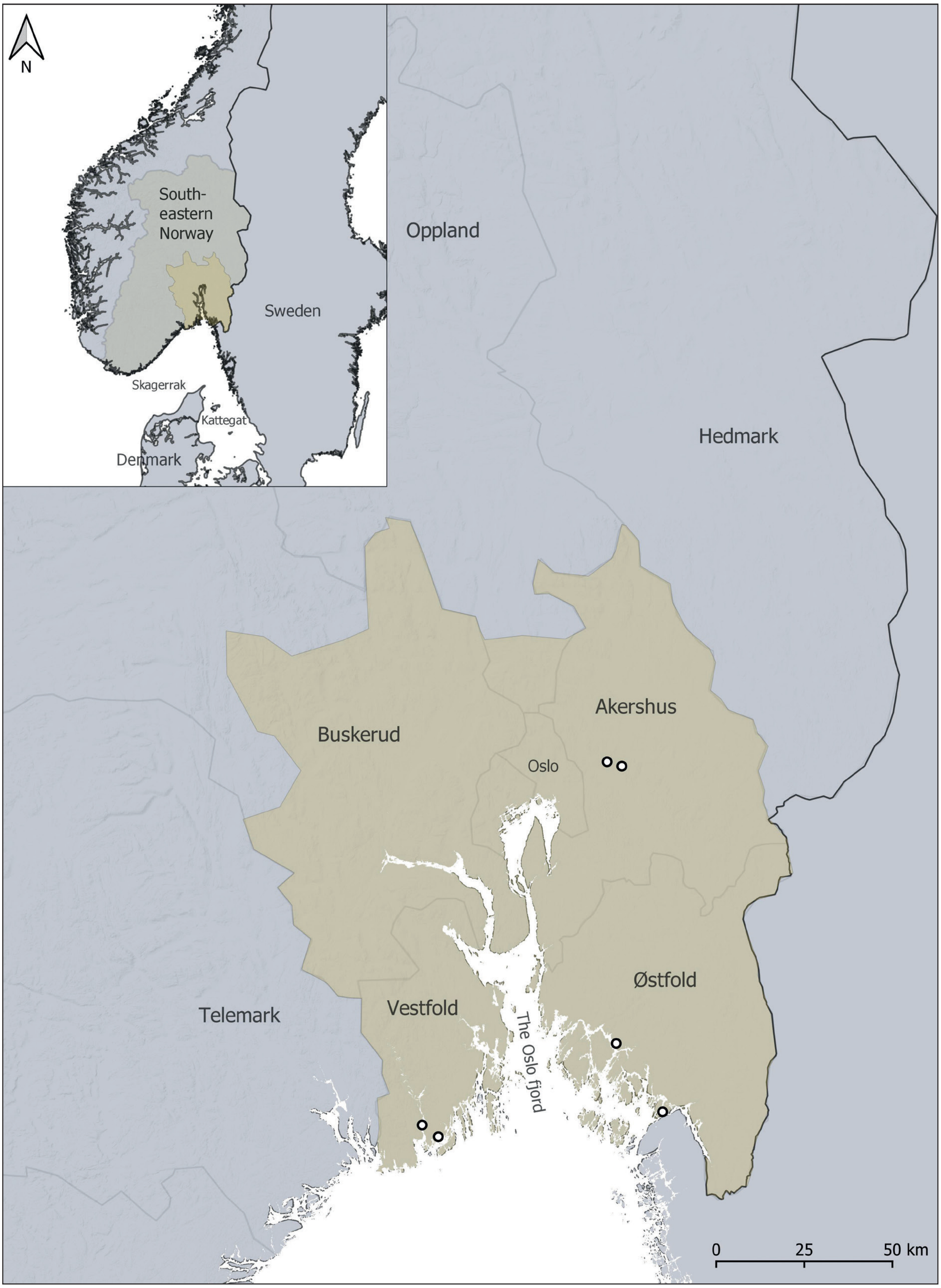

Figure 1. Map showing the Oslo Fjord area, with the different regions marked by boarders and name, and the six case sites marked in white (By A. Sand-Eriksen).

et al. 2007), as well as several new technologies and artefacts. For instance, the spread of different bifacial lithics, such as daggers, sickles and arrowheads, and metal artefacts across southern Norway (Apel 2012; Melheim and Prescott 2016; Mjærum 2012; Prescott, Sand-Eriksen, and Austvoll 2018;

Østmo 2005). These are artefacts and technologies argued to be signs of the influence of the Bell Beaker Culture (BBC) in southern Norway (Apel 2012; Glørstad 2012; Prescott 2005, 2012).

The theories of (a primary) external influence are not uncontested, however. Other scholars view the economic and cultural changes as results of internal processes as well, such as agriculture being adopted by the hunter-fisher populations earlier in the Neolithic (Bruen Olsen 1988). Such theories have later been (partly) supported by both archaeological evidence and palynological data, which, for instance, indicate that certain agricultural practices could have been performed on a small-scale basis prior to the LN in western Norway (e.g. Bergsvik et al. 2020; Hjelle, Hufthammer, and Bergsvik 2006). In lines with this latter theory, is evidence of continuous traditions of (local) lithic production and persisting subsistence practices of both hunting, fishing, and gathering across southern Norway (e.g. Nyland 2020, 71; Rundberget and Amundsen 2020, 62).

In our aim of bettering the understanding of the agricultural developments and establishment of farm-based societies in the Oslo Fjord area, we will also bring new knowledge to the outlined debate, hence reducing the knowledge gap between western and eastern Norway regarding the LN and EBA developments. We will first present results from an analysis of a larger body of radiocarbon-dated buildings dated to the LN and the EBA from all of the Oslo Fjord area (see Supplement), which will be further analysed and discussed alongside dated cereals grains (Solheim 2021a) and cultivation layers (Mjærum 2020) from the region. Thereafter, we will present three case areas of six settlement sites (see Appendix 4); two located in the region Vestfold on the western side of the fjord, two in Østfold on the eastern side and two in Akershus in the northern parts of the fjord (Figure 1). This paper is the first comprehensive analysis of the earliest farm-based settlements and their associated agro-pastoral activities in southeastern Norway.

The theoretical foundation of our inquiry relies on the concept of 'bounded rationality'. The theory was proposed by H. Simon (1955, 1959) in response to rational choice theory, which advocates how people always make optimised economic decisions. By contrast, the theory of bounded rationality argues how this is not possible due to the three limiting factors of cognitive ability, imperfect information, and time constraints. As a result, humans also make suboptimal decisions, where the mentioned limitations are overcome through satisficing. We will also draw on the concept of creolization (see e.g. Iversen 2015; Larsson 2015; Nielsen 2022), and use the combination of the concepts to move closer to the decision-making processes behind settling and becoming farmers in the Oslo Fjord area during the LN and EBA, as evident through the archaeological record.

Geography and climate

The geographical focus of this paper is the Oslo Fjord area[1], which broadly speaking consists of landscapes surrounding the 120 km long Oslo Fjord in southeastern Norway (Figure 1). Although the area of approx. 25.000 km^2 only makes up 20 % of the land coverage of southeastern Norway, large parts of this vast region consist of enormous mountain ranges, which separates it from western Norway. The geography between the mountain landscape and towards the coast, in which the Oslo Fjord area is situated, also vary. The area has large stretches of woodland and valleys, several with fertile farming areas (Puschmann 2005, 35, 43-44, 47-48; Puschmann et al. 2004), and excellent opportunities for hunting (Rundberget and Amundsen 2020, 62). The Oslo Fjord area is situated within parts of southeastern Norway referred to as lowlands, which has significant areas with drainable sandy subsoil and high mean annual temperature in a Norwegian scale, making it especially suitable for agriculture (Puschmann 2005, 19-20; Puschmann et al. 2004). Even so, the Oslo Fjord is considered as part of the boreonemoral vegetation zone, and the physical condition is thereby somewhat harsher than in the nemoral areas of southern Scandinavia (Moen 1999, 92).

The areas on and south of the terminal moraine Raet in the regions Østfold and Vestfold are highlighted as particularly suitable for early farming (Johansen 1976, 53; Østmo 1988, 123; 1993, 97-98). The southernmost parts of the area are also low-lying, particularly south of Raet, which in general do not surpass 100 m above present day sea-level. The areas further north have a divided topography alternating between small hills and flatlands and subsoils spanning from well drained sand to compact clay and unsorted moraine. In historical times, this affected land ownership and tenure, resulting in a scattered mosaic of small-scale and larger farming areas (Puschmann et al. 2004, 44, 47; see also Gjepe, 2017).

In the LN and EBA, the relative sea-level was 15-20 m higher than the present (Sørensen 2002), but the maximum distance across the fjord has nevertheless remained generally unaltered. Parts of the fjord were most likely relatively easy to cross with sufficient nautical experience or knowledge, especially compared to the argued crossing of the Skagerrak-strait (Austvoll 2021; Kvalø 2007; Østmo 2005). From the fjord, several lakes and rivers stretch inwards in all directions, effectively connecting the surrounding landscapes together. During the LN and EBA, anthropogenic effects on the area becomes more evident, indicating some degree of deforestation, most likely due to an increase in agro-pastoral activities (Mjærum, Loftsgarden, and Solheim 2022; Wieckowska-Lüth et al. 2018). Studies have indicated an overall temperature decline around 2200-2000 BCE (Hammarlund et al. 2003, 367-368), which also resulted in milder and wetter winter conditions (Nesje et al. 2001). The climatic data from the North Atlantic region are ambiguous (Bradley and Bakke 2019), but such an event could have affected subsistence and land use strategies (Blank 2021, 64; see also Gundersen 2022) and improved marine productivity (Polovodova Asteman et al. 2018, 252; see also Gundersen 2022, 365-367).

Background

The introduction of farming

The cultural and economic importance of farming has been discussed considerably in Norwegian archaeology (e.g. Bakka and Kaland 1971; Bruen Olsen 1992, 2009; Hjelle, Hufthammer, and Bergsvik 2006; Høgestøl and Prøsch-Danielsen 2006; Kaland 1986; Prescott 1996, 2005). Despite nuances, it is commonly agreed upon that crop farming was of limited economic importance before the LN in southern Norway (Bergsvik et al. 2020; Glørstad 2012; Nielsen, Persson, and Solheim 2019; Prescott 2020; Solheim 2021b). This stands in stark contrast to other areas in southern Scandinavia, where both animal husbandry and cereal cultivation were introduced around 3950-3700 BCE (Fischer 2002; Gron and Sørensen 2018; Gron et al. 2016; Sjögren 2012; Sørensen and Karg 2014). In southeastern Norway, on the other hand, only a single (secure) incidence of agricultural farming predating the LN is known (Reitan, Sundström, and Stokke 2018; Solheim 2021b).

Nevertheless, there are other components from the archaeological record that could indicate that the people inhabiting the region also knew farming prior to the LN, such as pottery and polished flint axes, as well as a low number of possible farming sites and (small scale) palynological data indicative of cereal cultivation and animal husbandry (Glørstad 2009, 2010; Glørstad and Solheim 2015; Nielsen 2021; Solheim 2012). A further example is the shift in the spread of finds in the landscape, with, for instance, Middle Neolithic (MN, 3300-2350 BCE) axes appearing more near the coast than the axes belonging to the Early Neolithic (EN, 3900-3300 BCE) did. This is by several interpreted as indicative of a de-neolithisation, where people returned back to fishing, hunting and gathering as their main subsistence strategies in the MN (Nielsen 2022, 116-117; Reitan, Sundström, and Stokke 2018, 550; see also Hinsch, 1950, 104; Østmo, 1988, 225-6). It has also been argued that during the MN, again based on the spread of artefacts, particularly axes in the southeastern mountain areas, farming practices could to a greater extent have been oriented towards pastoralism (e.g. Gundersen 2013; Hinsch 1956; Kilhavn 2013; Mikkelsen 1989; Prescott and Walderhaug 1995; Reitan 2005). Through the utilization of radiocarbon dated cereal grains from southeastern Norway, S. Solheim (2021a; 2021b) has recently demonstrated that the establishment of farming was a long-term development over several steps. He also suggests that the earliest agriculture most likely had a different form than in LN (Solheim 2021b, 10), which could explain why few archaeological traces of earlier farming are preserved or visible today (Nielsen, Persson, and Solheim 2019, 88).

Tendencies in the archaeological record

The widespread distribution of flint daggers to Norway, of which around 450[2] are known from the Oslo Fjord area (for details see Apel 2001; Scheen 1979), has been a recurring theme for researchers looking to assert and exemplify frequent contact and trade across Skagerrak from the onset of the LN (Apel 2001, 2012; Austvoll 2021; Scheen 1979; Solberg 1994; Østmo 2005, 58-61). This oversea travel, connecting southern Norway to central Scandinavia (Østmo 2005), is argued to have resulted in a swift and complete change of social life from 2350 BCE (Prescott, 2009, 200), consisting of the emergence of new settlement patterns, including two-aisled houses, farming, the introduction of bifacial technique and imported objects imitating metal artefacts, such as the abovementioned daggers, actual metal artefacts and metallurgy (Austvoll 2021; Børsheim 2003; Holberg 2000; Melheim and Prescott 2016; Mjærum 2012; Prescott and Walderhaug 1995; Østmo 2012).

Several scholars have argued that these changes were facilitated by migrations of people belonging to the BBC (Prescott 2012; Prescott, Sand-Eriksen, and Austvoll 2018). At the turn of the LN, the BBC formed broad trading networks along the European waterways and at sea (Fitzpatrick 2011; Vandkilde 2014), including the crossing of Skagerrak by boat into Norway (Melheim and Prescott 2016; Prescott 1996, 2005, 2009, 2012, 2020; Prescott and Glørstad 2012, 2015; Prescott and Walderhaug 1995; Østmo 2005, 2012). The earliest type of flint daggers (type IA) and barbed and tanged arrowheads are especially numerous along the southwest coast of Norway, interpreted as a consequence of the area's close contact to Jutland in Denmark (Austvoll 2020, 2021; Østmo 2005). Researchers advocating a longer and more gradual transition of farming, based on pollen records and MN domestic animal bones from western Norway, have argued that indigenous hunter-fisher-gatherers introduced farming to western Norway, even though they do not exclude the possibility for immigration of small groups of farmers during the MNB and LN (Bergsvik et al. 2020, 356-357; Hjelle, Hufthammer, and Bergsvik 2006, 164, with further ref.).

As in most studies on the spread of farming across Europe (for a review and discussion see e.g. Robb 2013), the above sections show that there are no clear-cut answer to whether it was the movement of farmers that led to the beginning of farming in southern Norway or if it was foragers that adopted farming. Although it is not the main purpose of this paper to address the issue of movement of 'pots or people', we will return to this inevitable question in the later discussion of our results.

Material, methods, and source criticism

The first evidence of farm-based settlement in southeastern Norway was not excavated until 2002 (Rønne 2003, 2004), and a decade later (Bruen Olsen 2013, 130) only two sites with two-aisled houses were accounted for in eastern Norway. In this paper, we present a much larger body of material. The rapid increase in the number of houses can mainly be attributed to a period of intensive archaeological activity over the last two decades, where development-led heritage management projects have generated an extensive body of high-quality data (Damlien et al. 2021; Iversen and Petersson 2017). Several sites have been 'hidden' in excavation reports, and the record of houses used in this paper is collected from reviewing reports from the Museum of Cultural History (MCH). This has resulted in a database of 60 buildings from the Oslo Fjord area, most of which are not previously published, and form part of a larger dataset from southeastern Norway currently under development. Apart from houses in the southernmost part of the region (Agder), the 60 buildings from the Oslo Fjord area make up the main part of the settlement material dated to the LN and EBA from all of southeastern Norway, and we regard the outlined trends in this paper as representative for the region.

Close to 80 % (n=47) of the buildings from the Oslo Fjord area had available information regarding the individual radiocarbon dates (see Supplement), while the remaining houses were either typologically/stratigraphically dated or had C14-data not available or retrievable, but with the dated period mentioned in the report. Dates that obviously did not have a connection with the houses, were omitted. In total, we have included 124 radiocarbon dates from the buildings in this study, which is a little low for reconstructing past events representatively (Hinz 2020; Williams 2012), as larger numbers is a more accurate indicator of robustness (Crema and Bevan 2021).

Nutshells and grains are in general seen as preferable materials for radiocarbon dating (cf. Soltvedt 2020), and used when accessible. Although likely remnants from living in and using the house, they can also be redeposited and represent earlier activities at sites (Baxter 2003, 189; Gjerpe 2008). Since wood charcoal is more commonly found at excavations in southeastern Norway, it is often used when dating the region's houses. A problem with this record is the inherent age of the dated charcoal itself, especially significant for long living species like pine and oak (Bowman 1990). To reduce this problem, botanists and archaeologists select charcoal from short-lived trees and/or young trunks and branches, as the most suitable material for dating. The dated wood charcoal might stem from the burning of the post to prevent decay, and thus represent the construction phase of the house, but can also be redeposited during the construction or later use.

To visualize the temporal distribution of the data, we provide summed probability plots (SPD). Since there is a large variation in the number of radiocarbon samples from the different sites in our study, which potentially can cause sampling bias, we have binned the data in 200-year long site phases. Several overlapping dates from one site were then counted as one if they represent a site phase of less than 200 years. The SPDs and bindings are made using the Rcarbon package (Crema and Bevan 2021) developed for R programming language (R Core Team 2020). The dates are calibrated using the IntCal 20 calibration curve (Reimer et al. 2020). We apply an exploratory approach to the SPDs, and are aware of the effects sampling biases and calibrations have on the record (Crema 2022). To mitigate these effects, we will focus on the large-scale trends and compare the house record with two other radiocarbon datasets from the Oslo Fjord area – cereals and cultivated fields. The record of dated cereals is based on a compilation of radiocarbon originally collected by S. Solheim (Solheim 2021a). We have, however, only included records from the Oslo Fjord area in our study, 514 dates altogether. The records from cultivated soils consist of 268 dates. Parts of this data is previously published (Mjærum 2020), but also here we have limited the dataset to the Oslo Fjord region and added dates from archaeological excavation reports published in 2020 and 2021.

Concerning the cultivation layers, dates of cereals are excluded from the dataset, something that makes this record fully independent from the cereal analysis. The dating of houses is based on wood charcoal (n=81), nutshells (n=4) and bone fragments (n=2), but also cereals (n=37). The house record is thereby only partly independent from the record of cereals. To test the interdependency of this record, we have also produced SPD plots of the houses without dated cereals (Appendix 1). No major differences between the plots with and without dated cereals were detected.

Results and interpretations

Of the 60 buildings, 48 are houses and 12 defined as other buildings. Of the houses, 31 are two-aisled and 17 three-aisled (Table 2). 19 of the two-aisled houses occur on the eastern side of the fjord, in the former county Østfold, while five is in Akershus towards the north, and the remaining seven in Vestfold on the western side (Figure 2). There is a total absence of three-aisled houses in Vestfold, however, this cannot be attributed to a general lack of excavations in the region since the early 2000s. There are, for instance, around 60 three-aisled houses dated to the Iron Age in the region (Gjerpe 2017, 83, Tabel 6.1).

Our detailed study of houses and associated material consists of six sites within three case areas. The first focuses on what we consider to be the first introduction of two-aisled houses south of Raet on the eastern side of the Oslo fjord. The second focuses on settlements and adaptions in the northern Oslo Fjord area, while the third case explores the more long-term development of farmyards on the western side of the fjord. The main objective is to examine the sites from a bottom-up perspective, situating them within the overarching results from our analyses and evaluations of radiocarbon datasets from the entire study area, hence testing these

Table 2. The settlement material from the Oslo Fjord area dated to the LN and EBA, sorted after type, period, and regions (most of the excavation reports use the same regions, as they were separate administrative counties in Norway until 2021)

	Period	Østfold	Akershus	Vestfold	Sum period
Two-aisled houses	LN I	3	-	1	4
	LN I-II	1	1	1	3
	LN II	3	2	-	5
	LN	2	-	-	2
	LN-EBA	5	1	3	9
	EBA I	1	1	-	2
	EBA I-II	-	-	1	1
	EBA II-III	-	-	1	1
	EBA-LBA	2	-	-	2
	EBA?	1	-	-	1
	Sum region	*19*	*5*	*7*	*31*
Three-aisled houses	EBA I	2	-	-	2
	EBA I-II	-	1	-	1
	EBA II	1	1	-	2
	EBA III	-	1	-	1
	EBA-LBA	2	1	-	3
	EBA	1	-	-	1
	BA	3	4	-	7
	Sum region	*9*	*8*	*0*	*17*
Other buildings	LN	-	1	-	1
	LN-EBA	-	2	-	2
	EBA I	1	1	-	2
	EBA I-II	-	-	1	1
	EBA II	2	-	-	2
	BA	4	-	-	4
	Sum region	*7*	*4*	*1*	*12*
	Total sum	35	17	8	60

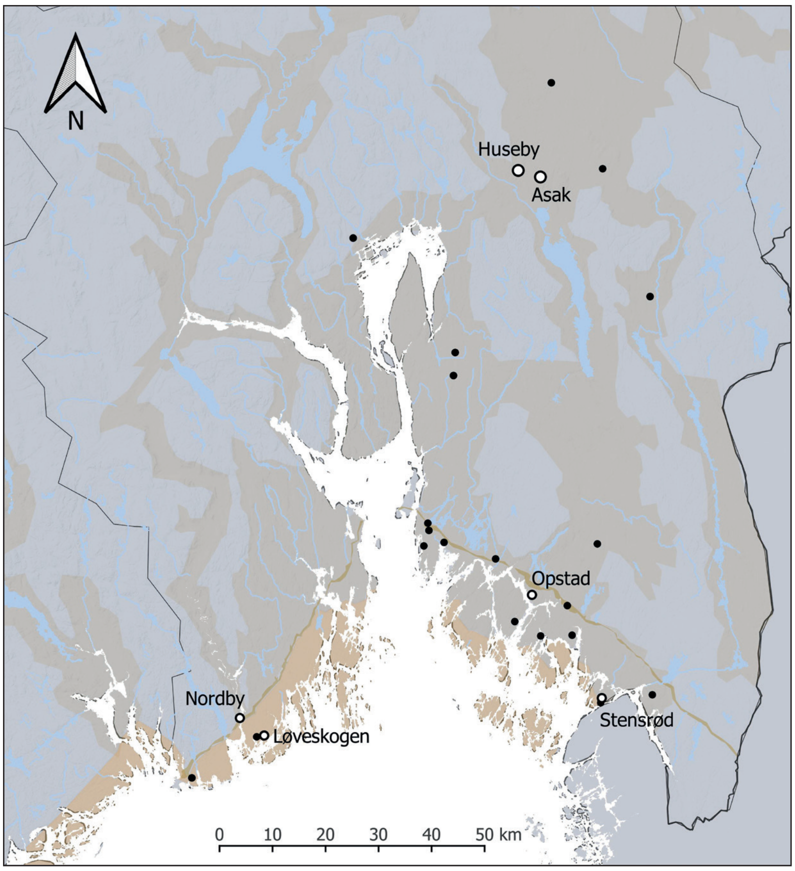

Figure 2. Map of the three case areas with the six sites marked with names, and other LN and EBA settlements sites added. Brown lines shows the terminal moraine, Raet, while light brown highlights areas favourable for agricultures. The light orange shows the coastal zone, with favourable mean annual temperatures. The sea level is raised 15 m higher than present (By A. Sand-Eriksen).

results also locally. First, we will present the results from the radiocarbon analysis of the settlements, cereals, and cultivation soils.

Results inferred from radiocarbon dates

From the settlement material, 124 radiocarbon dates ranging between 2835-2345 cal BCE (4000±110 BP, T8022) and 1020-900 cal BCE (2810±30 BP, Beta-426059) have been collected from excavation reports (Figure 3A, Supplement). The simulation shows a tail to the distribution of calibrated dates extending back to the late third millennium BCE, first rising marginally throughout the MN, before a small peak in the SPD gets visible around the onset of the LN, *c.*2350 BCE. Following this weak introductory curve is a more discernible establishment in the settlement material at around 2200 BCE. Due to source critical problems with the dated material (see above), together with tail and spreading effects of the standard error in radiocarbon dates, we regard 2200-2100 BCE as the time when two-aisled houses became common within the study area. Although the handful of previous dates in the weak introductory curve could be evidence of actual houses, they are not possible to construe form the data, nor were they noticed during excavations. The number of dates is relatively stable until the transition to the EBA, but from *c.*1700 BCE the SPD indicates a fall in the number of two-aisled houses, although occurring as late as 1300 BCE (see Case 3).

According to the SPD, three-aisled houses start to appear already in the LN (Figure 3B), which is too early. This is probably to some degree caused by source critical issues, as well as a couple of possible wrong interpretations of (partial) house plans. The second, more pronounced peak in three-aisled houses around 1600 BCE is in line with developments in southern Scandinavia (Artursson 2009; Børsheim 2003; Larsson and Brink 2013), and most likely represent the real entry of the three-aisled houses in the Oslo Fjord area, although earlier secure instances occur (see Case 2). Surprisingly, the three-aisled houses do not seem to get a real footing at this time, perhaps indicating that the building technique did not immediately replace the two-aisled. There is a continued fall in the presence of houses, resulting in a rather drastic decline in the settlement material just before 1400 BCE, followed by a period of few acknowledged houses throughout the EBA. This situation seems to have ended by an increase in the number of the three-aisled buildings from the onset of the Late Bronze Age (LBA, 1100-500 BCE).

The SPD for cereals gives us a partial picture of the outcome of actual farming in the study area (Figure 4A). No grains have been directly radiocarbon-dated to before 2200 BCE, and dates prior to 2000 BCE are few in numbers. The SPD from Østfold displays a slightly earlier introduction of cereal farming than the rest of the study area (Appendix 2), hence demonstrating certain local temporal developments. In the plot of dates from cultivated soils, there are six EN and MN radiocarbon dates (Figure 4B). Such layers commonly include charcoal fragments that predate the farming activity (Mjærum 2020, 6-10), and it is unlikely that these EN and MN dates indicate early farming. The SPD demonstrates a real onset of fossil tilled soil in the archaeological material in the study area during LN II, with an intensification from the transition to the EBA. This is particularly evident in Østfold (Appendix 3).

Summary

By combining the dataset of cereal cultivation with the settlement material, the different trajectories of the house establishments on the one hand and the beginning of cereal cultivation and cultivated soil on the other, become evident (Figure 5). Most importantly, the compilation indicates that the establishment of two-aisled houses and crop farming are not completely concurrent, with settlements preceding larger scale crop farming in the Oslo Fjord area with at least one century, perhaps more, followed by an even later entry of tilled soils in the archaeological record. We interpret this in opposition to a swift and complete change of social life at around 2350 BCE, but rather pointing to a more gradual process over several centuries. How does this fit together with archaeological records from individual settlement sites?

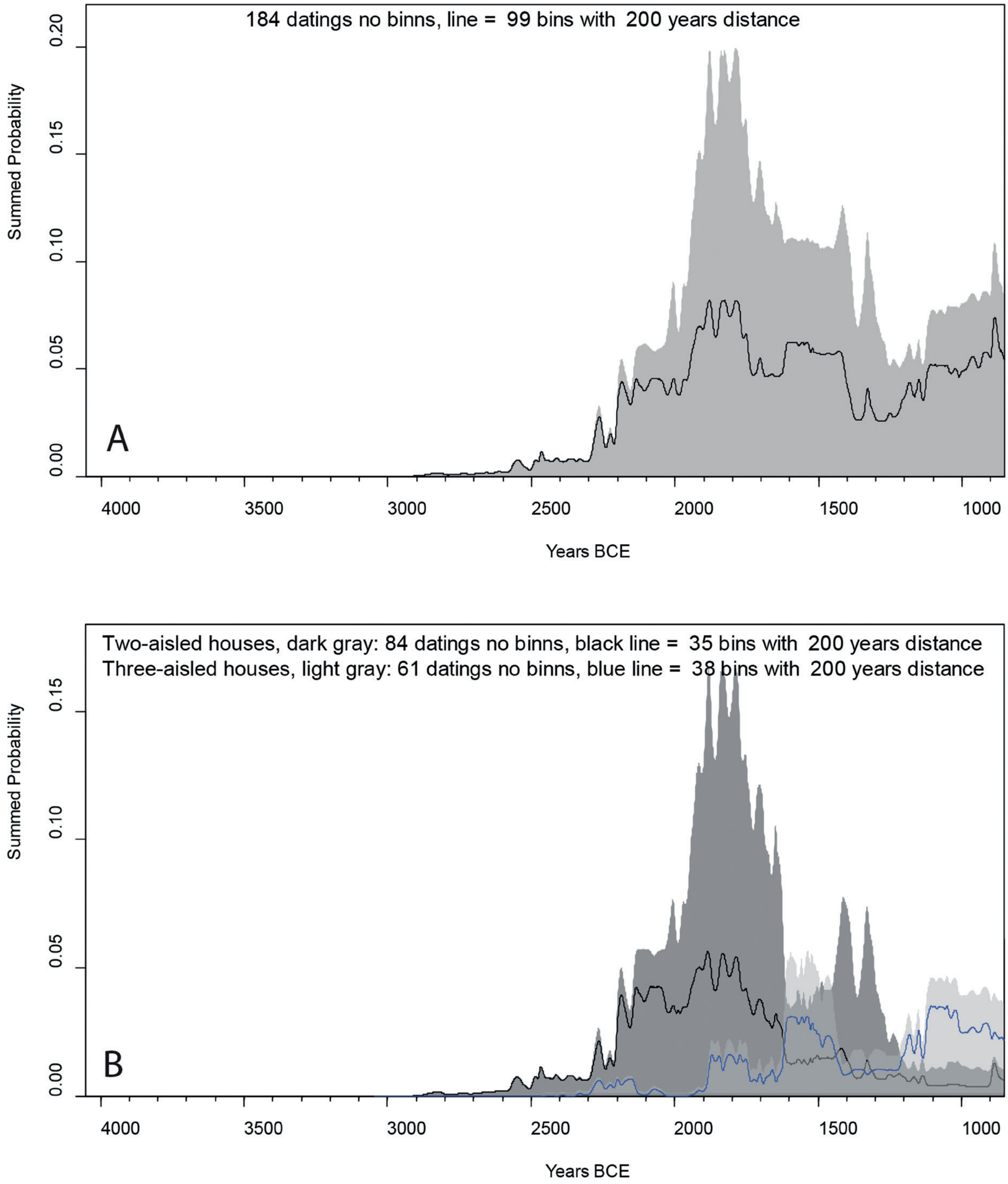

Figure 3. Summed probability distribution of dates from the houses, with and without binning.
A: The collected plot of all 184 radiocarbon dates from the settlement material from the Oslo Fjord area. LBA is included to a void a drop effect at 1100 BCE in the plots, but 124 dates are from the LN and EBA. Black line indicating the trajectory based on individual house.
B: Separated radiocarbon dates of two- and three-aisled houses in the region (By A. Mjærum).

Case studies

The case studies were partially chosen based on geographical representation within the study area (Figure 2), and partially due to some overall trends visible in the material (Table 2). For instance, close to 80 % of the total two-aisled material is found in Østfold on the eastern side of the fjord, especially in the areas south of Raet (Case 1), while a lower percentage of the three-aisled material is found in the same area (53 %). North of the fjord, the situation is the opposite (Case 2), with a higher percentage

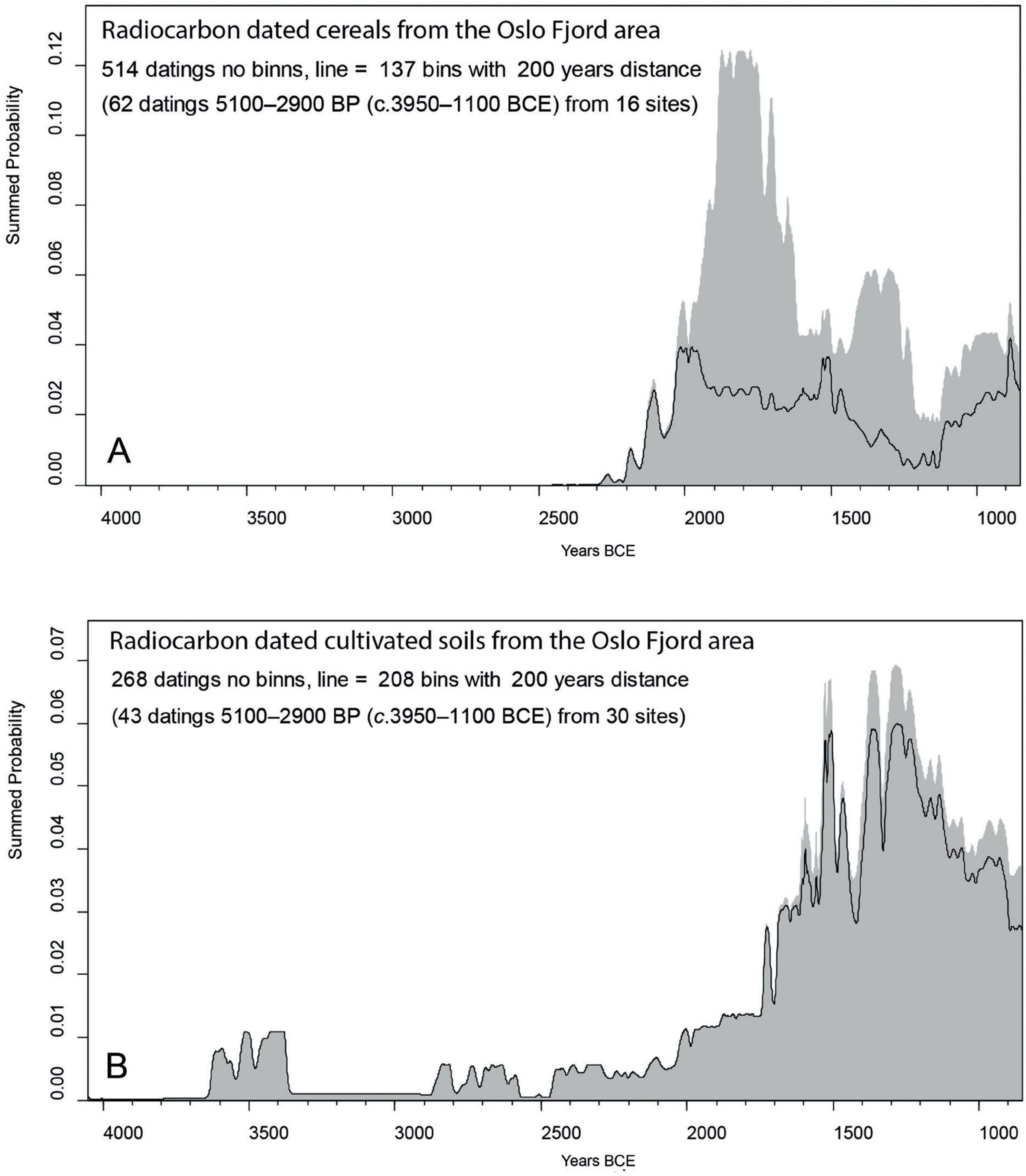

Figure 4. Summed probability distribution of A: dates from cereal and B: fossil tilled soils, with and without binning (By A. Mjærum).

of three-aisled houses than two-aisled ones. In the western part of the Oslo Fjord area (Case 3), three-aisled houses are not present in the material at all. In addition to these overall trends, we also chose the sites because they are among the best documented in the record. The following sections are rather short summaries of the sites, for further details about the settlements and the associated material found at the individual sites see Appendix 4 or the respective excavation reports referenced in Table 3.

Case 1: Eastern side of the fjord

Stensrød, Halden in Østfold

In 2002, three two-aisled houses were discovered at the site Stensrød (Rønne 2003), as the first recognition of houses dated to the LN and EBA in southeastern Norway. Two of the houses from Stensrød were complete (Figure 6), while a third close by building was only partially uncovered during excavation. The two complete houses were

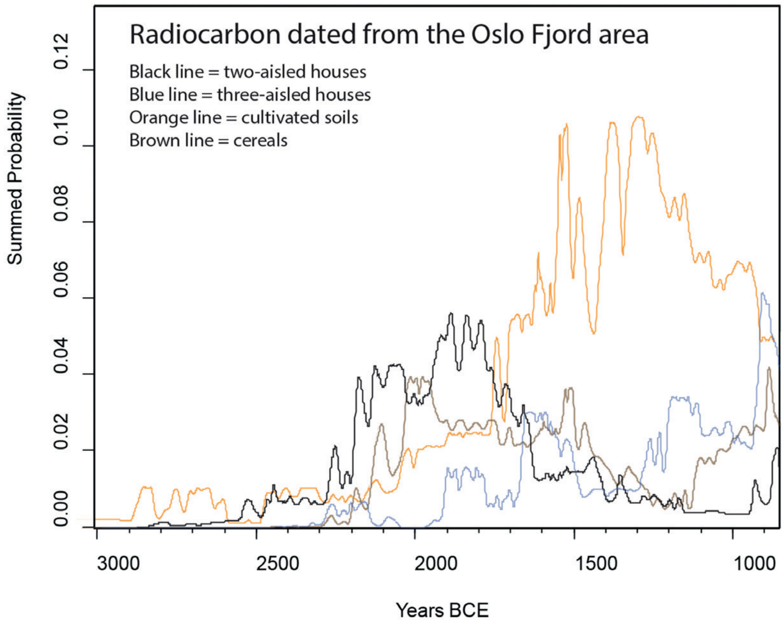

Figure 5. Compilation of the plots in figure 3B and 4. The combination effectively demonstrates the different trajectories of the establishment of longhouses to that of dated cereal and cultivated soil (By A. Sand-Eriksen)

Case	Site	Period	Estimated Absolute Dates	House types			Measurements		Cereals			Finds			References
				2-aisl.	3-aisl.	Other	Length (meters)	Width (meters)	Barley	Wheat	Other	Bones	Pottery	Lithics	
1	Stensrød	LN	2285-1775 calBCE	3	-	?	19.5-24.5	5.2-5.4	x	x	-	x	x	x	Rønne, 2003
	Opstad	LN	(2200/) 1975-1695 calBCE	4	2	-	19.2-23.1	4.8-6.7	x	x	x	x	x	x	Munch Havestein, in prep
2	Huseby	LN-EBA II	1880-1425 calBCE	1-3	3?	1?	13.5-17.5	5.2	x	x	-	x	x	x	Rødsrud, 2014
	Asak	LN II	(2110/) 1945-1775 calBCE	2	-	-	11-14	-	-	-	-	-	-	-	Eggen, 2010
3	Nordby	LN-EBA II	(2280/) 1960-1450 calBCE	2	-	1	17	4.8-5	x	-	-	x	x	x	Gjerpe & Bukkemoen,2008
	Løveskogen	LN-EBA III	(2285/) 1880-1115 calBCE	2>	-	1?	15.5>	5.5-5.7	x	x	-	x	x	x	Sand-Eriksen & Mjærum,2021

Table 3. Data from the case studies after sites. Estimated Absolute Dates shows the outliers, dates outside brackets are regarded as representative for the living phase. See Appendix 4 for further details about the settlements and the associated artefacts and ecofacts found at the respective sites.

partially superimposed (see Figure 1A in Appendix 4). The smallest of the houses (for details see Table 3) was stratigraphically older than the larger house, also supported by radiocarbon dating's of the buildings. The smaller house could be dated to between 2150-2050 BCE, while the larger house was dated to around the transition between LN I and II (for details on radiocarbon dates, see Table 1 in Appendix 4 or Supplement).

The site was located in a small valley *c.*600 m from the present coastline, in an area that with a 15-20 m higher sea level would have been an island, and the location was interpreted as indicating that conditions for agro-pastoral activities were more decisive than the sea (Glørstad 2004, 69-70). The location was also noted as marginal, suggested to be due to better locations for farming already being taken (Rønne, 2004, 66). Around a dozen cereal grains were found at Stensrød, and the site can be connected to some level of arable farming and pastoralism, most likely in combination with other subsistence practices (for details see Appendix 4).

Opstad Vest, Sarpsborg in Østfold

At the site Opstad, 23 km from Stensrød, four two-aisled houses were excavated in 2019 (Munch Havstein in prep.). As at Stensrød, two of the houses at Opstad were superimposed, both had (more or less) complete ground plans uncovered during the excavation (Figure 6, also see Figure 1B in Appendix 4). Both houses are dated within LN II (for details on radiocarbon dates, see Table 1 in Appendix 4 or Supplement), while the two partial houses found at Opstad predate the two complete houses. Compared to general trends in houses elsewhere in Scandinavia (Artursson 2009, 50-51, 70), the houses from both Stensrød and Opstad are lower- to medium-sized (Table 3).

At Opstad 265 cereal grains were found in connection with the definable two-aisled houses, and

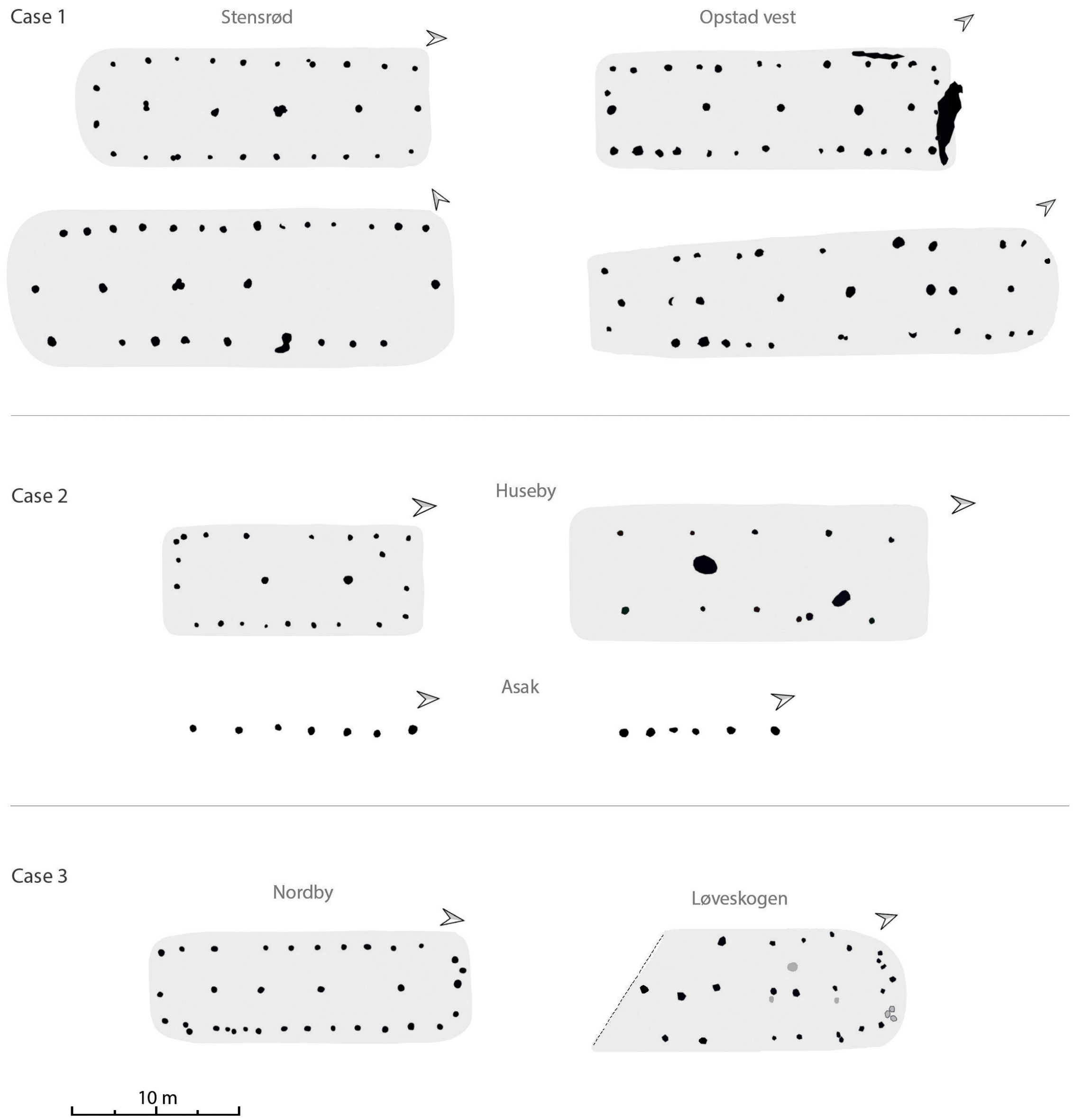

Figure 6. Ground plans of the most definable houses from the sites separated in the three cases. See Appendix 4 for more detailed depictions, including in-site relation between houses, other structures, etc. (By A. Sand-Eriksen).

this number is significantly higher than what is normally uncovered at archaeological excavations in southeastern Norway. Based on the radiocarbon dates of the cereals as well as their context in connection to the two definable houses, agricultural activity can only be connected to the later settlement phases at the site with certainty. The site was situated around 300-350 m away from the contemporary shoreline and was as such situated closer to the sea than Stensrød, and in addition, the data suggests a stronger empirical evidence of the presence of farming.

Case 2: North of the fjord

Huseby and Asak, Skedsmo in Akershus

At Huseby, remnants of four to six buildings were found during excavations in 2011 (Rødsrud 2014). Of the buildings, two are defined as two-aisled and three-aisled houses, while another two are defined as three-aisled in the excavation reports, however, there are some insecurities in the interpretations (for details see Appendix 4). We will therefore focus on the two definable houses at Huseby, and the two two-aisled houses from the nearby site Asak found during excavations in 2008 (Eggen 2010) in this paper. The two sites are located approximately

70 km north of Raet, around 20 km from the sea and 6.5 km from large lakes within the Glomma watershed, Norway's longest and largest river.

A striking feature in the house material from Case 2, is the fact that they are remarkably smaller than the LN and EBA houses found south of Raet (Figure 6; Table 3). The two-aisled houses from both sites are dated within the LN-EBA transition, making them younger than those from Case 1 (for details on radiocarbon dates see Table 3 in Appendix 4 or Supplement). The combination of younger dates and smaller sizes goes against the general architectonical trend of a gradual increase in building sizes from the LN II throughout EBA II (Artursson 2009, Fig. 2). However, it could, for instance, reflect the increased variations in the settlement material connected to increased hierarchy within the society (Brink 2013, 439). At Huseby, there is also an overall strong consolidation of arable farming, with cereals found in all buildings, and a wider variety of cereal types than at any other of the sites. There is also a remarkably low number of other finds, particularly flint (see Appendix 4).

Case 3: Western side of the fjord

Nordby, Larvik in Vestfold

During excavations in 2006, two two-aisled houses dated to the LN and a third house or building dated to the EBA I-II were found at Nordby (for details on radiocarbon dates see Table 4 in Appendix 4 or Supplement; Gjerpe and Bukkemoen 2008, 7). One of the houses had preserved wall-posts (Figure 6), and as rather similar to that from Stensrød, except smaller. A rock shelter 40 m west of the settlement was excavated simultaneously. While this included both finds and radiocarbon dates pre- and post-dating the settlement, C14-dates (3670±35BP, TUa-6692; 3120±35BP, TUa-6694) demonstrates that it could have been a working or storage place contemporary with the LN and EBA houses (Gjerpe and Bukkemoen 2008, 35). The mentioned dates were on bones from seal (*Phoca vitulina*) and beaver (*Castor fiber*), indicating a connection to water as part of their economy, further supported by its close proximity to the sea. With a 15-20 m higher sea-level, an inlet would make the distance to the contemporary shoreline no more than around 200 metres. There are also other finds demonstrating agro-pastoral and hunting activities at the site (see Appendix 4)

Løveskogen, Larvik in Vestfold

Only 5.5 km from Nordby, the site Løveskogen was excavated in 2019 (Sand-Eriksen and Mjærum 2021). At Løveskogen, two two-aisled houses and traces of a third building were uncovered. One of the houses is securely dated to the decades around 1300 BCE (for details on radiocarbon dates see Table 4 in Appendix 4 or Supplement), demonstrating that the two-aisled building technique survived much longer than expected, while the other buildings are older, based on both stratigraphical features and radiocarbon dates. The site demonstrates the persistence of a long-term farmyard, similar to Nordby, with continued settlement activity at the same places for several centuries, dating back to *c*.2000 BCE. As at Nordby, a rock shelter located relatively close to Løveskogen has previously been excavated (Østmo 1993), and could perhaps have been part of the larger farm.

In addition to the houses, a large refuse layer was found at Løveskogen, with numerous associated finds, such as 1.2 kg pottery, flint debitage, a flint dagger and a Nøklegård point, as well as several bone fragments. Although none could be securely identified, some are likely from domesticated animals (for details see Appendix 4). In addition to the bone fragments, traces of animal faeces were found in a sample from the layer, a direct evidence of animals being kept on or near the site. The local pollen diagram also showed a stronger presence of pastoralism compared to cultivation in the area (Høeg 2020, 4).

Discussion

The case studies demonstrate that the different trajectories of the establishment of houses on the one hand and the beginning of cereal cultivation and cultivated soil on the other, made visible in the SPD (Figure 5), also is detectable in the local site material. The late establishment of a full-scale agro-pastoral production in the Oslo Fjord area stands in particularly stark contrast to the more profound changes in the material culture around 2350 BCE, but there is also a pronounced delay in the onset of extensive crop farming compared to the establishment of two-aisled houses in the region, which, based on our results is at least a century. Consequently, these different trajectories demonstrate the likelihood of a more gradual farming development in the Oslo Fjord area, rather than a swift transition, which indirectly also opens the possibility of certain farming practices were introduced in the area before 2350 BCE. Moreover, the case studies also reveal a variety of settlements and economic practices in the region, evident both temporally and geographically.

The complexity of the development trajectories of the early farm-based settlements can in our opinion best be understood with the help of the concept of 'bounded rationality' (Simon 1955, 1959). The concept provides a conceptualisation of people's decision-making as 'rational behavior that is compatible with the access to information and the computational capacities that are actually possessed by organisms, including man, in the kinds of environments in which such organisms exist' (Simon 1955, 99). People exhibiting such bounded rationalities have a tendency to 'satisfice' rather than to 'optimise' given the available information in a specific environment (Foxon 2006). This also means that what would be an irrational decision strategy in one environment, can be entirely rational in another. The inertia in both crop farming and the establishment of a full-scale agro-pastoral production compared to the emergence of two-aisled houses in the Oslo Fjord area, could for the LN farmers living in, for instance, Jutland or perhaps even in southwestern Norway, be an irrational choice. In the Oslo Fjord area on the other hand, it demonstrates bounded rationalities within a given ecological structure, resulting in adaptability to environmental conditions. At Opstad, Østfold (Case 1), for instance, no large-scale agricultural activity can be connected to the first settlement phases, but then this became much more pronounced in the following phases. This does not mean that those settling there in the first phase could not have practiced farming. The low number of seeds may be caused by a low intensive cultivation, or that the processing chain for seeds deferred from later periods (see Soltvedt 2020, 31, with further ref.). However, our record indicates that the LN farming pioneers adapted in a way that was satisfactory in the given situation, and that it took generations to learn and master the local landscape affordances in regards to farming practices (cf. Robb 2013, 671). The people settling in the area could have needed to make (different) decisions based on limited or imperfect information (perhaps even ability and time).

Inherent in the above reasoning is the emergence of the two-aisled building technique as part of an expansion within the larger Scandinavian society (e.g. Kristiansen 2010), which Stensrød's similarity with LN houses from the district Vendsyssel in northern Jutland clearly exemplifies (for details see Appendix 4). This means that we see the introduction of farming happening at least partly because of migration and long-lasting contact, but do, however, not discount the possibility that foragers also learned how to grow crops. LN and EBA records of aDNA and isotopes support increased mobility of females, males and children in southwestern Sweden, especially from *c.*1950 cal. BCE (Blank et al. 2021, 64). Our architectural record, alongside the recorded artefacts, support the idea of a close contact, not only as a migration wave, but as established long-lasting relations between eastern Norway and parts of southern Scandinavia (Anthony 1990, 903-905). The inertia and variety in our findings could be a result of economic creolization between and within groups in this larger area, counterbalancing the 'bounded rationalities' and optimising the situation within the available information and environmental conditions. We will return to this concept after discussing the settlement and farming developments in the Oslo Fjord area.

Settlement developments

Since two-aisled houses first appeared in the eastern parts of Østfold (Stensrød, Case 1) bordering present-day Sweden, the processes happening around the Oslo Fjord cannot be seen isolated from this area, as mentioned above. However, the number of excavated houses is low along the northern parts of the southwestern coast of Sweden (Artursson 2009, 166), to which the Oslo Fjord area is directly connected. It has unfortunately not been possible with any direct comparison of the house structures between the areas. As previously mentioned, Stensrød do, however, show a striking similarity to LN houses from the district of Vendsyssel (see Appendix 4), situated just across the Kattegat strait (see Figure 1). Several of the houses in this area are suggested to have been built within the same template (Sarauw 2019, 164), one that Stensrød also might fit into.

Opstad, on the other hand, demonstrates a closer similarity to houses found at Limensgård on Bornholm, and House AB in particular (see Nielsen and Nielsen 2019; Nielsen 2019). A common trait in the large Limensgård houses, and in eastern Denmark and Scania in general throughout the LN (Björhem and Säfvestad 1989; Brink 2013; Nielsen 2019, 905), is the utilization of recessed supporting posts. This is not interpreted as present at Opstad in the excavation report. Since the rest of the ground plan is so similar, we see this a possible deliberate adaption of building technique within a specific environment. Such an adaption to regional conditions could also be present in the houses from Case 2, where a smaller size is a common feature compared to both Case 1 and 3. The houses from Case 2 are younger than most of the houses from the other cases, which goes against the general architectonical trend in southern Scandinavia of a gradual increase in building sizes from the LN II throughout the EBA II (Artursson 2009, Fig. 2). A possible explanation is that this reflects increased variations in the settlement material connected to an increased hierarchy within the society (Brink 2013, 439), but it could also be a deliberate adaption of the building technique in regards to environment and/or economy. Studies on houses have, for instance, noted that size is likely do decrease in colder climates, as this allows a more efficient heating, as well as within societies more reliant on pastoralism or other mobile subsistence practices compared to crop farming (Porčić 2011). Not only are the houses in Case 2 generally smaller than the houses from the other cases, the houses from both Case 1 and 3 are also quite small compared to general trends in houses elsewhere in Scandinavia (Artursson 2009, 50-51, 70). The outlined tendencies in the houses demonstrate both the potential and need for a more detailed study of the buildings from southeastern Norway.

A striking feature in the settlement material from the case studies, is the continued settlement activity at several of the sites. This is well illustrated by the site Løveskogen (Case 3), which was first settled around 2000 BCE, while the last two-aisled house was built as late as around 1300 BCE. Based on excavation data from the most excavated part of the region (Figure 7), there seems to have been broad habitual stretches of land accessible, and people could easily have moved their farms and carried out more extensive farming practices already from the LN. To continue the activity at the same places for centuries, as demonstrated in all three cases, stands out as a deliberate choice and a specific feature of the early farming settlements in the Oslo Fjord area. Compared to material components, such as daggers, houses are slow responders, however. The lifespan of a house can span anything from 20-30 years to 50-100 years, perhaps even as long as 150 years in certain cases (Artursson 2009, 34). As such, houses can potentially span multiple generations, and we must therefore exercise a certain caution when using houses to study change. Nevertheless, this caution does not affect the timing of the establishment of the houses in the Oslo Fjord area to 2200-2100 BCE and the fact that some of the settlements were inhabited for many generations, a conclusion derived from both the radiocarbon datasets and the case studies.

Farming developments

The long-lasting sedentary tendencies in our results are not in compliance with what is to be expected of slash-and-burn farming, which is argued to be the earliest method of cultivation (Fischer 2002, 350). Slash-and-burn consists of a shifting clearance technique for short-term cultivation, involving a regular moving of fields and settlements (Simonsen 2017, 279-285; Sørensen 2014, 3). This method has been criticised for requiring too much movement and larger areas than reasonably manageable for the early farmers, resulting in more long-lasting methods being suggested as alternatives (Gron and Rowley-Conwy 2017, 99), such as fixed fields managed and cultivated using hoes and digging sticks (Rowley-Conwy 2004, 93). Slash-and-burn agriculture has also been criticized

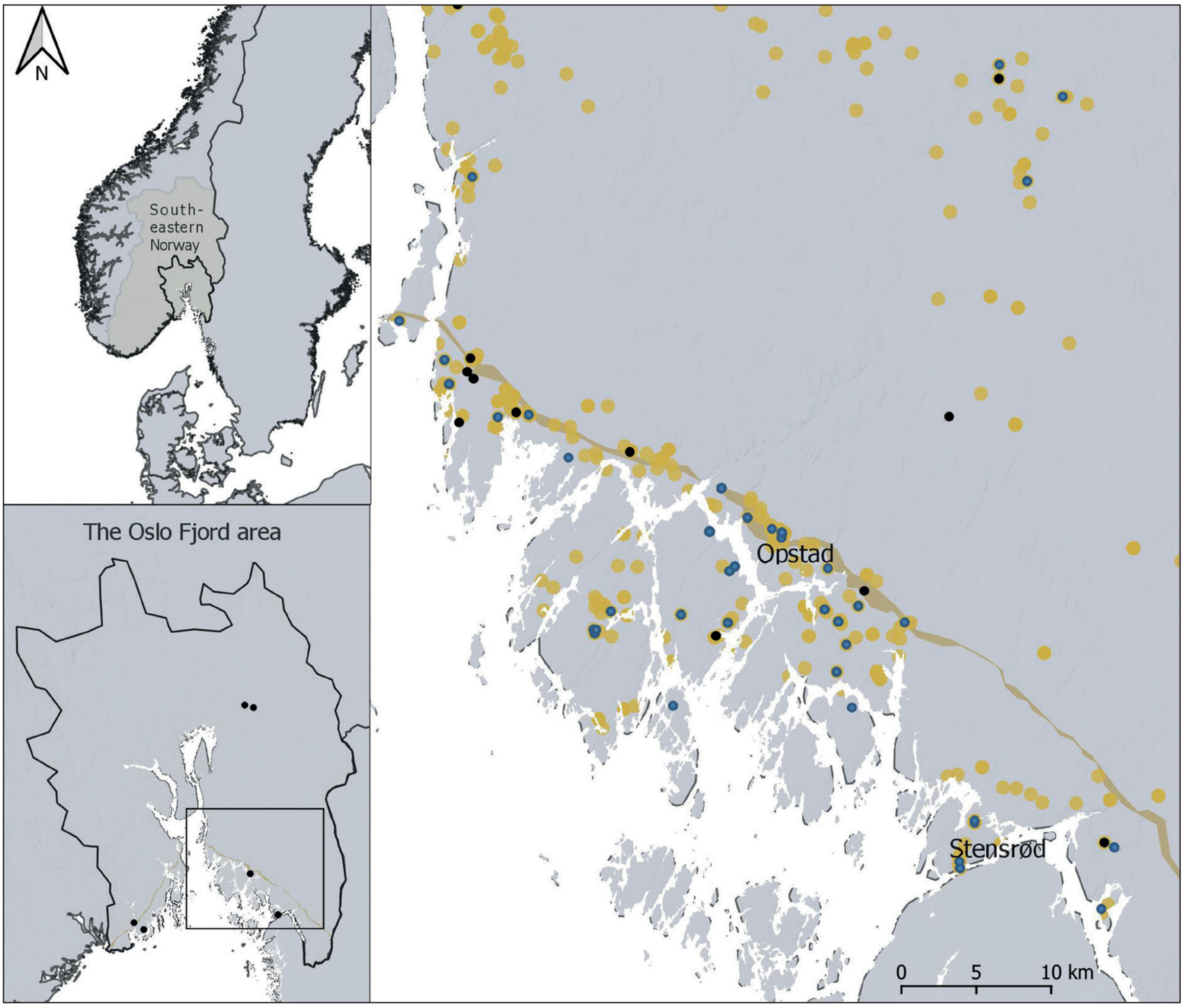

Figure 7. Map showing all archaeological excavations by MCH in the southernmost part of Østfold on the eastern side of the fjord marked in yellow. Black marks the settlement sites, while the blue indicates sites with archaeological features or structures radiocarbon dated to the LN and EBA (By A. Sand-Eriksen).

for being in direct conflict with keeping domesticated animals (Gron 2020, 322). Using livestock, such as sheep, cattle, and pigs, in the permanent field systems, would, according to P. Rowley-Conwy (1981, 91), make much more sense than slash-and-burn, as these animals would provide traction, manuring, cleaning, weeding, and even overturning the soil. Although there is still limited evidence, a recent study (Gron 2020) suggests that this could be an equally valid early farming system in Scandinavia as slash-and-burn. A recent study by R.R. Bishop and colleges (2022) have further reinforced the picture of variability in early cultivation practices across Neolithic northwestern Europe (Bishop et al. 2022, 4-9).

Based on our results, particularly the sedentary tendencies, which we believe could point towards a practice of long-lasting field systems, and delay in the establishment of full-scale agriculture, we want to suggest an existence of a subsistence practice where pastoralism was a better scenario than large scale crop agriculture for the farmers settling in the Oslo Fjord area during the LN. The traces of animal faeces found at Løveskogen (Case 3) is direct evidence that animals were being kept on or near the site. This is further supported by palynological data from the area, demonstrating a stronger presence of pastoralism compared to cultivation during the LN and EBA (Høeg 2020, 4). Except from Asak (Case 2), cereals were found at all sites, confirming that crop farming was part of their domestic economy, however. Apart from possible traces of fields and clearance at Stensrød (see Appendix 4), none of the sites yielded any tangible evidence of agricultural practices. If we consider the settlements long periods of use, this should have been more substantial than a couple of fragmented sickles (see Table 2 in Appendix 4). This could indicate that the earliest LN agriculture in the Oslo Fjord area had a different form than that suggested for other areas of southern Scandinavia from the same period, which could explain why few archaeological traces of earlier farming are preserved or visible today. Indirectly, our results also open up for farming being introduced before 2350 BCE, but perhaps not as how we intuitively imagine it to be.

Data from tilled soils suggest an intensification of farming practices towards the LN-EBA transition in the study area. This intensification coincides with the time new two-aisled houses replace old ones at several of the sites. A possible explanation for the intensification could be the necessity to invest more to maintain required levels of production in areas that had been cultivated for several generations. This process seems to appear a little earlier in Østfold compared to other parts of the Oslo Fjord area (Appendix 3), something which may be explained by the overall close connection to present-day Sweden, as discussed above, but also the area's overall suitable environmental conditions for agriculture, which could have eased an adaption of south Scandinavian farming practices.

Optimising through creolization?

Based on our results of an inertia in crop farming, which we see due to the existence of bounded rationalities, we have suggested an existence of a farming practice where pastoralism was a better scenario for the early farmers settling in the Oslo Fjord area. Moreover, the evidence of hunting, fishing, and gathering in the archaeological record from the case studies also indicates how this pastoralism existed in combination with other practices, also including (lower levels of) crop cultivation. We suggest that economic creolization could be a suitable term for the economic practices taking place in the Oslo Fjord area in the LN and EBA. This differs from a mixed or multiple economic practice by how it is adapted to local circumstances, and becomes a result of the interchange and ongoing dynamic between two (or more) groups (Eriksen 2007, 156, 171-172). This would explain the heterogeneity or variety of settlements and economic practices in the region made visible in the case studies, which blurs the otherwise proposed homogeneous cultural expression of the LN in southern Norway. Similar heterogeneity, or a blurred economic situation, has been applied to the cultural diversity in the MN material assemblage from southern Scandinavia (e.g. Iversen 2015).

Although the bounded rationalities, could have asserted itself when migrating farmers were faced with new environmental conditions, and directly resulting in an inertia in crop farming compared to the emergence of two-aisled longhouses, economic creolization could also be a way of optimising this circumstance. This implies that the economic expressions of the Oslo Fjord area to a larger degree were dependent on availability rather than cultural preference. Within this, the migrating farmers would have needed to familiarize themselves with local possibilities and restraints, challenges that may have been reinforced by the possible temperature decline *c.*2200 BCE (cf. Hammarlund et al. 2003, 367-368). During the time of transition, local inhabitants could have been more active agents than passive recipients in the Oslo Fjord area during the LN and EBA (also see Nyland 2020).

Concluding remarks

The study has used radiocarbon-dated buildings, cereals, and cultivated soils to address the establishment of farming in the Oslo Fjord area. This has demonstrated a delay in the onset of crop farming compared to the establishment of houses in the region, which also contrasts the more profound changes in the material culture around 2350 BCE. Overall, the study demonstrates the likelihood of a more gradual and adaptive farming development in the Oslo Fjord area in the LN and EBA, which in the earliest parts seems to be more oriented towards pastoralism, while the presence of agriculture grows throughout the EBA. We have suggested an understanding of the agricultural developments in the Oslo Fjord area from the onset of the LN as results of an economic creolization, where migrating farmers adapted to local circumstances, both in terms of landscape, environment and to/with those already inhabiting the area.

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Notes

1) The Oslo Fjord area is a commonly used term, but not a pre-defined area. Our definition is the coastal region and adjoining lowlands around the fjord and is based on historical landscape divisions and modern administrative borders.
2) Retrieved from the museum database Unimus in April 2022. From all of southeastern Norway the number is 661, all are, however, not listed by type in the database. The latest number of daggers with ascribed types are 445 from eastern Norway, which is approximately half of that from western Norway (see Apel, 2001, Table 9.2).

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Supplementary

Supplements see .xlsx- and .pdf-attachment

Tales from Ginderup Mound in Thisted County, Denmark

Further Investigations of Female Mobility in the Nordic Bronze Age

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ABSTRACT

The preservation of organic and human remains in Early Nordic Bronze Age mounds (1700 BCE -1100 BCE) permits new provenance work on this important period. To further extend the growing amount of comparative data, we conducted strontium isotope provenancing (Graves A and B) and osteological analysis (Graves A, B and C) on several individuals from the mound at Ginderup in Thisted County, Denmark. The mound contained both adult and juvenile remains from inhumation burials (of which Grave A also included a probable corded skirt) as well as several later cremation urns.

Our results revealed that the strontium isotope ratios obtained from the corded skirt grave (Grave A) yielded one ratio (M2) which was local to present-day Denmark and one non-local ratio (M3). The results from Grave B yielded a ratio which also falls within the local baseline of present-day Denmark. These results suggest that the Ginderup Woman was probably of local origin (i.e. from mainland Denmark), but that she also was repeatedly mobile during her life. We put these data in context relative to possible causes for mobility in the Nordic Bronze Age world, with a particular concentration on the consideration of fosterage practices, a somewhat under-studied cause for mobility (particularly for females) in this period. All in all, these new data are further evidence for the Nordic Bronze Age's complex socio-dynamics.

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Introduction

The Bronze Age was a period of rapid cultural transmission which may share some parallels with modern globalization (Reiter 2014; Vandkilde 2016). The frequent, sometimes long-distance movements of objects, materials and ideas during this time are evident in the archaeological record (Earle 2002; Earle and Kristiansen 2010; Frei et al. 2017a; Jockenhövel 1980, 1991, 1995; Jockenhövel and Kurbach 1994; Kristiansen 1998, 2017; Kristiansen et al. 2017; Kristiansen and Suchowska-Ducke 2015; Ling et al. 2012, 2014, 2019; Ling et al. 2018; Melheim et al. 2018; Nørgaard et al. 2019; Treherne 1995; Wels-Weyrauch 1989b, 1989a). Although it is clear that objects, materials and ideas are unlikely to have been made mobile in the Bronze Age without human intervention (Bergerbrant 2007), the many recent archaeometric analyses of human remains from this time add a new dimension to the extant material data (Bergerbrant et al. 2017; Cavazzutti et al. 2019a; Cavazzutti et al. 2019b; Felding et al. 2020; Frei et al. 2019; Frei et al. 2022; Frei et al. 2017b; Knipper et al. 2017; Mittnik et al. 2019; Nielsen et al. 2020; Oelze et al. 2011; Reiter et al. 2019; Reiter and Frei 2015; Taylor et al. 2020).

Further supporting the postulates of the New Mobilities Paradigm (Shellar and Urry 2006; Urry 2007), strontium isotope analysis conducted thus far on Southern Scandinavian human remains suggest that both enacting mobility (Bergerbrant et al. 2017; Felding et al. 2020; Frei et al. 2019; Frei et al. 2015a; Frei et al. 2015b; Frei et al. 2017b) and causing mobility to be enacted by others (Reiter et al. 2019; Reiter and Frei 2021) was present during this time. Interestingly, studies from various places in Europe have pointed to a high degree of specifically female mobility during the Bronze Age as a whole (Cavazzutti et al. 2019a; Cavazzutti et al. 2019b; Frei et al. 2015a; Frei et al. 2017b; Knipper et al. 2017). Archaeologists have also remarked upon the burials of 'Fremde Frauen': women from predominantly upper-class Bronze Age society who were buried with funerary equipment that was demonstratively foreign to the traditions of the area in which they were interred (Jockenhövel 1995; Wels-Weyrauch 1989b). Osteological data, however, suggests that elite Bronze Age women with non-local grave items are not necessarily themselves non-local. One such case is that of the Ølby Woman (who was likely local according to isotopic analyses in spite of the clear long- and short-range trade connections evidenced by her grave goods; Reiter et al. 2019). Similar examples have appeared elsewhere in Europe (for Bell Beaker contexts in UK, see Parker Pearson et al. 2016, 2019; for Scandinavia, see Bergerbrant et al. 2017; Frei et al. 2019).

Due in part to technical advances in strontium isotope provenancing methods (Font et al. 2012; Frei et al. 2015a; Harvig et al. 2014; Jørkov et al. 2009; Taylor et al. 2020; Tipple et al. 2013; Tipple et al. 2018a, 2018b) as well as the ever-increasing body of comparative data (and the periods of the lifespan associated therewith), we are beginning to be able to trace the mobility of people to hitherto unprecedented degrees of time resolution. Comparing this data against models of different patterns of mobility allows us to analyse archaeological and anthropological hypotheses in new ways. The mobility model which we reference in this text (Reiter and Frei 2019; see Table 1) represents a fusion of anthropological/geo-cultural understandings of mobility (e.g. Anthony 1990; Wendrich and Barnard 2008) with the kind of results produced by archaeometric analyses such as those which are also included in the present article.

One of the current scholarly models of Bronze Age society suggests that various chiefdoms were linked together with other groups (both near and

No.	Mobility pattern	Category	Description
1	(A)	Non-mobility	Stationary living
2	A→B	Point-to-point mobility	Single mobility/ migration
3	A→B (B) B→A Or A→B→A	Back-and-forth mobility	Mobility from A to B and from B to A interspersed with an interval at point B
4a	A→B B→C C→A Or A→B B→A	Repeated mobility (cyclical mobility)	Movements between two or more locations followed by short stays
4b	(A)→B…C…D…(A) Or A…B…C…D…etc.	Repeated mobility (non-cyclical mobility)	Sequential short- or long-term stays in different places or constant movement

Table 1. Mobility model (after Reiter and Frei 2019). Using such a framework as a point of comparison for the new provenancing data from human individuals allows us to identify possible similarities and differences between different individuals, thereby further nuancing our ability to interpret the potential causes of their movements.

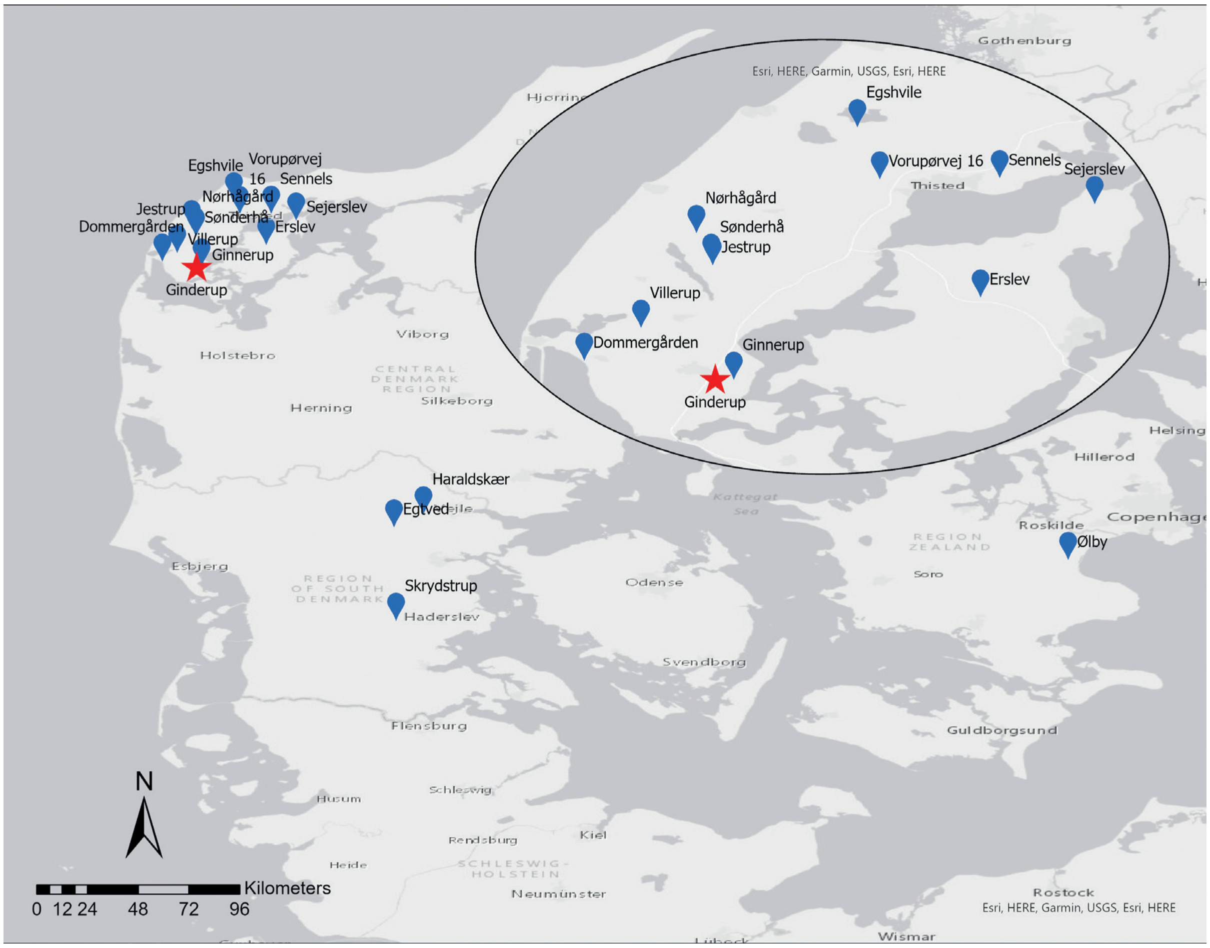

Figure 1. Map showing the location of Ginderup Mound/ FF 110605-47 (red star) alongside other Danish sites mentioned in the text (blue pins). This map was generated by SSR using ArgGIS Pro software and basemaps, licensed to the National Museum of Denmark.

far) through trade/exchange as well as through complex systems of marriage-like alliances and kinship (Earle 2002; Egeler 2009; Kristiansen 1994, 1998; Kristiansen and Larsson 2005; for contrary model see e.g. Holst et al. 2013). Scholars have argued that one of the principal modes for constructing such alliances was through the exchange of women (Lévi-Strauss 1969) within an exogamic and patrilocal system (Egeler 2009; Kristiansen and Larsson 2005 and references therein) . However, regardless of whether or not they were equipped with atypical jewellery styles or foreign materials in their tombs, the ever-increasing amount of data suggests that there may have been other types of mobility (including non-mobility) available to high-status females at this time. In order to investigate the question of female mobility in the Early Nordic Bronze Age further, we conducted provenance studies on the female interred with a possible corded skirt from the central grave at Ginderup in Thisted County, northern Jutland (Denmark). In pursuit of this, we conducted strontium isotope and osteological analyses from two of the deceased's molars and complemented these with strontium isotope and osteological analyses of other individuals who were buried inside the mound at a later point.

Site Description

The site of Ginderup lies in Thisted County (FF 110605-47; Ke 5451) and includes a loose group of 3-4 m high burial mounds on a slight elevation overlooking the Limfjord (Figure 1). The burial mound SB no. 47 was excavated by Johannes Brøndsted from 4-11 April, 1933 (Brøndsted 1934) and was already partially worn down by ploughing at the time of excavation. Broadly speaking, the area has a long history of human interactions, ranging from the elongated

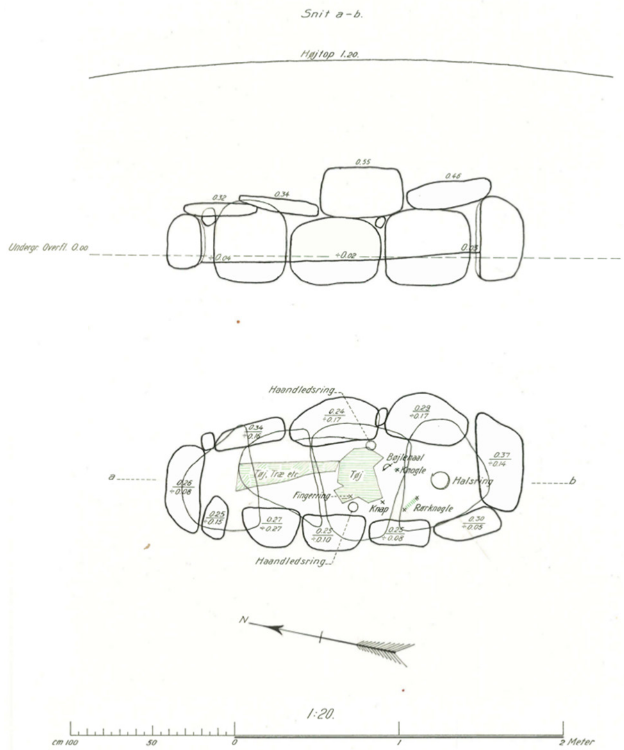

Figure 2. Original sketch of Grave A from 1933 excavation report (Nationalmuseet Archives; Brøndsted 1933).

Figure 3. Photo documentation of Grave A from 1933 excavation report (Nationalmuseet Archives, Brøndsted 1933).

Neolithic mound to the southwest of SB 47 as well as Roman Iron Age and even later burials in the vicinity. From inside the mound which concerns us here (SB 47), Brøndsted unearthed six funerary entities spread over what appears to have been five separate events. Of these, the central grave (Grave A) lay 70 cm below the top of what was left of the mound. The inhumation was placed in a stone cist and was accompanied by a thin twisted neck ring, a fibula, a double button, two arm rings (one each at the right and left wrists) and a finger ring (on the left hand side) (Aner and Kersten 2001; Brøndsted 1934). The grave is additionally described as having included both wool textiles as well as a wool fringe (Figures 2-3). Brøndsted suggested that the latter likely represented the remains of a corded skirt or, perhaps, the fringe of a blanket (1934, 3). Other scholars support the first interpretation, comparing it to the Egtved skirt (Bender Jørgensen 2016, 104; Bergerbrant et al. 2012). The grave goods suggest that the deceased may have been female.

Though not much of the individual was preserved, the crowns of several teeth survived until excavation. Initial analysis of these crowns by K. Fisher Møller suggested that the deceased (henceforth 'Ginderup Woman') was aged 16-18 at the time of her death (Broholm 1943, 161). Re-assessment of the teeth by Jørkov for the present study suggests a slightly younger age (14-15 years). For the purposes of this study, we sampled dental enamel from an M2 and an M3 from Ginderup Woman (Ginderup Grave A, AS 10/76, NM1 52/53).

Grave B from the same mound (SB no. 47; Ginderup Woman's mound) included a so-called 'cremation' within an irregular sub-circular stone cist (Figure 4). Although this last had no grave goods, due to the particularities of its construction Brøndsted nonetheless suggested that the grave seems to date from the later part of the Early Nordic Bronze (1934, 5). The only object associated with this grave was what excavators described as a strike-a-light within the backfill of the grave shaft. In the interest of obtaining as complete a picture as possible from this mound and in order to complement

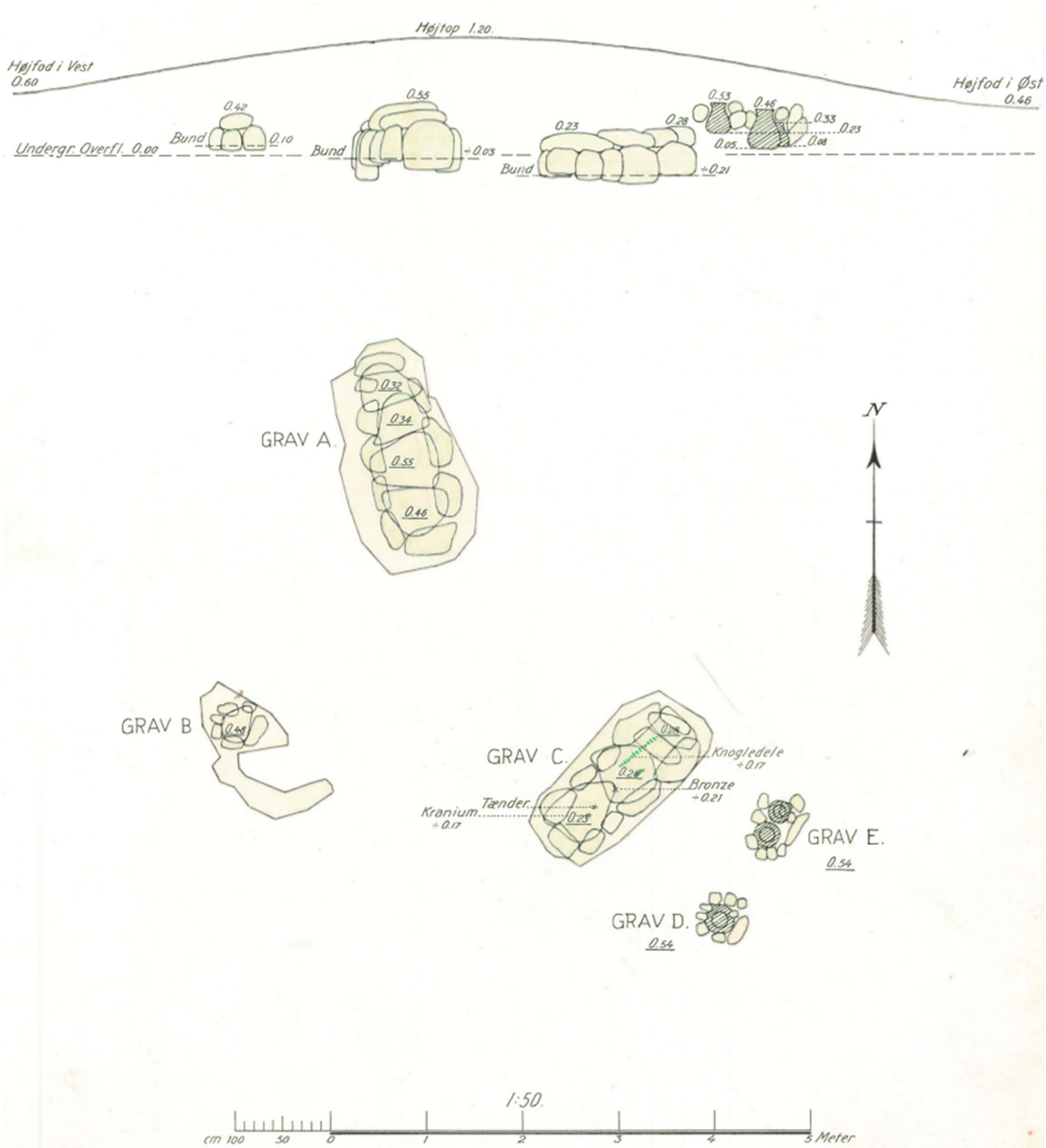

Figure 4: Original plan of Ginderup Mound SB. 47 from 1933 excavation report (Nationalmuseet Archives; Brøndsted 1933).

other studies (Frei et al. 2019; Kristiansen et al. 2020; Reiter et al. 2021), we also conducted strontium isotope analysis of dental enamel sampled from a first molar from this individual (Ginderup Grave B AS10/76, NM1 52/53). An analysis of the remains (also by Jørkov for this study) based on the dental development and fusion of bone elements (AlQahtani et al. 2010; Scheuer and Black 2000) indicate that the individual interred in Grave B may have been ca. 3-4 years upon his or her demise.

Although Grave C lay 25 cm deeper in the mound (Ginderup SB. 47) than Grave A, its deposition seems to have been secondary to that of Grave A (Aner and Kersten 2001; Brøndsted 1934). Like Grave A, Grave C was also an inhumation grave in a stone cist. The grave goods included a double button, an unknown and heavily-decayed bronze object and some kind of organic layer at the bottom of the grave cut. This last is assumed to represent either a hide or cloth cover/clothing. The button suggests a date from Period III (1300-1100 BC;

Jensen 2006; Montelius 1986). Jørkov's osteological analysis suggests an age of 14-15 years (similar to Grave A). It was not possible to assess sex. Unfortunately, as very little enamel remained from the skeletal material, we were not able to conduct strontium isotope analysis on this individual.

Two stone packed cists at the southern edge of the mound included single urn D as well as a double urn burial (E). While D contained no grave goods, one of the urns in cist E included a razor, tweezers and an awl. Due to the manner of internment, these could broadly be assumed to date from the Late Bronze Age. Unfortunately, no material suitable for strontium analysis was found from urn burials D or E.

Materials and Methods

Strontium isotope analyses conducted on tooth enamel from archaeological human remains can provide information on provenance and potential mobility at the individual level (Bentley 2006; Montgomery 2010). We conducted strontium isotope analysis on two upper molars (M2 and M3) from Grave A and an upper first molar (M1) from Grave B.

It is important to mention that our $^{87}Sr/^{86}Sr$ data do not represent the same periods of the human lifespan. The mineralization of tooth enamel occurs within different times over the life course from early childhood to adolescence (i.e. the formation of the first molar's tooth enamel takes place in utero until *c.*3 years of age, the second molar between the ages of ca. 2-8 years and the third molar from ca. 7-16 years) (AlQahtani et al. 2010).

The tooth enamel samples were pre-cleaned by removing the enamel's surface with a drill bit. Subsequently, a few milligrams of the precleaned enamel were sampled either by a cut or drilled from each tooth. The tooth enamel samples were dissolved in precleaned 7 ml Teflon beakers (Savillex) in a 1:1 solution of 0.5 ml 6 N HCl (Seastar) and 0.5 ml 30 % H_2O_2 (Seastar). The samples typically dissolved within five minutes, after which the solutions were dried on a hotplate at 80 °C. Thereafter, the enamel samples were taken up in a few drops of 3N HNO_3 and then loaded onto disposable 100 µl pipette tip extraction columns into which we fitted a frit which retained a 0.2 ml stem volume of intensively pre-cleaned mesh 50-100 SrSpec (TrisKem) chromatographic resin. The elution recipe essentially followed that by Horwitz et al. (1992), albeit scaled to our needs (i.e. strontium was eluted / stripped by pure deionized water and then the eluate dried on a hotplate).

Thermal ionization mass spectrometry was used to determine the Sr isotope ratios. Samples were dissolved in 2.5 µl of a Ta_2O_5-H_3PO_4-HF activator solution and directly loaded onto previously outgassed 99.98 % single rhenium filaments. Samples were measured at 1250-1300 °C in a dynamic multi-collection mode on a VG Sector 54 TI mass spectrometer equipped with eight Faraday detectors (Institute of Geosciences and Natural Resource Management, University of Copenhagen). Five nanogram loads of the NIST SRM 987 Sr standard that were ran during the time of the project yielded $^{87}Sr/^{86}Sr$ = 0.710239 +/- 0.000015 (n=4, 2σ), which we compare to the generally accepted value of $^{87}Sr/^{86}Sr$ = 0.710245 (Thirwall, 1991).

Results

The results of the strontium isotope analysis conducted on the human remains from Graves A and B ranged between $^{87}Sr/^{86}Sr$ = 0.70978 to 0.71176 (Table 2). However, in order for these results to have meaning, they need to be put into perspective. To that end, it is imperative to have knowledge of the

Individual	Tooth	Sample No.	$^{87}Sr/^{86}Sr$	(±2SE)
Grave A	Upper right M2 (7+)	KM114	0.71074	0.00001
Grave A	Upper right M3 (8+)	KM115	0.71176	0.00001
Grave B	Upper right M1 (6+)	KM116	0.70978	0.00002

Table 2. The results of the strontium isotope analysis from Ginderup Graves A and B.

local bioavailable strontium isotope baseline range for the region in which the human skeletal material was found (Frei 2012). While different kinds of proxy materials have been used to define bioavailable baseline ranges for specific regions, scholars have yet to reach a consensus regarding which type of proxy (e.g. surface water, plants, soil, fauna, etc.) is most suitable (Grimstead et al., 2017). Several baselines have been established for Denmark based on different types of environmental samples, including surface waters, plants, soil leachates and fauna (Frei 2012; Frei et al. 2022; Frei and Frei 2011, 2013; Frei and Price 2012). These are in accordance with a recently published baseline study for Europe which was based on the results from almost 1200 soil samples taken throughout Europe which, though more general, adds yet another layer of data (Hoogewerff et al. 2019).

Although there has been a discussion about the potential strontium contamination by agricultural lime in Danish surface waters (Andreasen and Thomsen 2021; Thomsen and Andreasen 2019; Thomsen et al. 2021), results from soil profiles studies from beneath agricultural farmland collected in the glaciogenic outwash plain of central West Jutland, Denmark, show that strontium (and its derived isotope composition) from lime products is efficiently retained near the surface (Frei et al. 2019). Consequently, the agricultural lime hosted strontium does not affect the surface waters (Frei et al. 2020, Frei 2021) to the extent previously postulated by Thomsen and Andreasen (2019) and by Andreasen and Thomsen (2021). Furthermore, Thomsen and Andreasen (2019) argued for the use of only environmental samples from what they called "pristine" forest sites for the purpose of constructing strontium baselines for archaeological studies. However, new investigations (Frei et al. 2022; Johnson et al. 2022) clearly reveal that sampling of such sites are inappropriate for archaeological studies. This is because samples from these "pristine" forest areas do not reflect the biosphere conditions of the past due to the acid leaching processes that took place over time in these areas (Frei et al. 2022; Johnson et al. 2022). Price (2021) argues that the conclusions of Thomsen and Andreasen (2019) about the impact of their finding on prehistoric mobility are not correct. Consequently, in the present study we apply the originally-proposed local bioavailable baseline ranges between $^{87}Sr/^{86}Sr$ = 0.7081 to 0.7111 for the area of present-day Denmark (excluding the island of Bornholm) (Frei 2012; Frei and Frei 2011; Frei and Price 2012).

Our results from Ginderup reveal that all but one sample yielded strontium isotopic values that fall within the baseline for present-day Denmark. The individual with the possible corded skirt from Grave A (from which we have two samples) yielded both a value within the above mentioned baseline (M2; $^{87}Sr/^{86}Sr$ = 0.71074) as well as a value outside it (M3; $^{87}Sr/^{86}Sr$ = 0.71176). The individual from Grave B yielded a $^{87}Sr/^{86}Sr$ result which falls within the Danish baseline.

Discussion

During the last 10 years, there has been a considerable number of mobility studies based on strontium isotope analyses made on Bronze Age human skeletal material unearthed in Europe. These studies have provided an ever-increasing background against which the present research can be compared (Bergerbrant et al. 2017; Cavazzutti et al. 2019a; Cavazzutti et al. 2019b; Felding et al. 2020; Frei et al. 2019; Frei et al. 2017b; Knipper et al. 2017; Knöpke 2010; Mittnik et al. 2019; Montgomery 2013; Montgomery et al. 2007; Nielsen et al. 2020; Oelze et al. 2011; Reiter et al. 2019; Reiter and Frei 2015, 2021; Taylor et al. 2020; Wahl 2009; Wahl and Price 2013). Thus far, research suggests that many different forms of mobility defined persons (elite or not) from this dynamic period of European prehistory. Moreover, mobility trajectories appear to have been individual-dependent, and may have been influenced by the specificities of the socio-political situation of the communities in which individuals were enmeshed (Austvoll 2021; Earle 2002, 19-42; 293-96; Earle and Kristiansen 2010; Ling et al. 2018b; Randsborg 1975). In order to address the Ginderup Woman's strontium isotope data in relation to extant work as well as the possible mobility scenarios which her data suggest, we first compare our new data with others from the mound as well as in relation to information obtained from other contemporary nearby sites.

The results of the strontium isotope analysis of one of the second molars of the Ginderup Woman (which provide information on potential mobility between the ages of approximately 2-8 years) suggest that she was living either locally or within another area (but with a similar or overlapping strontium isotope baseline to the one for present-day Denmark as defined above). By contrast, the $^{87}Sr/^{86}Sr$ ratio from her third molar yielded a value that falls outside the Danish strontium isotope bioavailable baseline range. This indicates some kind of mobility during the later part of her lifespan. Although the data from tooth enamel does not allow for a high-precision mobility timeline, such as is the case for hair like in for example the studies of the Egtved (Frei et al. 2015a) and the Skrydstrup females (Frei et al. 2017b), they do allow some insights as to when that mobility may have taken place. It seems that Ginderup Woman lived within the region of present-day Denmark (or within a region with an overlapping $^{87}Sr/^{86}Sr$ baseline bio-available range) during her childhood (e.g. between the ages of 2 and 8 years), but that somewhere during the time period in which her third molar mineralized (between the ages of approximately 7-16 years), the data suggests she may have lived or travelled for a considerable period in an area outside of present-day Denmark. These data from the Ginderup Woman can be contrasted with those from e.g. the Skrydstrup Woman, the Egtved Girl and the Ølby Woman. The Skrydstrup Woman exhibited non-local values for the both the M1 and M3 (Frei et al. 2017b), the Egtved Girl also exhibited non-local values from the M1 (Frei et al. 2015a) while the Ølby Woman exhibited values that fall within the strontium baseline for present-day Denmark from her M1, M2 and M3 (Reiter et al. 2019).

Seen very broadly, the two individuals analysed from Graves A and B from Ginderup mound had $^{87}Sr/^{86}Sr$ values which fit within the established baseline for present-day Denmark, at least at some point during their lifetimes. The sample from Grave B yielded a strontium isotope ratio that falls within the local baseline range (for present-day Denmark) and corresponds to the period in which the individual was in utero up until three years of age. Unfortunately, we were not able to conduct analyses on the individuals from Grave C or Urns D and E.

If we compare these new strontium isotope data from Ginderup mound with other extant studies from Thisted County, the results are similar insofar as the analysed $^{87}Sr/^{86}Sr$ values lie within the baseline for present-day Denmark. Data from a study on the introduction of the cremation rite to Early Nordic Bronze Age Denmark included material from five different Early Nordic Bronze Age sites from Thisted County, including Villerup, Egshvile, Erslev, Nørhågård and another of the Ginnerup mounds (SB no. 58) 1.2 km to the east of the Ginderup (SB no. 47) examined within the present research (Reiter et al. 2021). With the exception of a young child from Egshvile (KF2052), whose $^{87}Sr/^{86}Sr = 0.71205$, all other contemporary samples from Thisted County revealed values suggesting that the individuals may have been locals. Nevertheless, it is important to remark here once again that archaeological data supports the potential connection of Thisted County with especially northern Germany (Haack Olsen 1992) and the Frisian Island of Sylt (Bech et al. 2018, 71; Haack Olsen and Bech 1993; Kersten and La Baume 1958). However, given the overlapping strontium baseline ranges for these areas, it is difficult to winnow out further evidence for migration at present. A similar issue with respect to the difficulties in describing what is 'local' in terms of archaeological context versus what is understood as 'local' as seen from a strontium isotope baseline perspective and the issues related to the overlapping baselines has been previously discussed by Croix et al. (2020).

However, if we juxtapose the results from the present research with those from a recent large-scale study examining mobility data from the third and second millennium BC in Denmark, the picture becomes even more intriguing. That study (Frei et al. 2019) included strontium isotope analyses from 88 individuals of which seven (from the sites of Vorupørvej 16, Sennels, Sejerslev, Nørhågård, Sønderhå, Jestrup and Dommergården) are also located in Thisted County. Of the individuals tested within that dataset, only one exhibited $^{87}Sr/^{86}Sr$ suggesting that this individual may have been of non-local origin, and whose $^{87}Sr/^{86}Sr$ is statistically the same as that measured for the Ginderup Woman's second molar ($^{87}Sr/^{86}Sr = 0.71176$). Given the grave goods, this non-local individual from Jestrup – who has been interpreted as a male warrior (Kristiansen et al. 2020) – yielded a $^{87}Sr/^{86}Sr$ = 0.71177 (Frei et al. 2019). He was buried alongside a Rixheim sword typical of southwest Germany, Switzerland and eastern France (Reim 1974; Schauer 1971) as well as a Nordic-style fibula and double-button suggesting a date within Period II (1500-1300 BC; Aner and Kersten 2001; Jensen 2006; Montelius 1986), a combination evocative of the complex socio-dynamics underlying the time and region in which he was interred (Kristiansen et al. 2020).

Elsewhere in Thisted County (at Nørhågård), we have documented other similarly close instances of $^{87}Sr/^{86}Sr$ in the combined cremation and inhumation grave of a male ($^{87}Sr/^{86}Sr$ = 0.71046; Frei et al. 2019) and female ($^{87}Sr/^{86}Sr$ = 0.71040; Reiter et al. 2021) which also included burned ovid/capra bones ($^{87}Sr/^{86}Sr$ = 0.71041; Reiter et al. 2021). The tight connection in terms of potential provenance between humans (male and female, inhumation and cremation) and animal at Nørhågård can perhaps be further underscored due to deposition within a single grave. By contrast, in spite of the close similarity of their strontium values, the burial sites of the Jestrup male with the Rixheim sword ($^{87}Sr/^{86}Sr$ = 0.71177; Frei et al. 2019) and Ginderup Woman ($^{87}Sr/^{86}Sr$ = 0.71176; see above) lie a mere 15 km apart.

In the above, we have made use of the standard archaeometric strontium terminology for describing whether the individual values from Ginderup graves A and B fall within a specific baseline range (making them 'local') or outside of it (making them, therefore, 'non-local'). However, we also wish to consider these nominative categories in relation to archaeological understandings of localness/non-localness as well. Although most contexts within Southern Scandinavia are grouped chronologically into the Nordic Bronze Age and its composite periods (Jensen 2006; Montelius 1986), it is often understood in terms of smaller areas of regional influence and tradition (Anfinset and Wrigglesworth 2012; Earle et al. 2015; Ojala and Ojala 2020). As such, it may behoove us to consider Thisted County itself (sometimes the literature refers to the larger peninsula of Thy, though this is larger than Thisted County) as a particular regional unit, as it is unique not only within Denmark due to the richness of the Bronze Age finds located there, but also due to the many barrows which make the area one of the most authentic barrow landscapes in Europe (Bech et al. 2018; see also Earle et al. 1998; Earle et al. 2023).

But, let us return to the Ginderup Woman's particular case and the values which are not only non-local to Denmark, but also non-local to Thisted County. In terms of further drawing out these results, at least two possible interpretations can be put forward. In the first scenario, (1) she may have been a local individual who travelled during her adolescence outside present-day Denmark (here defined with the exclusion of the Danish island of Bornholm), thereafter returning to her place of origin within present-day Denmark. Alternatively, (2) she may have been a non-local, who originated from an area with a strontium baseline that overlaps with that of present-day Denmark who travelled in her adolescence. When working with strontium isotopes in archaeology it is important to remember that provenancing works off of the premise of exclusion; values which fall within a defined baseline can represent either local values or non-local values which fall within the same range. Consideration of alternative scenarios (i.e. with origins from different areas with overlapping baseline ranges) may be illuminative (see e.g. in relation to the similar material culture and chronological changes observed between Thisted County and the Frisian Islands as remarked by Haack Olsen and Bech 1993 and Kersten and La Baume 1958). In terms of strontium isotope values, the overlapping baseline ranges for Thisted County and the Frisian Islands has also been remarked upon (Reiter et al. 2021). If Ginderup Woman's mobility followed this second scenario, it would suggest that she travelled from her place of origin outside of present-day Denmark to another place characterized by values more radiogenic than the area from which she came. Finally, she may have made yet another journey, this time to Thisted County, Denmark, where she also found her final resting place.

In other words, in the light of Reiter and Frei's mobility model (2019, see above), the first scenario fits with a back and forth type of mobility, while the second scenario fits more with a repeated mobility pattern. As both hypotheses are possible, we will briefly assess both potential mobility patterns in the light of the present knowledge of Nordic Bronze Age socio-dynamics.

Scenario 1: Potential causes for back and forth mobility in the Bronze Age

In Bronze Age terms, a system in which an individual moved away from home as a young person, and then returned at (or after) the age of marriageability may be indicative of social, political and even economic strategies promoting the alliances of distant groups, such as the arrangement of marriage alliances (Kristiansen 1998, 85-98; Rowlands 1980 based on the anthropological frameworks proposed by Mauss 2002 and Lévi-Strauss 1969) or fosterage practices. Particularly in recent years, the passive female role in marriage alliance scenarios has come under critique; Frieman et al. (2019, 4) pointedly and poetically describe such thinking: "Indeed, the female body become a thing itself, an ambulatory manikin on which men's power is displayed."

As we have discussed such critiques of marriage models elsewhere in relation to mobility patterns from the emergent strontium data (Frei et al. 2017b; Reiter et al. 2019; Reiter and Frei 2015, 2021, 2022, forthcoming), we will focus our efforts in this section on fosterage, a practice which has had – as has been previously remarked – little attention thus far in Nordic Bronze Age research (Bergerbrant 2019).

Fosterage describes a system in which young persons particularly from influential upper social echelons would come to be raised in the household of other important (and often distant) society members in order to encourage social ties and alliances between the two units. Although scholars have hypothesized the presence of a fosterage system in Bronze Age Europe (e.g. Kaul 2017; Kristiansen 1998; Kristiansen and Larsson 2005; Mittnik et al. 2019), most interpretations and theories rely upon either comparisons with the Classical World (Finley 1977; Frank 2011; Matić 2015), or potentially through the careful analysis of later Iron Age cemeteries (Scheeres et al. 2014). Possible exceptions to this from Scandinavia focus on southern Sweden and include Blank et al.'s work on early Middle Neolithic to Early Bronze Age contexts and Bergerbant's (2019) interpretation of the six-eight year old child buried in the Early Bronze Age in grave 4/2 at Abbekås.

If we examine Viking Age and medieval accounts of fosterage, the typical age for placement with a foster family (which should be differentiated quite strongly from our modern-day associations with fosterage) would be between the ages of seven and approximately seventeen (Charles-Edwards 2000, 116; Hadley and Hemer 2014; O'Donnel 2017; O'Donnell 2020, 33). Although there is some evidence suggesting that even suckling infants may have been fostered in the ancient world (see ομογάλακτος; lit 'homogalaktos' or 'milk-sibling' (Aristotle 1889 and discussions in Derks 1995; von Wilamowitz-Moellendorff 2010) and 'ridā'a' (رضاعة) or 'milk-kinship' in Arab society (Altorki 1980), the seven year-to-later adolescence age range corresponds approximately with early traditions elsewhere. Interestingly, Blank et al.'s work (2021) on the site of Falbygden suggests that, if people were mobile, it seems that they were mobile in late childhood or adulthood. When viewed as a whole, their study of sites from southern Sweden suggests that women in late pregnancy and children up until the age of 10 months may have been stationary (Blank et al. 2021). Moreover, there may have been a temporal change in relation to children's mobility within their study region; it seems as if in the Early Middle Neolithic, children were mostly local or what Blank et al. call 'semi-local'; by contrast, in the Late Neolithic and Early Bronze Age, the dataset suggests a majority of non-local children and adults and only a single local juvenile (2021, 26).

Such a potential emphasis on movement in later childhood/adolescence finds support in the historical record. Later textual evidence suggests that this point in human development (later adolescence) marked the movement away from childhood and into social adulthood. For example, Roman males underwent a significant rite of passage between the ages of fourteen and sixteen at a ceremony in which they replaced their toga praetexta with the toga virilis and removed their bulla (Eyben 1993, 6). This event signified a new social age at which young men were considered to be more responsible adolescens until approximately twenty-five to thirty years of age (Weidemann 1989, 116). By contrast, it seems that females had no similar rite of passage in Roman times; it was only upon marriage that they experienced a change of status similar to that undergone by their male counterparts (Leijwegt 1991, 55). Epigraphic and documentary evidence from the Middle Ages, however, suggests that (at least within the upper echelons of society) a girl became eligible for marriage only after celebrating her twelfth birthday (Hopkins 1965). This age coincides with that recognized by Anglo-Saxon law codes as the age of legal majority (Crawford 1993, 17) as well as estimated age of menarche for prehistoric and early modern females (Papadimitriou 2016).

While this may seem quite young to modern sensibilities, it is important to point out that concepts of childhood are very strongly culturally-defined (Alanen 1988; Chamberlain 1997; James and Prout 2015). In being 'away from home' for a significant amount of time between the approximate ages of seven to early adolescence (a period which roughly corresponds to the timespan that the tooth enamel of the M3 represents; AlQahtani et al. 2010), young persons like the Ginderup Woman may have been living and developing within what we presume to be a foreign environment. In choosing precisely these early years for fostering, prehistoric Europeans were literally shaping society. Childhood/early adolescence is a period of physical, emotional and psychological development in which self-image is in a state of flux and in which peers and the surrounding environment hold increasing sway (Pletsch et al. 1991; Simmons et al. 1973). The importance of fosterage during this impressionable time in a person's life is expressed in the old Irish proverb which states "fostering is two-thirds of a child's nature" (Gwynn 1913, 106–7).

Scenario 2: Potential causes for repeated mobility in the Bronze Age

Above we have described a potential association between back-and-forth mobility at a young age within Nordic Bronze Age contexts. This can be contrasted with the second potential mobility pattern associated with the Ginderup Woman's new mobility data; namely that she may have engaged in repeated mobility (Reiter and Frei 2019). Such mobility could have involved Location A (a place outside of present-day Denmark, but with a similar overlapping strontium isotope baseline, Location B (a place which was more radiogenic than present-day Denmark) before her final interment at Location C (Thisted County) in Ginderup.

There are various potential causes for a repeated mobility pattern such as that possible for the Ginderup Woman within Bronze Age contexts. While it is entirely possible that Ginderup Woman may have grown up at Location A, been fostered at Location B and been sent to live with a new community at location C/Thisted County as part of a marriage alliance within an e.g. patrilocal, exogamous system, these are not the only potential causes for her specific mobility type. She may have taken part in a family trading operation, or even been apprenticed to a travelling craftsman or ritual specialist, as has previously been suggested in relation to mobile women (see Frieman 2012; Frieman et al. 2019).

It is worth noting that repeated mobility has also been associated with transhumance, especially in terms seasonal migration. Recent examples of this include the remains of a group of Early Neolithic juveniles from Nieder-Mörlen, Hesse (Germany), who Nehlich et al. suggested may have been transhumant herders (2009, 1797) as well the Chalcolithic "Iceman" colloquially known as "Ötzi" (Müller et al. 2003; Ruff et al. 2006). Here we must emphasize that, due to the preservation of the human remains from the Ginderup Woman, the resolution of the mobility data obtainable is not fine enough to either support or deny whether she engaged in seasonal transhumance, such as has posited for the above examples, though transhumance has been suggested as a possible organization type for this area in the Nordic Bronze Age (Rasmussen and Holst 2013) .

Alternatively, one may also consider examples such as the Neolithic Granhammer Man from Sweden (Lindström 2021) or even the Iron Age Haraldskær Woman from Denmark (Frei et al. 2015b) who also seem to have travelled shortly prior to their deaths. However, as these individuals' burial contexts are not only from different historical and socio-political contexts but are also otherwise unusual insofar as they contain a distinct ritual or sacrificial aspect which is not evident in the grave of the Ginderup Woman, Granhammer Man and Haraldskær Woman's potential as comparisons is not ideal.

Comparison with other female mobility patterns

Comparison with the mobility patterns of other Nordic Bronze Age females unfortunately offers no exact parallel to which Ginderup Woman can be likened. Recent research regarding the provenance of the Egtved Girl (Frei et al. 2015a), the Skrydstrup Woman (Frei et al. 2017b) and the Ølby Woman (Reiter et al. 2019) has demonstrated different mobility patterns. According to Reiter and Frei's model (2019), the Egtved Girl exemplifies back and forth mobility, the Skrydstrup Woman demonstrates point-to-point mobility and the Ølby Woman shows non-mobility.

Nevertheless, we must remember that there are some other important differences within the scales of analysis to which these ladies' remains have been subjected. Due to the preservation of organic remains, the high-resolution mobility timelines available for the Egtved Girl and the Skrydstrup Woman were not possible for other sets of (comparable) human remains, providing a lower time-resolution of mobility data. New evidence for movement at such comparatively young ages can be juxtaposed with e.g. Bergerbrant's suggestion (2007, 118 ; see also references therein) that the Fremde Frauen we see in the archaeological record might represent post-menopausal females, citing the removal of the possibility of childbearing as a potential additional freedom in relation to mobility.

To return to the strontium values, however, it is interesting to note that the strontium isotope ratio of the Egtved girl's first molar ($^{87}Sr/^{86}Sr$ = 0.71187; Frei et al. 2015a) is quite similar to that of the Ginderup Woman's third molar ($^{87}Sr/^{86}Sr$ = 0.71176; see above). While this may be coincidental, it may also point to a specific area outside present-day Denmark with which Jutland had close contact. This possibility is further suggested by the similarity of the strontium isotope ratio measured on the Jestrup male warrior (again, $^{87}Sr/^{86}Sr$ = 0.71177; Frei et al. 2019) to the ratios measured for the two females.

One important factor to consider in relation to the evidence for mobile females in the Nordic Bronze Age is that the very presence of their rich bronze accoutrements may have contributed to the preservation of their skeletal material (Kibblewhite et al. 2015). Secondly, there is also a certain bias in the archaeological data which gives pause. Due to preservation issues, many of the prehistoric skeletons found in Scandinavia are classed as male or female according to the artefacts buried with them rather than their osteological characteristics. Importantly, research suggests that the number of female graves identified in this fashion (e.g. by grave goods) is significantly lower than the number of male graves (Bergerbrant 2007, 65-80; Holst et al. 2013, 85). However, proportions of male versus female burials exhibit some chronological and geographic variation across Southern Scandinavia (Asingh and Rasmussen 1989; Austvoll 2021; Bergerbrant 2007, 89-90; Bergerbrant et al. 2017, 3-40). This intersects with the current study insofar as it affects our ongoing conceptualization of not only mobility in the Nordic Bronze Age, but also male and female mobility in this period. What we find may not just be examples of mobile females, but instead be examples of certain kinds of females who were mobile. That some of those mobile women have been observed to have had different kinds of mobility patterns opens up a wealth of further interpretational possibilities which both include and expand upon those linked with marriage alliances (Kristiansen 1998; Rowlands 1980).

One further area of similarity between three of the four female graves described above lies within elements of funeral dress. Egtved Girl, Ølby Woman and Ginderup Woman seem to have been buried with corded skirts, which can be contrasted with the longer woven skirt allocated to the Skrydstrup Woman. Various interpretations have been put forward in relation to the unique corded (or string) garments associated with the female burials from Egtved, Ølby and Ginderup which may have some impact on the potential types of mobility/non-mobility expressed during their lifetimes. Thomsen (1929) suggested that it was the clothing of a young rather than a mature woman. Not fifty years later, Nielsen (1971) posited that shorter kilts could have been remade from longer skirts, leading Eskildsen and Lomborg (1977) to go a step further and suggest that corded skirts may have been characteristic of married matrons rather than unmarried maidens. Randsborg (2011) proposed that the skirts represented summer clothing, or indeed clothing which may have had a more ritual aspect. As an item of dress, the corded skirt has become a modern-day icon for prehistoric dress which is often linked (whether or not this is erroneous) to Denmark in particular. In her review of scholarly thought on the corded skirt. Bergerbrant (2014) suggested that the skirts may have been more common than their extraordinary appearance might otherwise suggest.

Although further data is necessary in order to investigate this fascinating aspect of the Bronze Age world, our new data provides new insights about the time and pace of the mobility enacted by the corded-skirt wearer we refer to here as the Ginderup Woman and which may help to point future research in a new direction. Renaissance thinker Erasmus of Rotterdam claimed 'vestis virum facit,' literally 'clothes make the man'. However, continuing examination of the mobility patterns associated with Bronze Age females – especially those who, like the Ginderup Woman, seem to have been clad with similar iconic corded skirts – may show that clothing (and the social roles therewith associated) may not necessarily have 'made the woman', or at least dictated the trajectory of her movement(s)/ non-movements across Europe.

Conclusion

The present study presents strontium isotope data and new osteological analyses from Early Bronze Age human remains from two different individuals from the same burial mound from Ginderup in Thisted County, northern Jutland (Denmark). The aim was to investigate mobility in light of previous analyses of other Early Bronze Age elite female burials unearthed in Denmark from other Bronze Age burial mounds. Osteological analyses of three individuals suggested the presence of two 14-15 year old individuals in Graves A and C as well as one 3-4 year old subadult from Grave B. Our strontium isotope analyses revealed that the subadult from Grave B yielded a $^{87}Sr/^{86}Sr$ ratio which falls within the baseline range for present-day Denmark, suggesting that this individual may have been of local origin. By contrast, the female individual interred with a possible corded skirt from the mound's central grave (Grave A) and from whom we were able to analyse two teeth, had one strontium isotope ratio that fell within (M2) and another that fell outside (M3) the local bio-available baseline range. This can be interpreted in several ways. In relation to Reiter and Frei's mobility model (2019), we present two possible scenarios for the interpretation of the strontium isotope ratios measured for this female individual.

1) She may have been a local individual that travelled during her adolescence outside present-day Denmark, who returned thereafter to her place of origin within present-day Denmark.
2) Alternatively, she may have been a non-local (who originated from an area with a strontium baseline that overlaps with that of present-day Denmark, such as has been suggested for other contemporary graves from Thisted County; Reiter et al. 2021). If this is the case, it will suggest that she travelled from her place of origin outside present-day Denmark to another place characterized by values more radiogenic than the place from which she originated, before finally moving a third time to what would become Thisted County.

According to the mobility model (Reiter and Frei 2019), the first scenario fits with a back and forth type of mobility, while the second scenario fits more with a repeated mobility pattern. We have discussed back and forth mobility patterns specifically in relation to fosterage practices and repeated mobility within the light of fosterage, marriage alliances, trading systems and potential travel associated with e.g. ritual specialists, transhumance and/ or ritual sacrifice.

Interestingly, another conclusion drawn from this new study is related to dress. Ginderup Woman, like the Egtved Girl and Ølby Woman, seems to have been interred wearing a corded skirt. Current research suggests that these three women engaged in very different kinds of mobility in spite of their similarities in dress. This may perhaps mean that wearing corded skirts (or the role that the wearing of such items of dress represented) may not have demanded a specific form of mobility in and of itself.

Although further data is needed in order to gain a better hold of how mobility/non-mobility may have played a role in Nordic Bronze Age social dynamics, the ever-increasing amount of human provenance and mobility data suggests that there may have been a larger variety of different paths that women could have taken in relation to mobility than previously anticipated. Our study also emphasizes the importance of investigating several teeth from single individuals representing different time spans when investigating socio-dynamics in prehistory wherever possible.

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'Where Water wells up'

Revisiting a forgotten Deposition Tradition from the Late Bronze Age on Funen, Denmark

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ABSTRACT

The article presents a deposition of ornaments from the Late Nordic Bronze Age period V. An archaeological excavation along with non-pollen Palynomorph (NPP) and pollen analysis has resulted in new knowledge about the poorly illuminated Bronze Age tradition of spring offerings. With a starting point in the find at Hedegyden this article aims to improve the understanding of the Bronze Age depositional practices in relation to springs. The article presents the ornaments, but focuses on their context as regards to the relationship between the objects within the deposition, as well as the site of deposition. Based on the stratigraphic observations, the preserved organic materials in the Hedegyden find and the scientific analyses, a *chaîne opératoire* is presented for the various sub-elements and phases of the depositional act.

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Introduction

Interest in the use of metal detectors has increased dramatically in recent years. This is also reflected by the growing number of Bronze Age detector finds. These finds help to improve our understanding of the utilisation of the landscape during this period – including the areas outside or between settlements and burials. The numbers of single and multi-type depositions have increased intensively since the turn of the century, almost matching the numerous finds that were made in agricultural fields and bogs during the 19th and 20th centuries (Frost and Beck 2023a, Fig. 3).

The Bronze Age deposition tradition is associated with water in its various forms (Bradley 2017; Dunkin et al. 2020; Fredengren 2011; Frost and Beck 2023a; Rundkvist 2015; Yates and Bradley 2010a). The specific relationship between the deposition contents and the landscape characteristics of the deposition site has however often been blurred by the broad generic terms 'field/ bog finds' or 'wetland finds'. Historically, archaeological research often focused more on the objects themselves than their context, which for example has been underlined by S. Hansen and others in the same publication (Hansen 2012, 23). This has however changed in recent years with the focus now also being placed on the context of depositions in the landscape (Bradley 2000, 2017; Fontijn 2002; Fredengren 2015, 2018; Frost 2008, 2015; Rundkvist 2015). Several studies indicate that water with different characteristics, or affordances as C. Fredengren refers to them (Fredengren 2011, 114-118), was decisive for the choice of deposition site. This can, for example, involve affordances in the form of water flowing out of the ground, water that runs quickly or stands still, or one water source that merges with another water source.

With this article, we aim to improve the perception and understanding of the Bronze Age offering traditions in relation to springs in particular. Firstly we present the spring find from Hedegyden with regards as to the content of metal artefacts and organic materials as well as their internal stratigraphic relationship. Especially the preserved organic material and the pollen and non-pollen palynomorph

(NPP) analysis are important aspects for our interpretation. Secondly, the Hedegyden find is placed in a local and regional landscape context and finally, we present a chaîne opératoire for a spring deposition, based on the excavation observations and scientific analysis made at Hedegyden, compared with observations from other offering finds.

Spring Offerings

Offerings and shrines placed around springs is a worldwide phenomenon known throughout most of prehistory and into historic times. The perplexing phenomenon of water flowing out of the ground was apparently of special value or even of divine importance, either constituting a passage between two worlds or reflecting the idea that the water had special qualities (Bradley 2017, 188; Fredengren 2015, 161-169, 2018, 227; Schoueri 2016, 63-66; Strang 2020, 113). The numerous Danish sacred springs that were frequented up until modern times emphasizes that the power of the spring was not exclusively associated with a pre-Christian world of beliefs (Henriksen 2003; Schmidt 1926, 23; Svane 1984, 13-24).

Despite their apparent frequency, both in geographical and chronological terms, only a few prehistoric spring offerings have been excavated and described within a Danish and Scandinavian context (e.g. Nilsson and Nilsson 2003; Nørlund 1973; Rasmussen and Skousen 2012, 153; Rundkvist 2015, 44-45; Skousen 2008, 161; Stjernquist 1997; Vebæk 1944, 1945). Danish spring offerings dating to the Bronze Age are mentioned in the archaeological literature (Kjær 1925, 123; Nordman 1920), but only a few well-documented examples have been investigated (Frost and Beck 2023b). From a broader North-West European perspective, in recent decades more emphasis has been placed on springs constituting an important factor or affordance in connection with the prehistoric offering tradition (e.g. Bradley 2017, 58-60; Bradley et al. 2015; Dunkin et al. 2020, 69; Fontijn and Roymans 2015; Fredengren 2015, 166 , 2018, 227; Yates and Bradley 2010a, 413, 2010b, 59).

The limited number of published spring offerings in a Danish/Scandinavian context is obviously related to the fact that such depositions are hard to recognise without an archaeological excavation of the find or thorough analyses of the landscape context. As the majority of the finds were made accidentally and in connection with agricultural work in fields or peat digging, only a very small proportion of the Danish Bronze Age depositions have been archaeologically investigated. They have therefore often been described simply as 'bog/wetland finds'. This generic term obscure the nuances of the find circumstances, and there is a marked tendency to only focus on whether a deposition was made on dry land or in wetland. This is due to both inadequate information about the circumstances of discovery in the case of many of the finds, but probably also the summary nature of the data and information about the finds when they are referred to in the literature (Hansen 2012, 40). There are therefore undoubtedly considerable numbers of spring offerings amongst the large group of finds that have been attributed to 'bogs/wetlands' (Frost and Beck 2023b). In the thoroughly cultivated and drained Danish landscape, many springs have dried out, but they are often still visible as marks in the subsoil, in the form of sand pockets with concentric rings. An excavation is required to detect the geological phenomenon with certainty, as well as, for instance, scientific analyses to support the reconstruction of the landscape (e.g. Frost and Beck 2023b; Skousen 2008, 161).

The Spring Offering from Hedegyden

In January 2020, a metal detectorist contacted Østfyns Museer, because he had found two hanging vessels in a field at Hedegyden near Kullerup Hede, 4 km west of Nyborg on Funen. A few days later, the museum excavated the remaining part of the find and documented, that the ornaments had been buried at a spring.[1] The find from Hedegyden provides a unique opportunity to study the relationship between objects and site of deposition at a micro level, and to shed light on spring offerings in general.

Topography and Place of Deposition

Today, the finding place is a cultivated field (Figure 1). To the south, the terrain rises and becomes

Figure 1. The offering find at Hedegyden is located west of Nyborg near a small tributary of Vindinge Å. Base map 25 cm map. Data from Styrelsen for Dataforsyning og Infrastruktur (Graphics: Malene R. Beck).

slightly undulating, but to the west, north and east it drops gradually down to Vindinge Å and two of its tributaries, which form a natural boundary in the landscape. A depression in the terrain, corresponding with information on the O1 map (First Cadastral Map), indicates that a fossilised stream flowed into a tributary of Vindinge Å 60-70 m west of the find spot. On the O1 map, large areas are marked with the wet meadow symbol, which to the north and east almost defines the finding place as a headland. The area was likely characterised by several springs or by water periodically flowing out of the ground. Within a radius of more than 1 km from the find spot no other archaeological finds from the Bronze Age are recorded.

The finder had dug up a considerable proportion of the find from the original deposition and important information therefore lost. It cannot be determined to what extent the ornaments have been damaged during the period in the ground or by partly being dug up by the detectorist. Information about the interrelationships between the objects and their packing is also deficient. Fortunately, parts of one hanging vessel and a belt ornament were still *in situ* (Figure 2). During the archaeologial excavation, the two objects were taken up in a block lift, and subsequently excavated by a conservator. The remaining ornaments were situated on the south side of a spring, which was visible as a 1.12 m east-west × 0.93 m north-south oval mark of white-yellow sand, with clear wavy marks and rust red iron deposits along the edge. Water still seeps out at the site. The colour of the fill around the objects indicates that they were buried at the edge of the spring in a pit, that eventually filled up with darker and more humus depositions. A grey-white stone measuring *c*.10 cm in diameter was recorded in the sand layer below the offering. Close to the bottom-most hanging vessel and in the same dark fill and level was a red granite crushing stone. It was not possible to determine whether the grey-white stone was part of the depositional activity, but on basis of the stratigraphic relationships, the crushing stone is interpreted as being part of the same event as the deposition of ornaments. Crushing stones and stones associated with spring offerings are known from Röekillorne (Stjernquist 1997, 41, 50) and white or light-coloured stones are common amongst Early Iron Age bog offerings. It remains uncertain what the

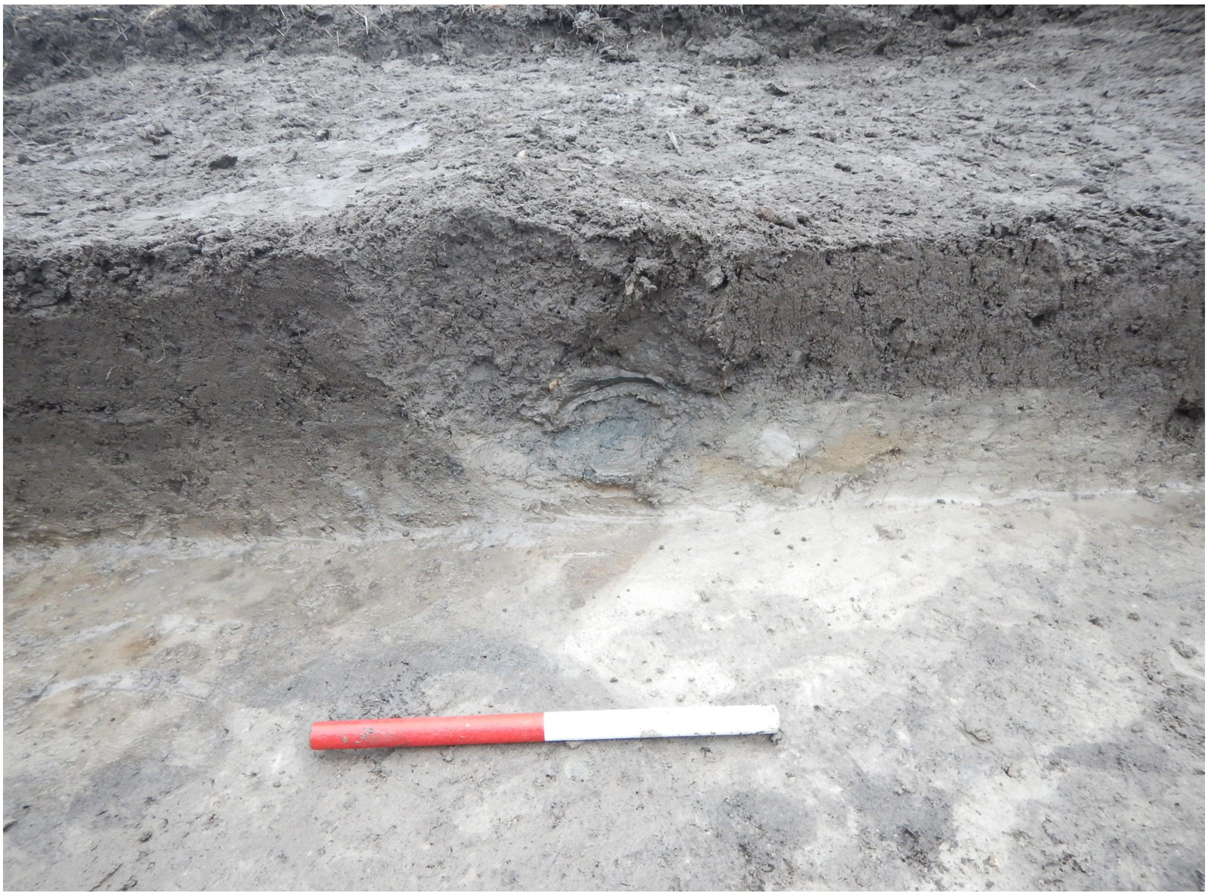

Figure 2. Photo from the excavation of the find at Hedegyden. The remains of a hanging vessel (1090x4) and a belt ornament (1090x3) are visible in the section. The light-coloured, white-yellow sand constitutes the spring itself, from which water still seeps up (Photo: Østfyns Museer).

stones symbolise, but they seem to be a fixed element of various depositional activities, and often appear to have been thrown into bogs (Lund 2002, 184; Pantmann 2020). The two stones in the spring at Hedegyden perhaps reflect the same act or thought associated with a deposition situation.

Presentation of the Find

The find from Hedegyden is a multi-type deposition from the Late Bronze Age period V (LBA V, *c*.900-700 BC), consisting of three hanging vessels, a belt ornament and three smelting lumps of copper alloy. The find also contained remains of a wooden lid or small container in one of the hanging vessels, and bark and wood fragments, probably from a larger bucket. The bronzes are generally in very good conditions and the ornaments are covered in verdigris, with areas of bright metal and only small amounts of corrosion. None of the objects are complete. The belt ornament is only represented by fragments and the two large hanging vessels have major fractures, some of which are fresh.

The Hanging Vessels

Approximately two thirds of the lower part of the largest hanging vessel 1090x1 is preserved (Figure 3a). Parts of the shoulder are intact, but there are no definite remains of the neck and suspension holes. The hanging vessel measure 25 cm in diameter, but other dimensions cannot be determined. Remains of a bronze lamina (Frost 2010, 16) can be observed inside the vessel.

At the transition between the neck and shoulder is an encircling plastic rib with diagonal hatching, and the decoration on the belly is divided into four zones, separated by two to four encircling plastic ribs, with alternating diagonal hatching, which is very worn in places. The centre of the belly is marked by a separate flat knob, decorated with a

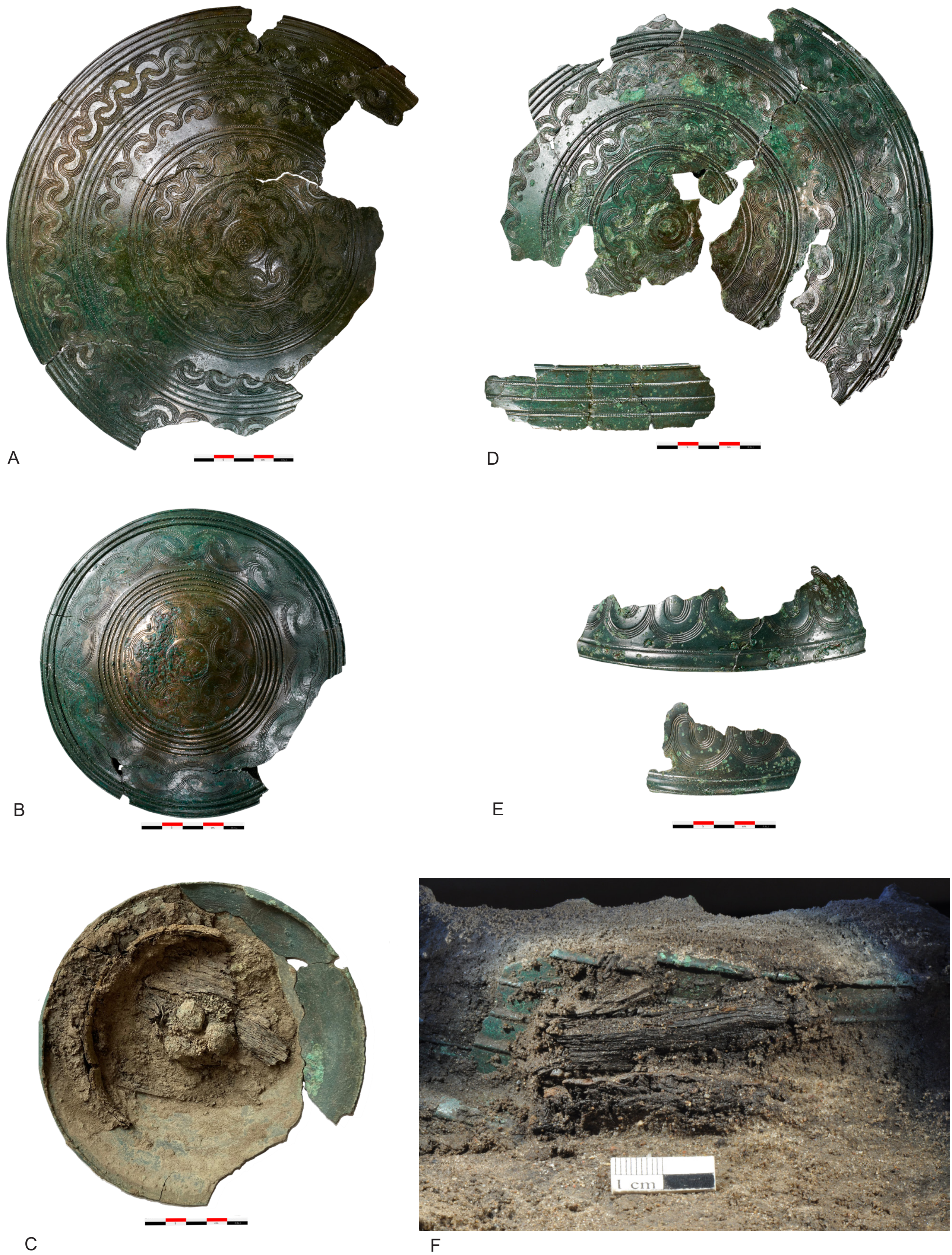

Figure 3. a) hanging vessel 1090x1; b) the smallest of the three hanging vessels 1090x2; c) the small hanging vessel 1090x2 during excavation and conservation. Inside the vessel, remains of a ring-shaped piece of bark can be seen, which in size corresponds to the opening of the hanging vessel. Thin wood/ bark flakes are also visible at the bottom, as well as three smelting lumps of copper alloy; d) hanging vessel 1090x4; e) the largest fragments of the belt ornament 1090x3; f) remains of the bark layer around the neck of the hanging vessel 1090x4, which were taken up in the block lift. A layer of bark was also found under the hanging vessel (Photos a, b, d, e by Rógvi N. Johansen, Moesgaard Museum, photo c by Malene R. Beck, Østfyns Museer, photo f by Ida Hovmand, Bevaringscenter Fyn).

dot surrounded by four circles. The first zone of decoration is filled with a wave motif, in which three to four lines form fourteen opposing, mushroom-like shapes. Zone two is filled with a classic, running-dog motif consisting of up to five lines. The motif in the third zone is a variation on the running dog, which only fills the bottom half of the zone. Instead of a continuous sequence, each wave ends as an open, upward facing S. The fourth and outermost zone is filled by the same variation of the running dog motif that is seen in zone two. This, however, involves the variation that the wave courses also have small fringes on the side that faces away from the centre of the vessel.

The smallest of the hanging vessels 1090x2 is relatively well preserved (Figure 3b). The vessel measures 14.3 cm in diameter and its mouth is 10.6 cm in diameter. At the neck-shoulder transition is an encircling, plastic rib with diagonal hatching. The centre of the belly is marked by a separate, flat knob. The surface of the knob is worn, where decoration consisting of four opposing arcs, each consisting of three lines, can still be clearly seen. Together, the arcs form a (sun) cross-like figure. The belly has a zoned ornamentation that is separated by three to six plastic ribs with diagonal hatching; the rib closest to the centre of the vessel are obviously worn. The first zone is decorated with a wave motif consisting of two to four lines, which forms mushroom-like figures. The motif can be deciphered in both 'negative' and 'positive', so that there are both six figures that face the top in towards the middle knob and six which face away from it. The uppermost arc of each of the 12 mushroom figures is decorated with small, upright fringes. The next decorative zone is filled with a variation of the running dog, in which 14 S-shaped figures intersect with one another and form a wave-like sequence. The figures consist of four to five lines. Short lines form a fringe-like pattern at the top of all inner and outer arcs in the motif. The characteristic fringe or line motif, as well as the use of the mushroom-like motif, correspond to the decoration on the largest of the hanging vessels 1090x1. The top of the hanging vessel and the uppermost plastic rib, as well as one of the preserved suspension holes, show obvious signs of wear, so it was used for some time before the deposition took place. The soil-filled inside of the hanging vessel contained preserved remains of wood and bark in a circular shape, which precisely corresponded to the diameter of the neck aperture (Figure 3c). This represents the remains of a lid, or perhaps a small bark container inside the vessel. At the bottom was another thin layer of wood, which may have been associated with the circular piece. Analyses indicate that this was most likely wood and bark from *Betula* (birch), all though *Acer* (sycamore) or *Pomoideae* (pome) cannot be ruled out.[2]

Very little is known about how the hanging vessels were closed and used, but they probably had some form of lid (Friis 1968). There are several examples of belt ornaments from EBA III (1300-1100 BC) and LBA IV (1100-900 BC) with metal lids (Broholm 1943, 225, M87 and M88, 1945, 190, M47). Lids of organic material in the form of wood are known from the Sæsing deposition from LBA IV (Friis 1961, 39), and at Hverrestrup bakker in Vesthimmerland, a hoard from LBA V (900-700 BC) has recently been excavated which also included remains of a wooden lid (Nielsen and Hjortlund 2021, 22).

At the bottom of the vessel 1090x2 and covered by the thin layer of wood, lay three much corroded smelting lumps of copper alloy (Figure 3c). These probably represent casting waste, but their poor condition make it difficult to determine their function and origin. The drops are 1.4-1.6 cm in diameter. Remains of casting, in the form of casting waste, 'scrap metal' and smelting lumps, are common elements of the Bronze Age deposition tradition (Broholm 1945, 263; Frost 2008, 57, 2010, 26; Jantzen 2008, 286-289; Thrane and Juottojärvi 2020), and may have been of symbolic importance (Hansen 2013, 186; Rundkvist 2011, 161).

Hanging vessel 1090x4 (Figure 3d) was placed on its belly and constituted the base of the deposition. Approximately half of the belly of the vessel is preserved. In addition, a quarter of the neck and some fragments of the shoulder are present. The diameter measures 24-25 cm and the neck is 3.1 cm high. The decoration is identical to that on hanging vessel 1090x1, although there are no fringes on the running dog motif on this vessel. At the transition between the neck and shoulder, there is a plastic rib with diagonal hatching (cord decoration). The decoration on the belly is divided into four zones separated by two to four encircling plastic ribs with alternating diagonal hatching. The ribs show some signs of wear, but this is not as pronounced as on hanging vessel 1090x1. The middle of the belly is marked by a separate flat knob decorated with a dot surrounded by four circular strokes. The first zone of decoration is filled with a wave motif, in which three to four lines together make up 14 opposing mushroom-like figures. Zone two is filled with a classic running dog motif. The motif in the third zone is a variation on the running dog, which only fills the bottom half of the zone. Instead of a continuous course, each wave ends with an open, upward-facing S. The fourth and outermost zone is filled with the same variation of the running dog motif that is seen in zone two. The neck of the hanging vessel is decorated with three plastic ribs with diagonal hatching and the suspension holes are integrated into the neck.

Apart from the differences in size, the hanging vessels are so uniform in appearance and quality, that the same bronze caster may have produced them (Appel and Olsen 2011, 13; Kristiansen 1974, 22). The hanging vessels corresponds to Baudou's type XXII B2a (Baudou 1960, 70) and can be relatively dated to LBA V (900-700 BC).

The Belt Ornament

The belt ornament 1090x3 (Figure 3e) is very fragmented. The largest fragment was excavated from the block lift, which also contained hanging vessel 1090x4. It is therefore certain that the belt ornament was placed inside this hanging vessel.

Three quarters of the edge of the ornament are preserved and the diameter is 16 cm. Along the preserved edge fragments are remains of two suspension holes and a secondary hole has also been drilled near the edge, 2.7 cm away from one suspension hole. This suggests that the ornament has been repaired. On the inside of the belt ornament is a protrusion which ended in a disc for fastening the belt. Around the shank of the protrusion, on the inner side of the belt ornament, is a plastic swastika figure.

The belt ornament had two zones of decoration, in the form of the running dog motif. The bottom zone has closed, wave-like courses and the uppermost zone open courses. A band filled with punches and framed by diagonal hatched borders separates the two zones of decoration. The edge of the ornament is more domed and surrounded by plastic ribs with diagonal hatching.

The belt ornament has close parallels in the Lindø hoard (Thrane 1987, 204), and the find from Villingerød (Broholm 1945, 207, M101a), both in terms of size and decoration. It features the same decoration scheme as the hanging vessels and corresponds to Baudous type XXIIIB with a relative date to LBA V (Baudou 1960, 70). However, the dimensions of the belt ornament and the two hanging vessels 1090x1 and 1090x4 are quite considerable, which makes a dating closer to LBA VI (700-500 BC) more likely (Baudou 1960, 72). The obvious wear and evidence of repair of the ornaments indicates that they were used for a considerable period of time and the stylistic dating therefore does not necessarily correspond with the time of deposition (Jensen 1997, 153; Kristiansen 1974, 22; Lund and Melheim 2011, 449).

Packing Materials of Wood, Bark and Straw

Thanks to favourable conditions for the preservation of organic material, the find from Hedegyden has provided information about how the ornaments were packed in connection with the deposition, as well as knowledge about the landscape in which the deposition was placed.[3]

Remains of bark and hardwood around and under the lower hanging vessel 1090x4 suggest that the ornaments were stored in a wooden or bark container when they were deposited (Figure 3f). The wood cannot be identified more closely than as deciduous. Remains of wood/bark were also found between the hanging vessel 1090x4 and belt ornament 1090x3, as were patches of straw at the bottom of hanging vessel 1090x1.

It was apparently a common feature to wrap the bronze objects or deposit them in different kinds of containers. Remains of various organic material and raffia have been recorded in several cases in connection with deposited bronze objects, which may originate from the packing of the objects. This, for example, applies at Rannerød (Broholm 1945, 198, M67), to the Lindø hoard (Thrane 1987, 200), Mariesminde II (Thrane and

Jouttojärvi 2020), Røjle mose (Jensen and Runge 2008), Bækkedal (Sarauw 2015), and Vaseholm (Frost 2003). The most recent discoveries are the tanged sword from Håre packed in raffia (Madsen and Hansen 2021, 13), as well as two metal hoards from Baunshøjgård, which contained remains of wood and fur (Nielsen and Hjortlund 2021, 22). The phenomenon is also known from the beginning of the EBA where five large flanged axes from Boest in Central Jutland lay packed in a grass-lined depression (Christensen 2017, 4).

Several examples of depositions in pottery vessels are known (Broholm 1943, M89, M96, 1945, M47, M69, M96, M104, M122, M141, M148, M156, M162, M166, M190, M195 and M229; Sarauw 2015; Thrane 1987; Thrane and Jouttojärvi 2020; Varberg 2008), and fewer in metal vessels (Broholm 1945, 272; Frost 2003; Thrane 1975, 143-153). Depositions in wooden or bark containers or packing in other forms of organic material were probably a widespread phenomenon. In most cases, the organic material has either disappeared or not been documented, because the finds were discovered by accident. A number of bark buckets have been found in the oak coffin graves from EBA II and III (1500-1100 BC) (Boye 1896, 186; Thomsen 1929, 183-185). Wooden and bark containers have been recorded in LBA burials (Thrane 2004, 107, 258) and in North Zealand two bark buckets were recently found in well structures dating to LBA IV-V (1100-700 BC).[4] Remains of a bark bucket were also found in a house offering from Spjald (Becker 1989, 202-203). Some of the bark buckets in the oak coffin graves originally contained drinks, but there are also examples of bark buckets used as hatboxes (Boye 1896, 91). It is quite possible that ornaments were stored in a similar way, hidden away in a container when they were not in use. Bark buckets of a size and diameter, which could contain a set of ornaments like that which was found at Hedegyden are known from Norway (Henriksen 2014, 160).

Pollen and non-pollen Palynomorph (NPP) Analyses

Pollen and NPP analyses of preserved organic material in and around the hanging vessels from Hedegyden help provide a more nuanced picture of the landscape in which the deposition was made, as well as nuancing the deposition event itself and increasing our knowledge of the use of the hanging vessels. Two pollen samples were analysed, taken from inside the bottom-most hanging vessel 1090x4, and from the straw found in the largest hanging vessel 1090x1. The sample from inside the vessel 1090x1 was also analysed for NPP. The pollen and NPP analyses and the preparation procedure are presented in detail in Appendix 1.

Amongst the preserved pollen, the composition of grasses and herbs indicates that the immediate surroundings of the deposition site were meadow areas. This fits well with the landscape as it appears on the O1 map, with large areas described as wet meadows. The high frequency of ascospores from *coprophilous fungi* in the NPP analysis indicates that the meadow areas were grazed by large herbivores, possibly cattle.

The identification of a small number of the pollen grains as barley, as well as a number of the type including rye or barley, suggests that there were cultivated fields only a short distance from the deposition site (Robinson 1993, 20). The cultivated areas are also indicated by the straw that was used as packing material. A low proportion of pollen from hazel, alder, pine and oak indicate that there was scrubs or isolated trees within the area. In other words, the deposition seems to have been made at the edge of a landscape that was characterised by human activity.

Honey in the Hanging Vessel?

The NPP analysis revealed possible remains of bees' hairs. The bees' hairs may originate from honey or beeswax, and together with the considerable amounts of pollen from flowering herbs of the *Brassicaceae* family and *Cichorium*-type, this indicates that the vessel originally contained honey or more likely honeycombs. Studies demonstrate that pollen from the *Brassicaceae* family, if available, is favoured by honeybees (Guillermina and Caccavari 2006). Was a piece of honeycomb included in the deposition, or did the hanging vessel contain a honeycomb or beeswax, when it was in use? The latter is a possibility that we cannot rule out, given the medical properties of honey. Honey is an antiseptic and was a fixed ingredient in the medicine chests of the ancient world and was also used to treat wounds up until modern times (Crane 1999, 502; Eteraf-Oskouei and Najafi 2013). We know very little about what function the hanging vessels had, but a medicine bag containing various remedies is a possibility. The EBA III female burial from Maglehøj on Zealand can be mentioned as a parallel. In the grave was a belt container in which there were horse teeth, bones from small animals, such as wild cats, birds, stoats and grass snakes, fragments of wood, and pieces of bronze sheet and thread. This group of objects may have been associated with esoteric or magical qualities (Kaul 1998, 16).

Considering how vital a resource beeswax was in relation to bronze casting, another possibility is that it was the beeswax rather than the honey that was important. In this connection, the three smelting lumps, which were also part of the deposition at Hedegyden, may constitute a ritual starter pack for a new casting process, together with beeswax. They may have been part of a symbolic transformation of the objects in the deposition (Brück and Fontijn 2013, 212; Lund and Melheim 2011, 449). Casting cones, casting cakes or 'bronze scraps', which were apparently intended for melting down, are relatively common elements of multi-type depositions. Nor is it uncommon for different kinds of organic material to be present together with bronze objects (Frost 2003; Matthews 2008; Madsen and Hansen 2021; Nielsen and Hjortlund 2021; Jensen and Runge 2008; Sarauw 2015; Thrane 1987, 200). Scientific analyses of the organic materials from the depositions, which could clarify whether beeswax was also a fixed element of an offering package, are, however, required. A single example is the find from Tranegård near Ramløse, North Zealand, consisting of an oath ring, two gold spiral rings and a gold bar (Jørgensen and Petersen 1998, 43). The objects were found encapsulated in an organic mass, which also contained beeswax. The cast bronze container shaped like a straw beehive in the Late Neolithic find from Skeldal can be regarded as a symbolic example of the close association between valuable metal craftsmanship and beekeeping, or rather the products of beekeeping (Jørgensen and Petersen 1998, 39; Vandkilde 1990, 117).

A third possible interpretation for the concentration of honey-indicating pollen is that honey or liquid containing honey constituted part of the overall offering package. The use of honey and honey-based drinks as offering gifts (libation) is described in ancient sources and depicted in art (Bowie 2020; Burkert 1985, 70-72). When Odysseus is to bring the souls of the dead up from the underworld, he digs an offering pit, around which he offers honey, wine, water and barley (Homer Od. 10,518-26, 11.26-34 in Otto Steen Due's translation). The use of honey in connection with Bronze Age depositions or offering activities is represented in a North European archaeological context by the offering well from Lichterfelde, Berlin, where more clay vessels contained honey-sweetened beer (Koch 2018, 82-84; Müller 1964, 25-27). In addition, Norwegian bog finds of bark buckets contain remains including beeswax (Henriksen 2014, 158-159) and honey-based mead in several oak coffin graves can also be mentioned in this context (Koch 2018, 71; Thomsen 1929, 184).

Overall Assessment of the Find

Based on the stratigraphic observations made during excavation of the site and the excavation of the block lift the following assessment can be made regarding the internal relationship between the ornaments in the deposition. Hanging vessel 1090x4 formed the base which the belt ornament 1090x3 was placed on top of. The straw in the largest of the hanging vessels 1090x1 suggests that something was packed down inside it, probably the smallest of the hanging vessels 1090x2. The preserved wood in hanging vessel 1090x2 indicates that, until quite recently, it lay undisturbed in an oxygen-poor environment. Because of the circumstances associated with the find, it cannot be determined whether this was a single combined deposition, or it was a contemporary deposition of two different sets of ornaments. The uniformity of the ornaments, compared with various examples of multi-type depositions consisting of carefully packed objects deposited together, indicates that the deposition at Hedegyden should be interpreted as one single event.

Four AMS dates have been undertaken on the organic material in the find (Figure 4, Appendix 2). The calibrated AMS dates of straw (AAR 34082), which has been used as packing material in hanging vessel 1090x1 and presumably is of the lowest age, falls within the date range 753-403 cal BC (95.4 % probability). This broad date range reflects the problems associated with the so-called Hallstatt plateau in relation to absolute dating in the late part of the Bronze Age (e.g. Kneisel 2013, 109; Olsen et al. 2011). A calibrated date (AAR 34083) on wood/bark found under the bottom-most hanging vessel 1090x4 falls within the period 909-800 cal BC (95.4 % probability), and thus within the classic period V division. The other two dates on wood/bark found between hanging vessel 1090x4 and belt ornament 1090x3 (AAR 35030), and from bark around the neck of vessel 1090x4 (AAR 35031), are however somewhat earlier, with calibrated date ranges within period III-IV.

Despite the unhelpfully long calibrated date spans, the AMS dating of the straw indicates that the deposition was made in the last part of the LBA, presumably around the period V-VI transition.

Hedegyden, the local and regional Context

Østfyns Museer has in recent years carried out excavations of three other offering finds dating to the Bronze Age. All discovered by detectorists. The finds all seem to be associated with springs or terrain where water flows out.[5]

At Mensalgård, south of Ladby, two highly corroded hanging vessels were found in 2020 (Frost and Beck 2023a, C19) (Figure 5). The two vessels were packed closely with a layer of straw between them and they had probably been twisted out of shape to fit into a very small hole. The straw has been AMS dated to 898-774 cal BC (95.4 % probability, AAR 34552; Figure 4, Appendix 2). Typologically, the two vessels can be placed in LBA V (900-700 BC) and the AMS dating of the packing material supports this. Charcoal found in the soil close to the vessels has been AMS dated to 1376-1057 cal BC (95.4 % probability, AAR 33358). This indicates that activities took place here during the EBA and could underline the sacred character of the area.

A pocket of light-coloured sand could be observed around the pit containing the hanging vessels. The sand differed from the otherwise clayey subsoil, suggesting that this was a dried out spring, where the objects had been deposited. The finding place is located in an area that according to both the O1 map and Historical Topographic Map (Høje målebordsblade 1842-1899) was wet meadow, and modern data shows that groundwater is still at a high level. From here a tributary of the brook Vejlebækken emanates, which around 1.6 km further north flows out into Kerteminde Fjord (Figure 6). The area must have been of special importance in the LBA, as the two hanging vessels are not the only finds. Within a short distance metal detector surveys have also resulted in the discovery of a celt and a socketed chisel, as well as a fragment of a gold bowl of the same type as the Mariesminde and Midskov vessels (Ebbesen and Abrahamsen 2012).

At Holemose, east of Ullerslev, in 2019 the museum excavated a multi-type deposition containing different types of equipment, often considered as either male or female objects, respectively, from EBA II (1500-1300 BC). On the basis of results of the excavation, as well as information from the O1 map and LIDAR maps, the find is associated with a probable spring, which runs down to Holemose, a small kettle bog just to the south of the find spot (Beck 2020, Frost and Beck 2023a, C300).

Only 1 km west of the find at Holemose, in 2021 a multi-type deposition containing ornaments from LBA IV (1100-900 BC) was found and excavated (Beck 2022, Frost and Beck 2023a, C301). Remains of the pottery vessel in which the ornaments were deposited were also present. The vessel had been placed with its rim facing downwards. The remains of the vessel were taken away from the site in a block lift and excavated. Charcoal found during this work has been AMS dated (Figure 4, Appendix 2). The calibrated dates fall within the EBA and can therefore hardly be directly associated with the deposition event. A small pocket of light-coloured, yellow sand was observed in connection to the pottery vessel. The

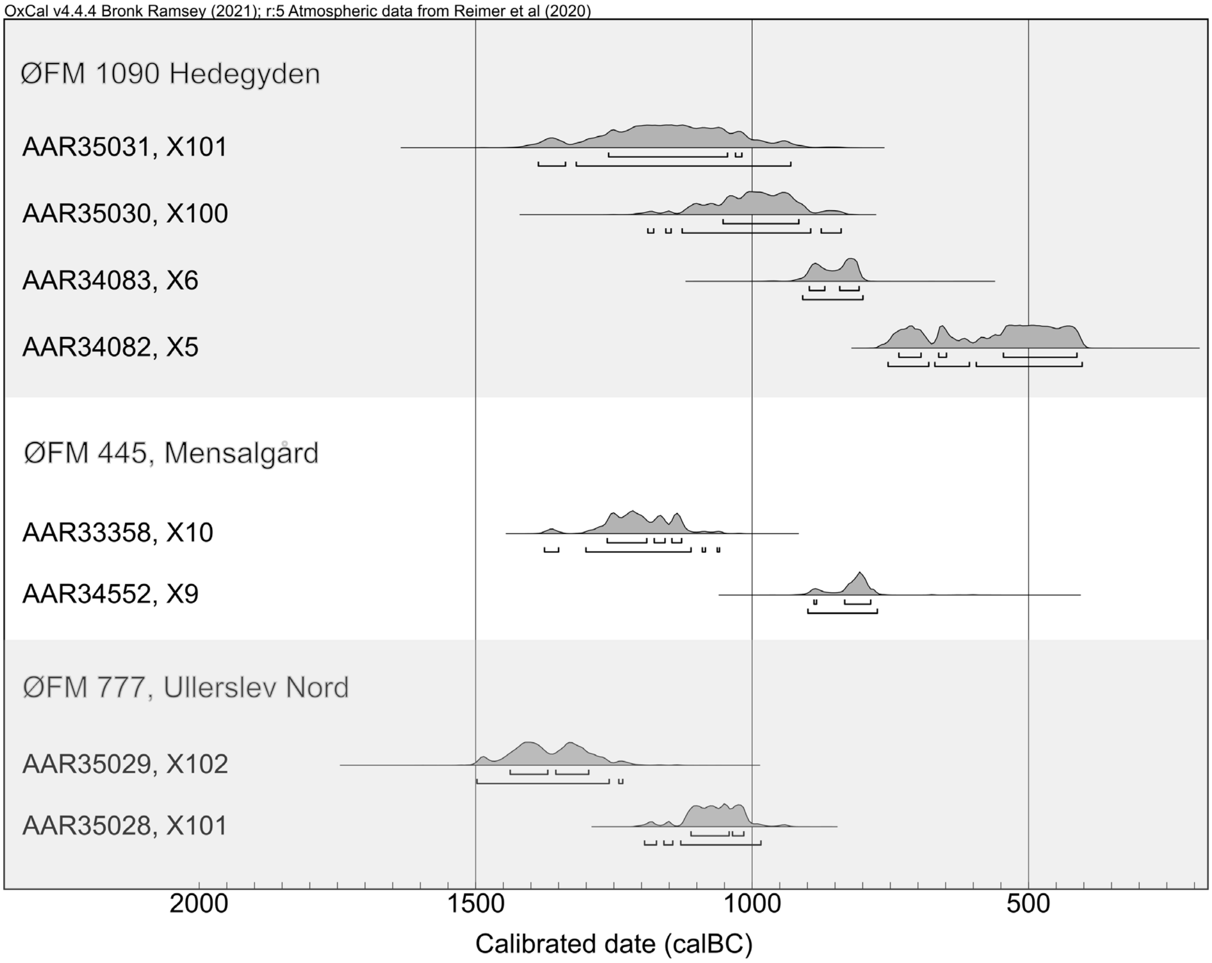

Figure 4. Calibrated AMS dates of three new offering finds excavated at Hedegyden, Ullerslev and Mensalgård in East Funen. For primary data see supplementary material Appendix 2 (Graphics: Jonas Ogdal Jensen, Moesgaard Museum).

subsoil at the location otherwise consisted of moraine clay. It cannot be established with any certainty whether this is a dried-out spring or merely a coincidental geological phenomenon. Excavations carried out in 2022 and 2023 testify a high ground water level in connection to geological phenomena of larger sand pockets in the morainic clay close to the deposition, and 12 m south of the deposition site, a well pit from LBA IV has been excavated. There are thus indications that the find may have been associated with water flowing out. However, as traces of a workshop site from the LBA have also been excavated, the hoard find may just as likely have been associated with this.

Besides these new finds a large number of Bronze Age depositions have been found near one of the sources of the Vindinge Å system in the Mariesminde bog area. The river runs close to the cooking

Figure 5. The best preserved of the two hanging vessels from Mensalgård. The maximum diameter is 14 cm. The surface of the hanging vessel is decorated with a punched dot running dog motif (Photo: Rógvi N. Johansen, Moesgaard Museum).

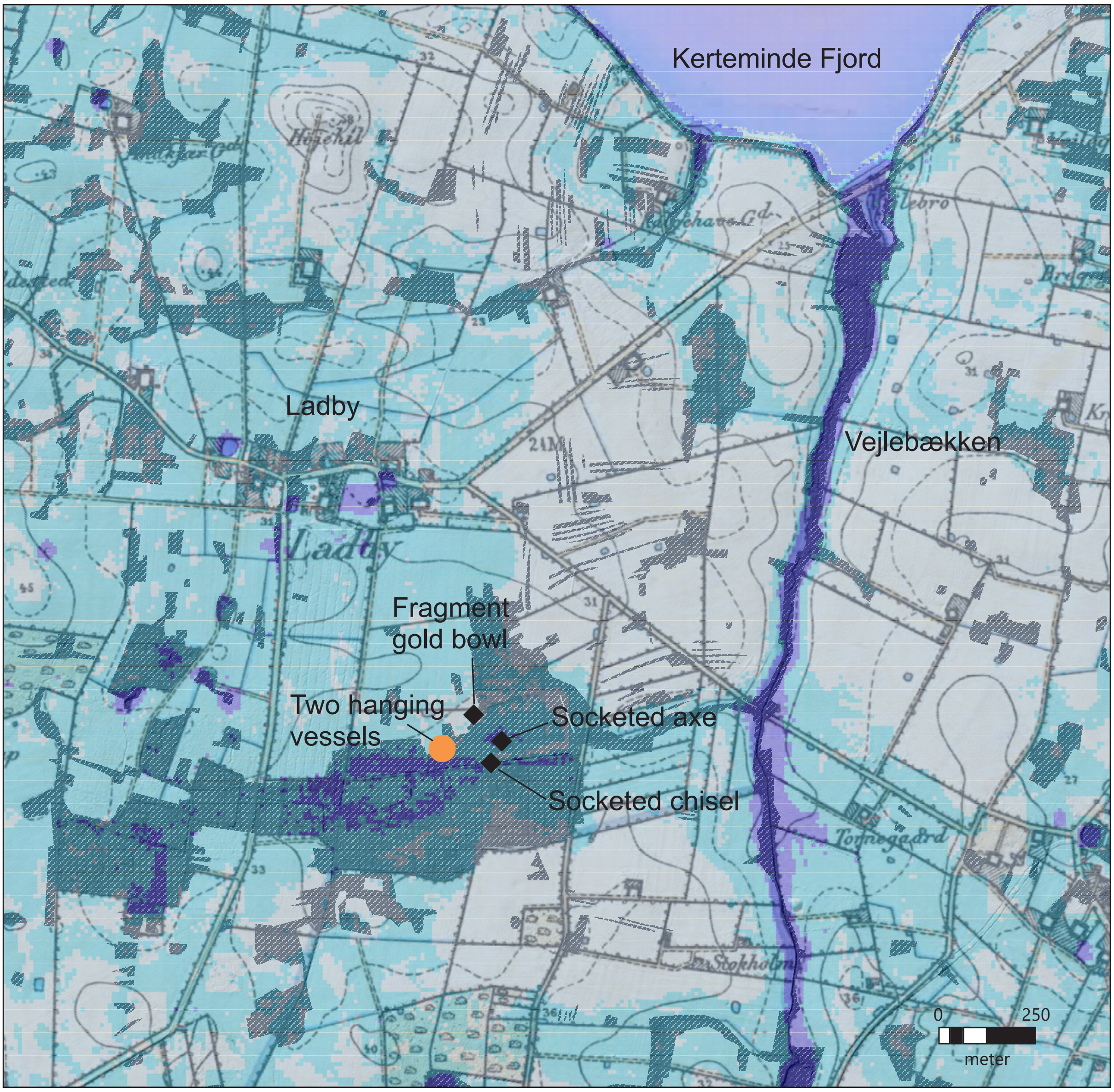

Figure 6. Distribution map of finds in the Mensalgård area. Base map involves Høje målebordsblade (1842-99), digitised wet meadows from the First Cadastral map marked with hatching, and present day summer groundwater level. Dark blue colour: groundwater 0-0.5 m below surface. Data from Styrelsen for Dataforsyning og Infrastruktur and Østfyns Museer (Graphics: Malene R. Beck).

pit area at Rønninge Søgård (Thrane 1974, 2009; Jensen 2011; Frost and Beck 2023a, fig.13), and flows around Nyborg and out into the Great Belt (Figure 7). A number of hoard finds from both the EBA and LBA are associated with the river, its tributaries and associated wetlands. Most of the finds are single finds of axes, which are distributed along the whole course of the river. In the lowest part of the river's course out towards the Great Belt coast, several sword finds have been made (Frost and Beck 2023a, Fig. 19), a situation often observed in a broader North European context (Fontijn 2012, 63). In the upper part of the Vindinge Å system and close to its different sources, however, greater numbers of arm and neck rings have been recorded (Frost and Beck 2023a, Fig. 9). It is uncertain whether different stretches of the river were associated with different meanings, but a number of researchers have pointed out that the changing nature of water in a watercourse may have been perceived as different characteristics (affordances such as slow running water, places where the water flows out, where one stream of water runs into another or where fresh water meets the sea), which also encouraged different approaches to which objects were selected for deposition (Fredengren 2011, 110).

Figure 7. Vindinge Å with offering finds and wetlands (dark grey) digitised from the First Cadastral Map. Early Bronze Age offering finds marked with green symbols. Per. I: dark green, Per. II: green, Per. III: light green. Late Bronze Age offering finds marked with yellow, orange and red symbols. Per. IV: yellow, Per. V: orange, Per. VI: red (Graphics: Malene R. Beck).

Even though both the EBA and LBA are represented amongst the hoard finds along the Vindinge Å, there is clear variation in terms of which areas were most actively or intensively utilised through the Bronze Age (Frost and Beck 2023a).

The find at Hedegyden is located in a landscape that is dominated by offering finds from the LBA. Along the course of the river, both to the west and east, however, depositions dating to the EBA are dominant. The chronological distribution may be the result of new landscapes being taken into use during the course of the LBA (Holst et. al 2013, 25; Kristiansen 2018, 128). In recent years, remains of settlements dating to the LBA have been excavated at several sites north of Vindinge Å. These include examples of sites with possible specialised functions in the form of metalworking.[6] The archaeological finds suggest that the northeastern part of Funen was quite densely populated in the LBA, both in the coastal areas and the central part of the island (Runge 2010, 91-102). Almost no traces of LBA settlements have so far been recorded in the landscape south of Vindinge Å. This could reflect modern circumstances rather than the actual prehistoric situation. The pollen analyses suggest that cultivated fields were located only a short distance away from the deposition site at Hedegyden, and that the landscape nearby was also used for grazing animals. The deposition was therefore made in a border zone, between areas that had obviously been affected by human activity and a largely undisturbed natural landscape. Based on the topography, it is tempting to assume that a contemporary settlement with associated fields was located between 250 and 500 m to the south of the deposition, on the higher terrain.

The find from Hedegyden can be added to a group of multi-type depositions dating to LBA V (900-700 BC) from northeast Funen. These include the hoards from Lindø (Thrane 1987), Kertinge, Tårup and Mensalgård, all of which contain hanging vessels combined with a number of other objects (Frost and Beck 2023a Cat. no. 19, 22-23, 60 and 262). Several of the finds are located near the coast and none more than a few kilometres from open sea. There are suitable natural harbours at both Holckenhavn/Nyborg Fjord and Kerteminde Fjord (Beck et. al 2021; Crumlin-Pedersen et al. 1996, 71, 81), which may have been the starting point for contacts across the Great Belt (Höckmann 2012, 68) or for networks via the Baltic Sea and further south. The natural conditions around the Helnæsbugt bay in south-west Funen, with its suitable natural harbours, perhaps have a parallel in northeast Funen. So far no high-status burials or settlements are known from north-east Funen which match the level of the Voldtofte area (Henriksen 2011, 2018, 2021; Thrane 1984, 1989).

Recent excavations of settlements, where remains of casting moulds have been found, show that there were specialised metal workers in north-east Funen and therefore perhaps also a foundation for production, trading networks and contacts at a high social level, which are reflected by the offering finds.

Chaîne opératoire for the depositional Act at Hedegyden

Based on the internal relationships between the ornaments and stratigraphy, as well as the analyses of the organic remains, a *chaîne opératoire* is proposed for the depositional act at Hedegyden (Figure 8, Table 1). The *chaîne opératoire* is based on concrete observations from Hedegyden, but also proposes sub-elements and activities, which can be found in or demonstrated by other finds.

Preparation

The ornaments were carefully packed together in a specific order and according to an overall idea in a bark bucket (Figure 8.1). Perhaps the container in which they were usually stored when not in use. A piece of honeycomb filled with honey was placed in one of the hanging vessels and three smelting lumps of copper alloy in another hanging vessel. A layer of straw was placed between each ornament. The straw suggests that this part of the deposition event occurred in a settlement area, within the context in which the ornaments were normally used, and where straw was probably easily accessible after cereals had been threshed. Alternatively, the straw may have been directly removed from the field close to the settlement. If the last scenario is correct, the deposition probably took place in late summer, although threshed straw may have been available during longer periods of the year.

This first part of the act of deposition event may have been a private occurrence, involving only a few people. But it is also possible that a larger group of individuals witnessed the ornaments being packed down as part of a ritual practice. The deposition could emphasise the status of specific people or families (Frost 2011, 39; Kaul 1998, 44; Leonard 2015, 2). More likely though the ornaments, which based on the use-wear traces already had a long life behind them, were imbued with specific meaning and qualities that made them suitable for deposition at this exact place in the landscape (Brück and Fontijn 2013, 205).

After the ornaments were carefully packed down into the bark bucket, they were carried from the settlement area to the chosen deposition site – the spring (Figure 8.2). Different stages and activities may have taken place along the way, or a procession of people could have followed the journey of the ornaments from the settlement to the deposition site at the spring and thus out into the more open and probably common meadows or grazing area (Henriksen 2014, 301; Kaul 2004, 55).

The excavation indicated that the spring was a clearly delimited sand pocket in subsoil otherwise consisting of moraine clay. It must therefore be assumed that clear water flowed up from the ground within a quite well-defined area, and then ran down towards the tributary of Vindinge Å.

The ornaments were not merely placed at the spring: a pit was instead dug down at the edge of the area where the water flowed out (Figure 8.3).

Deposition

First, a crushing stone was placed in the pit (Figure 8.4), perhaps as an initiation of the site before the actual deposition.

Following the crushing stone, the bucket containing the ornaments was placed in the pit, into which the spring water had probably already flowed (Figure 8.5). The preservation of wood and the patination of the bronze objects indicate that the objects were rapidly absorbed into a wet/oxygen-poor environment (Figure 8.6). The water was probably clear, and the objects were therefore visible, so that the bright bronze of the ornaments could reflect in the water and sunlight (Fredengren 2011, 117). The spring had been decorated and the participating actors had witnessed the event.

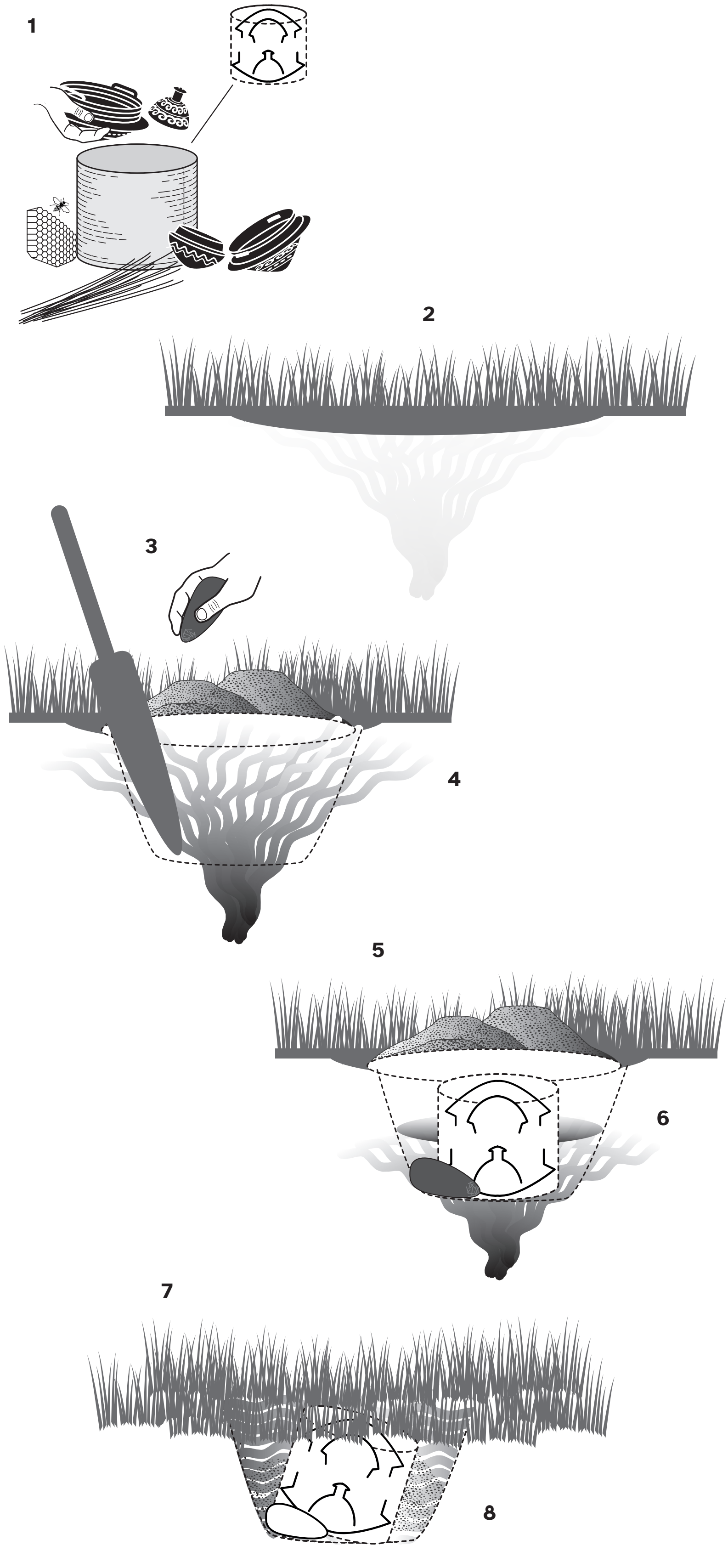

Figure 8. *Chaîne opératoire* of the deposit event at Hedegyden (Graphics: Louise Hilmar, Moesgaard Museum).

Post-deposition

After a few years, the pit became filled up with deposits from the spring and its surroundings (Figure 8.7). The water/landscape had encapsulated and accepted the deposition of ornaments, which were no longer visible, and perhaps only existed in the stories about the landscape and the memory of the sacrificial event. By digging a hole in the spring, the natural landscape was interacted with,

		Hedegyden	Overall idea and course of activity
Preparation	1	The ornaments are packed in a bark bucket in a specific order, with layers of straw between them. A piece of honeycomb containing honey is placed in the bottom hanging vessel.	Objects are selected, arranged and packed according to an adopted order and ritual.
	2	The offering package and crushing stone are carried down to the spring.	Procession with the objects to the chosen deposition site.
	3	A hole is dug into/at the spring.	Interaction with the landscape I. Intervention into the landscape. The deposition site is opened up.
Deposition	4	The crushing stone is laid down in the hole as an initiation.	Interaction with the landscape II. The deposition site is inaugurated.
	5	The bark bucket containing the ornaments is placed down in the hole, in which the water has begun to rise up.	Interaction with the landscape III. Deposition of the objects. Participants observe the site receiving the deposition.
Post-deposition	6	The ornaments are surrounded by spring water, which flows into the hole and fills it up. The ornaments are still visible for a period of time, perhaps several years.	The water/landscape accepts and surrounds the deposition.
	7	The hole becomes filled with deposits.	The water/landscape conceals and absorbs the deposition. The deposition is integrated into the landscape.
	8	The landscape is changed by the deposition.	The landscape is modified or humanised. The story of the deposition and its significance is handed down.

Table 1. *Chaîne opératoire* for the find at Hedegyden and depositions in general (Graphics: Louise Hilmar, Moesgaard Museum).

modified and humanised (Figure 8.8). The landscape was quite literally opened up and a mark was made by placing the crushing stone and then the hoard of ornaments into the water of the spring. The gift was possibly a humanisation of the spring (Fredengren 2018, 221, 234; Stevens 2008, 243), which perhaps ensured help and continued access to the life-giving water. The deposition could, however, also have been a way of making a (in)visible mark on an otherwise uncultivated landscape. For the participants and spectators attending the deposition act, the deposition added an extra dimension and meaning to the landscape. This knowledge and meaning could be handed down to future generations in stories and legends (Fredengren 2018, 232; Leonard 2015, 9) and also mark the right of to access and use of a landscape (Fontijn 2008).

Spring Offerings in a new Light

The new investigations in East Funen show that we need to adjust our perception of Bronze Age offering traditions in relation to spring offerings. A proportion of the many old wetland finds are undoubtedly associated with places in the landscape where water flows out, rather than simply depositions associated with water or wetlands in the broad sense (Frost and Beck 2023a, 2023b).

Today, the Hedegyden area consists of cultivated fields, and the character of the prehistoric landscape, in terms of wet and dry land, cannot be immediately deciphered. The metal detector find therefore highlights the important role played by archaeological and scientific investigations in understanding the character of the deposition site. Several new discoveries from East Funen emphasise that offerings in and around springs are probably an overlooked component of the deposition tradition during the Bronze Age. In the case of

Hedegyden, the interpretation from the excavation is supported by pollen analysis, which indicates that there was a meadow in the immediate surroundings. The same picture is also indicated by wet symbols on historical map material. Four ^{14}C dates, together with the typology of the objects, suggest that the deposition was probably made in late LBA V. The NPP analyses indicated that bees' hair was present, suggesting that honey or beeswax were included in the deposition. There is a marked tendency to focus on the metal objects when hoard finds are analysed. The Hedegyden find emphasises that the depositions not only consisted of ornaments, tools and weapons, but also organic materials, which were included in and were probably just as important to the rituals associated with the deposition (Matthews 2008, 106) as the antiquities that were less susceptible to decomposition.

The deposition itself, what happened before and what followed can be placed into a *chaîne opératoire*. This schematisation of the act provides detailed insight into the offering event itself. The find is significant in a local context along Vindinge Å, as well as in a regional context, emphasising the importance of the East Funen area. In terms of landscape and organisation, the deposition at Hedegyden also makes a valuable contribution to our knowledge about the Bronze Age communities' use of the landscapes located in border areas or completely outside settlements and fields.

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Declaration of Interests

No conflicts of interest are known by the authors in relation to the material addressed in this article.

Notes

1 The finding place is registered in the Danish Sites and Monuments database no. 090609-18. It has journal no. ØFM 1090 and the original documentation from the excavation is stored with Østfyns Museer. The excavation of the block lift was undertaken by conservator Ida Hovmand, Bevaringscenter Fyn.
2 Analyses of botanical material undertaken by PhD Peter Hambro Mikkelsen, MOMU. Rapport FHM 4296/3292.
3 Analyses of botanical material undertaken by PhD Peter Hambro Mikkelsen, MOMU. FHM 4296/3292. Pollen analyses by PhD Renée Enevold, MOMU.
4 Pers. comm. Thomas Jørgensen, curator, Museum Nordsjælland.
5 Mensalgård, Sites and Monuments no. 080106-108, Holemose, Sites and Monuments no. 090616-88 excavation carried out with a grant from SLKS, and Ullerslev Nord Sites and Monuments no. 090616-85 excavation carried out with a grant from SLKS.
6 Sites and Monuments no. 090110-44 Anhof, no. 090601-106, Bakkely, no. 090616-92 and 93 Kertemindevej.

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Supplementary

Supplements see .pdf-attachment

Viking Age Windows

A reassessment of windowpane fragments based on chemical analysis (LA-ICP-MS) and their find contexts

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ABSTRACT

In the last 25 years a conspicuous amount of plane glass – windowpane fragments – has surfaced on archaeological sites from the Viking Age. These finds have not received scholarly attention as they are not recognised as a genuine prehistoric (*i.e.* pre-1050 Scandinavia) occurrence. This paper aims to investigate a select group of archaeological localities that all have a significant amount of glass objects and fragments, and which also serve as mainstays for continental influences, commercial trade, as well as ritual activities. It offers the study of the chemical composition of these windowpane fragments, their distribution, provenience, and discusses their potential use as windows in Viking Age Scandinavia. Based on the chemical composition of the analysed plane glass (via LA-ICP-MS) the paper argues, firstly, that the glass most likely should be dated to the 9th to 11th centuries; secondly, that there are two possible import paths of raw material with one recognized at the early emporia based on east Mediterranean types of glass, and another with a continental type of glass found at the aristocratic sites. Finally, the paper proposes that the windowpanes very likely could have been used in contemporary glassed windows placed in wooden buildings at these sites.

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The context of window glass in Scandinavia

Glass from windowpanes have not been regarded as genuine prehistoric objects (*i.e.* pre-1050 in Scandinavia), and have for that reason avoided the eye of the Viking Age researcher. Accordingly, the present paper aims to investigate a select group of archaeological localities that all have a significant amount of glass objects and fragments of plane glass, that is, windowpanes.

The sites of the present study (Haithabu, Germany; Birka and Uppåkra, Sweden; Sorte Muld, Tissø, and Strøby Toftegård, Denmark) all have a significant biographical 'depth' where the use-phase of the sites span several centuries, in some cases perhaps even a millennium (Figure 1). The sites at Tissø, Strøby Toftegård, Sorte Muld, and Uppåkra are all characterized by a significant number of high-status objects found in the central areas that are also dominated by monumental architecture (Adamsen et al. 2008; Beck 2017; Harrison 2022; Jørgensen 2002, 2005, 2009, 2010, 2014; Jørgensen et al. 2014; Lenntorp and Hårdh 2009; Larsson and Lenntorp 2004; Roslund 2021; Tornbjerg 1998a, 1998b, 2000; Watt 2011). In general, they have an archaic appearance to them with large wooden hall-buildings placed prominently and centrally at each of the sites. Several large silver or even gold deposits can be found in their vicinity, and in general, they have a more ritualistic find material in combination with imported objects and large productions areas. These include gold foil figurines, weapons, and riding equipment, together with a very high frequency of imported goods urging them to be interpreted as commercial, political, and religious centers. They are characterized by an almost chaotic palimpsest of surrounding settlements with numerous pit-houses and smaller post-built buildings, and often with clear evidence of local production. Despite their

Figure 1. Map of southern Scandinavia and sites (Graphic: M.D. Jessen, National Museum of Denmark).

century-long use-phase and pronounced size and wealth, they are all curiously 'silent' in the historical sources – we have no contemporary written record mentioning any of them.

The early *emporia* of Haithabu and Birka (together with the early town of Ribe, western Jutland, Denmark) were among the most important Viking Age trading centers in southern Scandinavia (Ambrosiani 1995; Arbman 1939; von Carnap-Bornheim and Hilberg 2007; Hedenstierna-Jonson 2012; Hilberg 2009, 2020, 2022; Kalmring 2020). The former is situated near the modern German city of Schleswig, at the head of a narrow, navigable fjord known as the Schlei, which provided seafarers with a connection to the Baltic Sea and land-based travel to the Continent. The latter is located on the small island of Björkö in Lake Mälaren, 30 kilometers west of Stockholm, Sweden, where it attracted traders and craftsmen from a large area and formed a link to the Baltic areas, the Russian rivers, and large trade hubs such as Staraja Ladoga and Novgorod. As such, these sites appear as easily accessible multicultural hot-spots for trade and knowledge-sharing, not least for the continental Christian mission targeting exactly these sites.

The analyzed material

During the excavations of the aristocratic residence at Tissø, together with fragments of continental drinking glasses, glass beads, and bead-making waste, five fragments of window glass were found. Fragments of windowpanes have also been recovered at several of the other pre-Christian cult sites. More than 20 pieces of window glass have been found at Sorte Muld on Bornholm. During the excavations at Uppåkra three fragments of window glass were retrieved, and four fragments have been registered from Strøby Toftegård.

At Viking Age Haithabu 15 brown and 10 light green pieces of window glass were found during the excavations in the 1990s (Stepphun 1998), as well as a larger number of unpublished examples from previous excavations (Figure 2). At Birka, 81 fragments of window glass have been recorded, many of which were found during the excavations of the harbour area (Danielsson 1973). From Björn Ambrosiani's excavation at Birka (1990-1998) more than 200 fragments of windowpanes were found. A large part of these was found outside the gable of a wooden building from phase 7 and later (*i.e.* of the 10th century, see Gaut 2011, 227), and small fragments of window glass have also been found in three graves at Birka, which led Arbman to suggest that these may have functioned as amulets (Arbman 1937, 35, grave Bj 124, Bj 348, and Bj 557).[1]

Importantly, very abrupt endings characterise these localities, wherefore finds from the early medieval period (post-1050) are excessively rare, and a distinct decrease in activities beginning in the first decades of the second millennium is easily recognised. Accordingly, the settlements are best described as disbanded before 1050 (Ambrosiani 1995; Brandt, Müller-Wille and Radke 2002; Jørgensen 2009, 2014; Lenntorp and Hårdh 2009; Larsson and Lenntorp 2004; Tornbjerg 2000; Watt 2011). For that reason, the finding of several fragments of plane glass becomes conspicuous because the traditional threshold for the introduction of more regular glassed windows has been set in connection with the main wave of building of the Danish rural parish churches from around 1100 (Johannsen 1982).

So, what are these glass fragments doing on sites earlier than the assumed introduction of windows? One possibility is the contamination of later debris whereof glass could form part, but as mentioned very little in the find material indicates any kind of later influx nor primary activities taking place after 1050. The use of glass as raw material is also possible, for example for the production of beads as can be seen at Haithabu and Birka, but the more classical settlement sites (*i.e.* Tissø, Strøby Toftegård, Sorte Muld, and partly Uppåkra) only show very limited evidence for the local reuse of glass.

Another route to follow is the possibility that in the Viking Age (or even earlier) the find-rich sites here investigated already saw the use of glassed windows. Taking into consideration that these sites have a significant amount of imported goods (measured in the hundreds) from the Continent or of insular provenience, where glassed windows were a regular occurrence, why would the concept of placing glass in windows not have reached southern Scandinavian's aristocratic sites as well? Not least the spectacular and ritualized hall-buildings found on the aristocratic sites already characterized by extraordinary and exotic architectural features seem obvious candidates for the implementation of windows, and here represented by Strøby Toftegård, Uppåkra, Sorte Muld, and Tissø (Figure 3). We already know that special care was taken to have these large, monumental buildings appear unique, such as whitewashing the daubed walls (Bican 2018; Holst and Henriksen 2015) or occupying prominent positions in the landscape providing them with important signal value and making them visible from a considerable distance

Figure 2. Fragments of windowpanes from Haithabu (Illustration: C.S. Andersen, Moesgaard Museum/Museum für Archäologie Schloss Gottorf) M: 2:1.

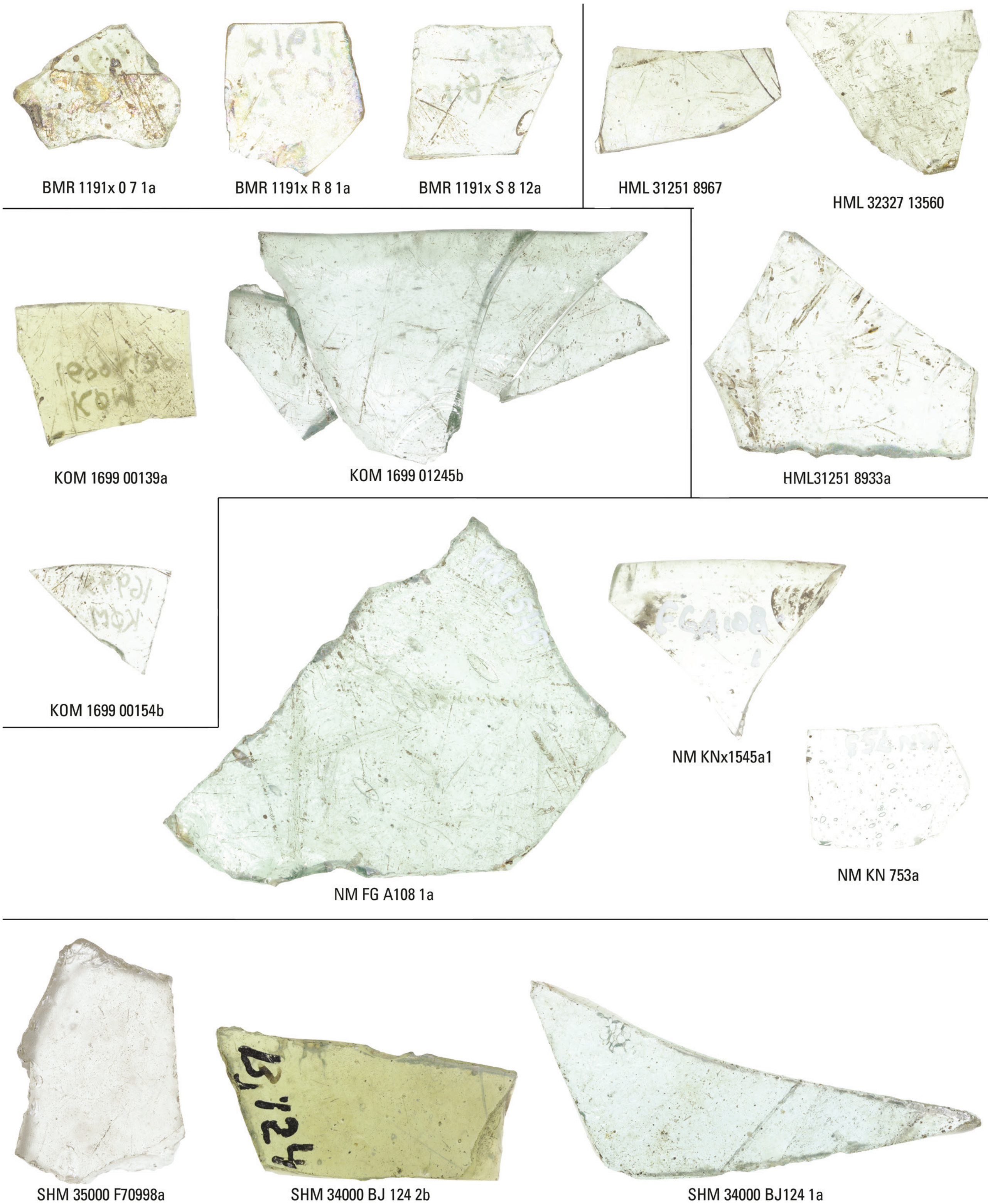

Figure 3. Examples of windowpanes from all the remaining sampled sites. BMR = Sorte Muld; HML = Uppåkra; KOM = Strøby Toftegård; NM = Tissø; SHM = Birka (Illustration: C.S. Andersen, Moesgaard Museum/T. Sode) M: 2:1.

Glass-groups/ sites	**Number of samples**	**Recycled or reused natron glass**				**Wood-ash glass**	**Woodash lime glass**		
Glass-sub-groups	62	Egypt 2	Foy 2 (Egypt)	3.2 (Egypt)	Le-vant		High CaO/ K_2O ratio	Low CaO/ K_2O ratio, negative corre-lation K-Na	Low CaO/ K_2O ratio, positive corre-lation K-Na
Haithabu (Germany)	31					30	1		
Birka (Sweden)	9	4		1	1	2		1	
Uppåkra (Sweden)	3							1	2
Sorte Muld (Denmark)	3						1	2	
Tissø (Denmark)	11		5				2	3	1
Strøby Toftegård (Denmark)	4						1		3

Table 1. Sites, numbers of samples, and distribution of types of glass.

(Jessen 2011; Jessen and Terkildsen 2016). Would glass windows in these exceptional building not be a worthwhile consideration?

To better understand the characteristics of the rather numerous finds of fragments of window-panes, the assemblages were compared and analysed at a chemical level – an analysis that potentially would reveal the place of production, the function of the glass, and to a large extent also the dating of the glass.

Analysis and method

All the glass fragments were analysed at the French research laboratory Centre Ernest-Babelon, Institut de Recherche sur les Archéomatériaux, CNRS/ University of Orléans, France.

Analysed corpus

A total of 61 fragments of window glass were analysed, originating from six different sites and dated between the 9th and 11th centuries (see below), in Germany (Haithabu), Sweden (Birka and Uppåkra), and Denmark (Tissø, Sorte Muld, and Strøby Toftegård). The sample corpus was chosen on the basis of accessible glass fragments in combination with a wish to cover both the large aristocratic sites as well as the early emporium-type settlements (see Table 1). An initial visual evaluation of the fragments was carried out by T. Sode in order to select fragments suitable for chemical analysis. Except for Birka and Sorte Muld, the analysis covered the totality of available window glass from the included sites.

Analytical method

The analyses of the window glass were carried out by Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS). The instrumentation consisted of a Resolution M50E UV laser probe from Resonetics/ASI (Excimer ArF laser working at 193 nm equipped with the S155 cell) coupled with a Thermo Fisher Scientific ELEMENT XR mass spectrometer (Gratuze 2016). LA-ICP-MS allows a nearly non-destructive analysis, invisible to the naked eye, of the glass objects. Analytical parameters were as follows: the excimer laser was operated at 5.5 mJ with a repetition rate of 10 Hz, ablation time was set to 50 seconds: 20 seconds pre-ablation, so that contamination could be removed, and 30 seconds collection time corresponding to 9 mass scans from lithium to uranium. The signal was measured in counts/second, in a low-resolution mode for 58 different isotopes. These 58 elements include all major, minor (except sulphur), and trace elements which are usually present in glass samples (Gratuze 2016). Blanks were run periodically between a series of 20 samples. Spot sizes were set to 100 µm (although reduced down to 70 µm when saturation occurred for an element such as manganese). During analysis live counts were continuously observed: when element spikes signifying the presence of inclusions were observed, results were discarded, and a new area was selected. From one to three areas were analysed per sample; homogeneity and agreement between runs were consistently good.

Calibration was performed using five reference glass-standards: NIST610, Corning B, C, and D, and APL1 (an in-house reference glass used for chlorine determination), which were run periodically (every 15 to 20 samples) to correct for eventual drifts. The standards are used to calculate the response coefficient (k) of each element. The measured values were normalised against ^{28}Si, the internal standard. Concentrations are calculated assuming that the sum of the concentrations of the measured elements is equal to 100 weight percent. For the major and minor elements, accuracy and precision were within 5 % relative and within 10 % for most trace elements.

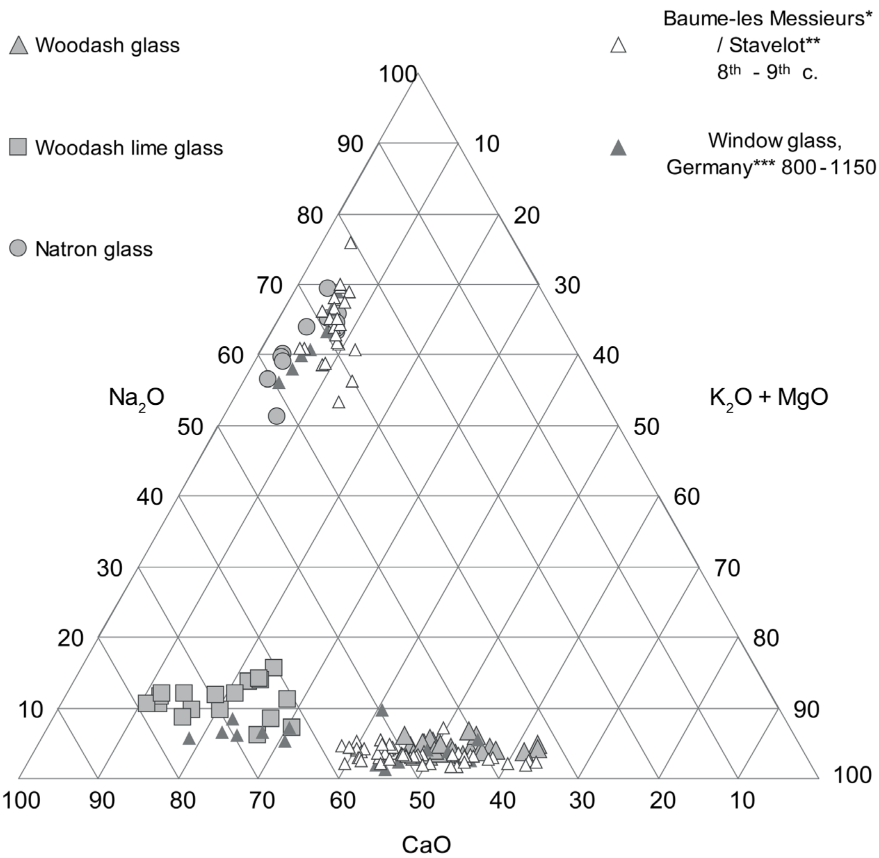

Table 2. The distribution of principal fluxes constituents shows three clusters.

Results

According to the principal constituents brought by the fluxes (Na_2O, MgO, K_2O, P_2O_5, and CaO), the results obtained enable the classification of the 61 analysed window glass fragments into three main compositional groups (Table 2).

The first group consists of 11 glasses made with natron. Five of these originate from Tissø (Denmark) and the six others from Birka (Sweden). The characteristics of the glasses from both sites appear different.

The second group contains 32 glasses made with woodash, containing similar amounts of lime and potash ($0.71 < CaO/K_2O < 1.69$). It consists of 30 of the 31 Haithabu glasses and 2 Birka glasses. This group will be further referred to as the woodash glass group (Table 3).

The third and last group consists of the 18 remaining glasses, made with woodash containing more lime than potash ($3.25 < CaO/K_2O < 20.7$). We find in this group 1 Haithabu glass, 1 Birka glass, 3 Uppåkra glass, 6 Tissø glass, 3 Sorte Muld glass, and 4 glass from Strøby Toftegård. According to the value of their CaO/K_2O ratio, the glass of this group can be further subdivided into two main subgroups. On one side 13 glasses with $CaO/K_2O < 11.7$ and on the other side 5 glasses with $CaO/K_2O > 15.8$. These 18 window glass fragments will be further referred to as the wood-ash-lime glass group.

The natron glasses

All glass from this group is soda-lime glass ($13.1 < \%\ Na_2O < 18.1$ and $6.9 < \%\ CaO < 9.5$) characterized by low contents of magnesia (MgO < 0.92 %), potash (K_2O < 1.22 %) and phosphorus pentoxide (P_2O_5 < 0.19 %). They share all the characteristics of Near Eastern glasses (Egypt and Levant) produced after the 5th century (Ceglia et al. 2015; Cholakova et al. 2016; Foy et al. 2003; Freestone et al. 2018). Window glass of this composition has also been found at Baume-les-Messieurs in France (van Wersch et al. 2016), at Stavelot in Belgium (van Wersch et al. 2014), and Corvey in Germany (Wedepohl 1997, 2000, 2001; Wedepohl et al. 2010).

At Tissø, according to their contents in metallic elements (Table 4), such as copper ($0.12 < \%\ CuO < 0.18$), tin ($0.03 < \%\ SnO_2 < 0.08$), and lead

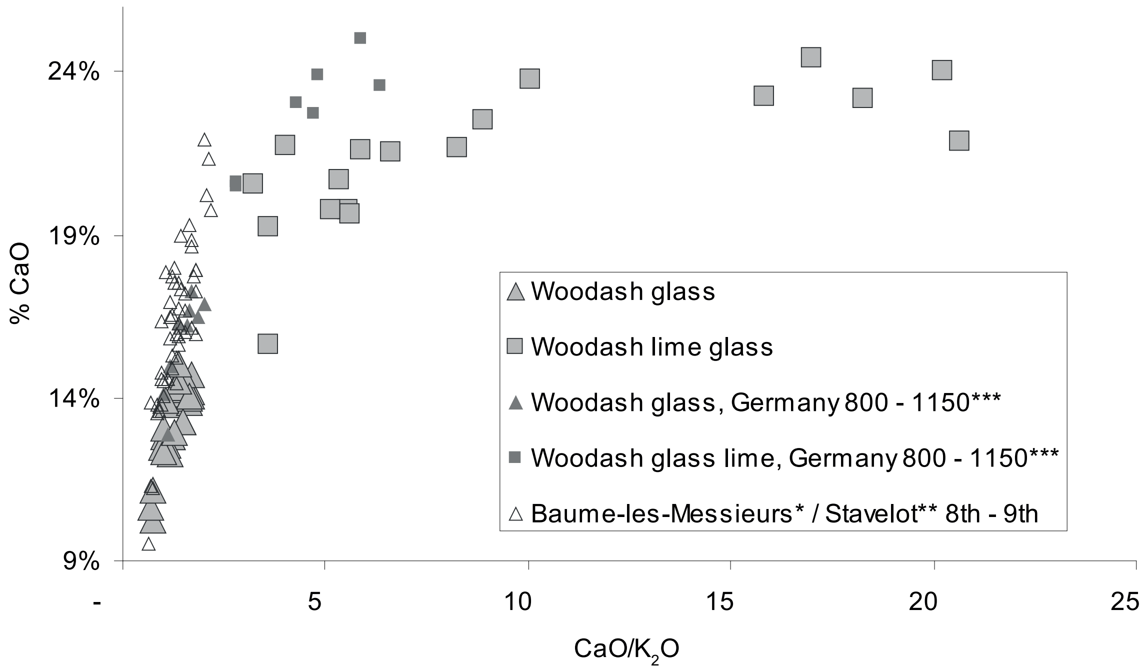

Table 3. CaO/K_2O ratio of sampled glass.

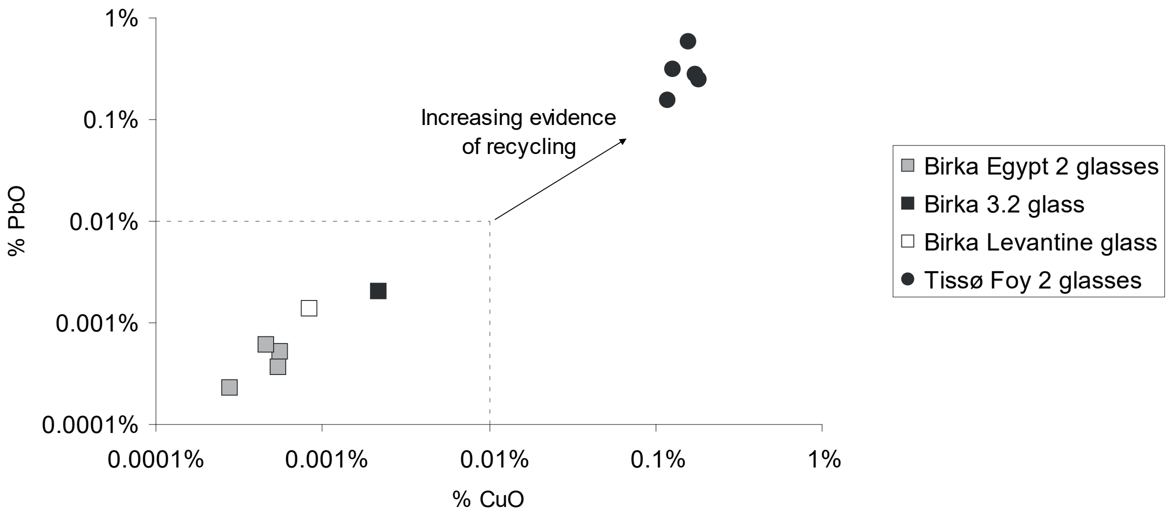

Table 4. Metallic elements in the Tissø and Birka samples.

(0.15 < % PbO < 0.59), the five natron glasses can be classified as highly recycled glasses. They contain also high contents of manganese (0.59 < % MnO < 0.86), antimony (0.17 < % Sb_2O_3 < 0.25), titanium (0.12 < % TiO_2 < 0.13), and zirconium (99 < ppm ZrO_2 < 104), which is characteristic of the Egyptian Foy 2 glass group produced during the 5th and 6th century (Foy et al. 2003; Schibille et al. 2016).

At Birka four of the six glasses belong to the Egypt 2 glass group (Schibille et al. 2019). Their soda contents suggest that two of them (Na_2O > 15.2 %) may have been produced before 815 and the two other pieces (Na_2O < 14.3 %) after this date. None of these glasses show evidence of recycling. Among the two last glass fragments from Birka, we have one Egyptian glass belonging to the group Foy 3.2 (produced mainly in the 5th century) and one later Levantine glass (Foy et al. 2003; Rosenow and Rehren 2018; Schibille et al. 2016). Here again, there is no evidence of recycling in these glasses.

The woodash glasses

This large group of glass is probably the most frequently encountered among window glass dated between the end of the 8th century and the 12th century. Glass of this composition has been identified at Baume-les-Messieurs in France (van Wersch et al. 2016), at Stavelot in Belgium (van Wersch et al. 2014), and several German sites: Paderborn, Höxter, Corvey, Drudewenshusen, Brunshausen, and Lorsch (Wedepohl 1997, 2000, 2001; Wedepohl et al. 2010). Currently, no subgroup correlated with chronology or provenance can be identified in this large group which shows, however, an important variability for most of its minor oxide components (Table 5). All these glasses were most probably produced in northwestern European glass workshops from the end of the 8th century and after.

The woodash-lime glasses

Probably, glasses from this group originate from northern Europe too, albeit from a different geographical area than those of the previous woodash glass group. The main difference between the two groups lies in their CaO/K_2O ratios, in the contents of some components of the fluxing agent, and in some trace elements (Table 5). Woodash-lime glasses contain two and a half times more soda than woodash glasses. As shown by Wedepohl, woodash-lime glass requires a higher amount of soda because its low potassium concentration needs to be supplemented by the addition of sodium chloride (Gerth et al. 1998). For the period in question, one could also hypothesize that soda was mixed into the glass batch by adding a natron glass

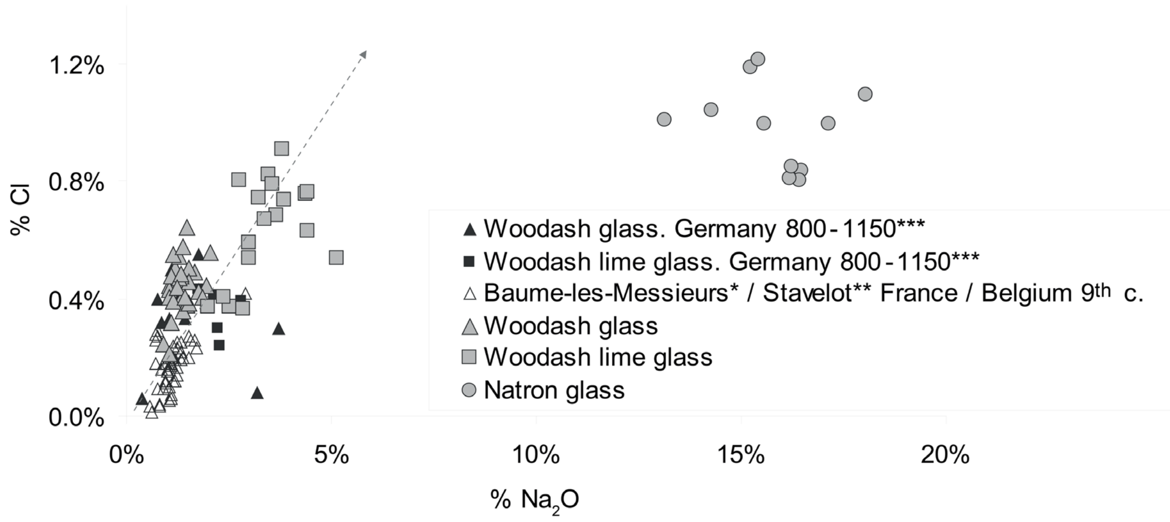

Table 5. Sodium oxide and chlorine content.

cullet. However, if we plot the contents of sodium oxide and chlorine for natron, woodash, and woodash-lime glasses, it appears that the chlorine contents of the two latter are too high to be correlated with the average chlorine content of natron glass.

It seems therefore that glassworkers were probably adding sodium chloride directly to their glass batch for both woodash and woodash-lime glasses. Woodash-lime glasses also contain more alumina and less magnesia than woodash glasses.

As mentioned above, this glass group is more heterogeneous than the woodash glass group. Five of these glasses have high CaO/K_2O (> 15.8) ratios while the 13 others have lower CaO/K_2O ratios (< 11.7), which are in the same range as those determined by Wedepohl on German window glass. The distribution of these 13 glasses as a function of their soda and potash contents shows two different trends.

Firstly, soda and potash are negatively correlated, soda contents increase while potash contents decrease. Secondly, both types of oxides are positively correlated and increase together. We can thus distinguish three subgroups which contain respectively:

Five finds from Haithabu (1), Tissø (2), Sorte Muld (1), and Strøby Toftegård (1) have high CaO/K_2O ratios (> 15.8).

Six finds from Birka (1), Uppåkra (1), Tissø (2), and Sorte Muld (2) have low CaO/K_2O ratios (< 11.7) and negatively correlated potash and soda contents.

Seven finds from Uppåkra (2), Tissø (2), and Strøby Toftegård (3) have low CaO/K_2O (< 11.7) ratios and positively correlated potash and soda contents.

We observe that window glass from these different subgroups is not characteristic of a particular archaeological site but is unevenly distributed among the different sites. It, therefore, seems more likely that these different types of glass were produced and used during the same period rather than successively at different times. They most probably characterise the variability of the composition of woodash glasses produced during the same period, rather than an evolution of their compositions over time. This hypothesis is reinforced by the presence at Tissø and Sorte Muld of three glass smoothers with compositions very similar to those of the window glass of this group (Figure 4). These three smoothers have low CaO/K_2O ratios and have negatively correlated potash and soda contents for two of them (Tissø NM KN 728 and Sorte Muld 1191X40) and positively correlated potash and soda contents for the last one (Tissø NM KN 1394). The association of these types of glass, within the different studied sites, could also suggest the existence, during this

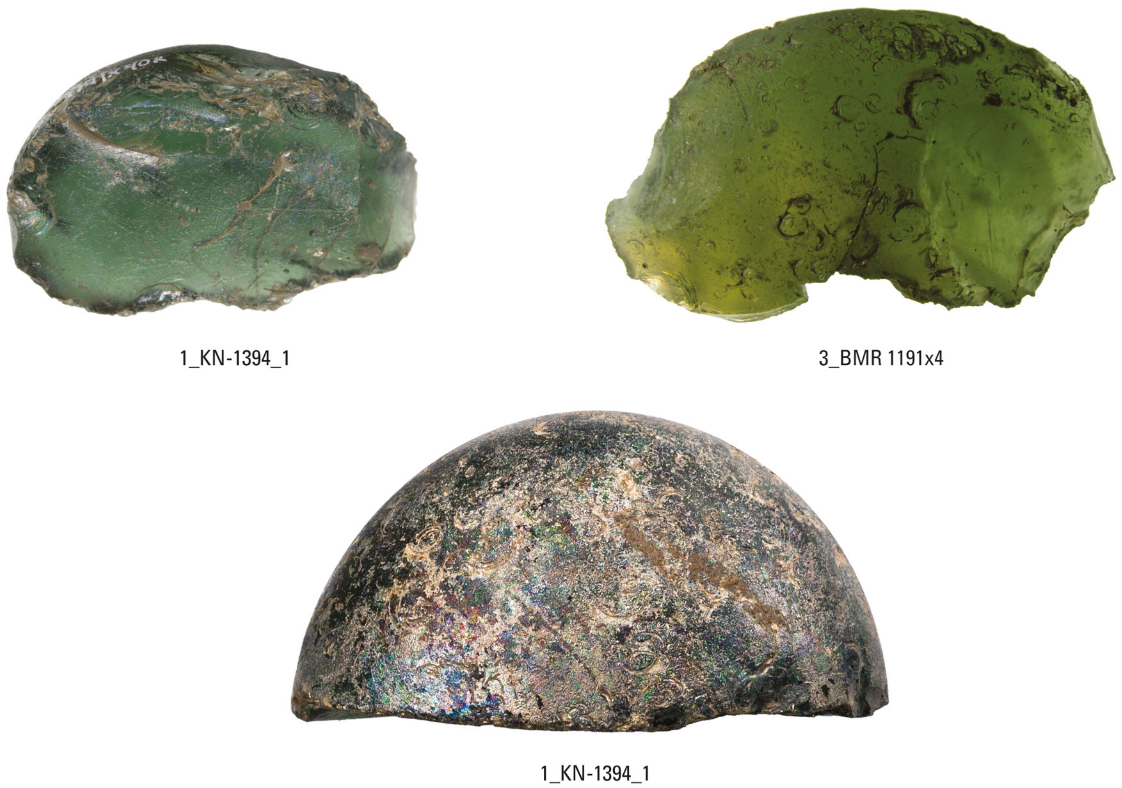

Figure 4. Fragments of glass smoothers from Tissø and Sorte Muld (Illustration: C.S. Andersen, Moesgaard Museum/ M.D. Jessen and T. Sode) M: 1:1.

period, of a single and relatively centralised production and supply system for window glass and glass smoothers. This may also reflect the relative contemporaneity of the finds from these sites.

Comparison with contemporary European early medieval window glass

According to Wedepohl, the production of wood-based plant-ash glass in northwestern Europe can be divided into three main phases (Wedepohl 1997, 2000, 2007).

From 800 to 1000-1050, using window glass and vessels originating from Paderborn, Höxter, Corvey, Drudewenshusen, Brunshausen, and Lorsch, he defined a group named early woodash glass. It contains potash lime glass, with a highly variable proportion of lime and potash, their CaO/K_2O ratios varying between 1.0 and 6.4. These glasses could be defined as the precursor of future woodash and woodash-lime glass. On most of the Carolingian and post-Carolingian sites, these early woodash glasses are found associated with recycled Near-Eastern natron glasses (either of Roman, early medieval, or Islamic origin).

Then, between 1000 and 1400, using glasses originating from the German monasteries and towns of Corvey, Höxter, Brunshausen-Gandersheim, and the glassworks of Steimcke in the Bramwald Mountains, he defined another group of woodash glass. These glasses are all potash-lime glasses containing analogous amounts of lime and potash. Their CaO/K_2O ratios vary between 0.5 and 1.6, thus indicating a more controlled and skilful mode of production.

The last phase began around 1300. For Wedepohl, who mainly defines woodash lime glass based on vessel fragments from Höxter (1370 to 1500) and the Eichsfeld glassworks (1400 to 1600), the 14th century is the period when the manufacturing processes for woodash lime glass were finalised and standardised. This glass also known as HLLA glass, for High Lime Low Alkali, contains a large amount of lime (CaO > 20 %) and has high

CaO/K_2O ratios (from 1.6 to 8.0 with an average value between 4.0 and 5.0). Studies on architectural glass show that from the 14th century onwards, it was the main type of glass used for stained glass and windowpanes (Schalm et al. 2005, 2007).

However, in our studied corpus, some of the woodash-lime glasses from Denmark (Tissø 3 and Sorte Muld 2) and Sweden (Birka 1 and Uppåkra 1) are fairly similar to both the early woodash glasses analysed by Wedepohl (Table 6) and to some woodash-lime glass smoothers, while others show different characteristics: either higher CaO/K_2O ratios or positively correlated soda and potash contents. According to literature values, all the woodash-lime or HLLA glasses produced from 1300 have a CaO/K_2O-ratio lower than 8 (Schalm et al. 2005, 2007; Wedepohl 1997). Thus, most of the glasses analysed here do not correspond to the strict definition of HLLA glasses, their characteristics (composition and CaO/K_2O ratio) seem to correspond rather to the early woodash glass defined by Wedepohl (Wedepohl 1997). The presence of recycled or reused natron glasses, at Tissø and Birka, reinforces this hypothesis. It is thus highly probable that these windowpanes were used between the beginning of the 9th and the end of the 11th centuries.

At Birka (Sweden), all the early woodash-lime glasses are found associated with Egypt 2 natron glasses and woodash glasses, similar to those found at Haithabu (Germany). At the Danish sites (Tissø, Sorte Muld, Strøby Toftegård) and at Uppåkra (Sweden), the early woodash-lime glasses are similar to those found at Birka and Haithabu. At Tissø (Denmark), the woodash-lime glasses are also found associated with highly recycled Foy 2 natron glass.

Foy 2 natron glasses were produced in Egypt between the 5th and 6th centuries but are continuously found in large amounts in western Europe until the 11th century (Foy et al. 2003). Egypt 2 natron glasses were probably produced in Egypt during the 9th century (Schibille et al. 2019). Although glasses from this group have spread outside Egypt to a lesser extent than the Foy 2 glasses, they are occasionally found in Europe until the 11th century.

Among our corpus, Haithabu and to a lesser extent Birka show a fairly distinct distribution of the glass types. In Haithabu we have a clear majority of woodash glass, while in Birka we find mainly reused natron glass and woodash glass. At the four other sites (Uppåkra, Sorte Muld, Tissø, Strøby Toftegård), we have a majority of woodash-lime glass which is associated with reused natron glass

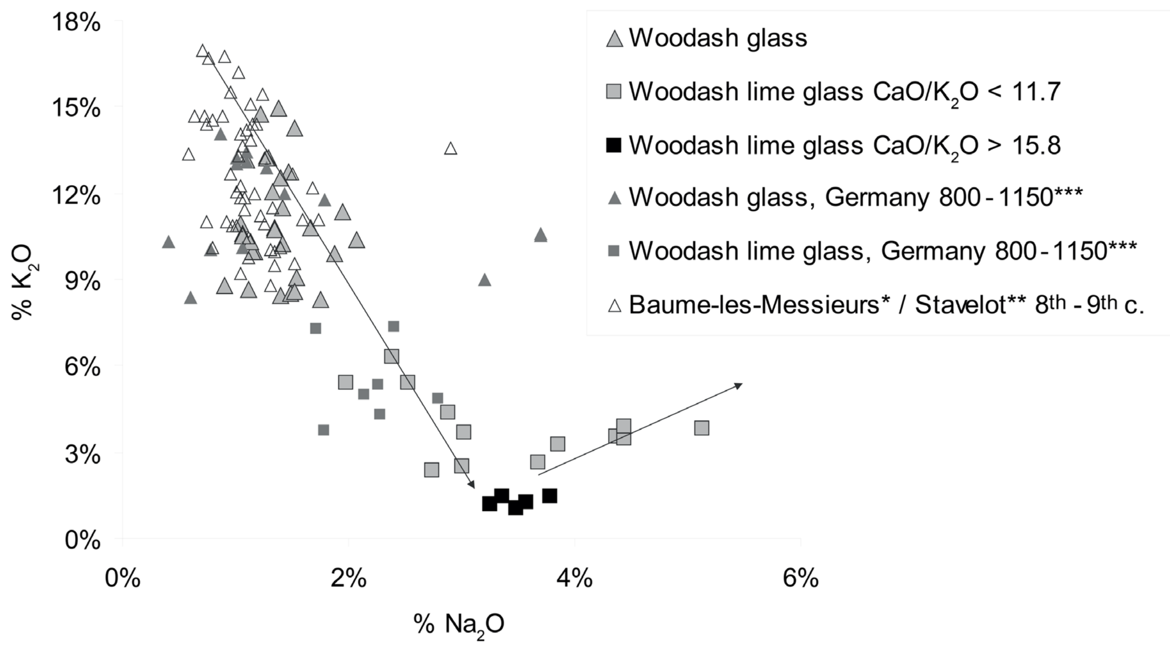

Table 6. Trends in distribution as a function of soda and potash contents.

at Tissø. The fact that the different types of woodash-lime glass are found randomly associated at these four last sites could suggest that they are more or less contemporary and that they could be associated with the same supply network, different from the one that supplied Haithabu and Birka. According to Wedepohl's chronology, it means that the woodash-lime glass fragments studied here were certainly produced before the 13th century and do not exclude that they may, based on his glass chronology, all belong to occupation phases dated between the 9th and the 11th centuries. However, we must also consider that the number of glasses analysed for each site is relatively small and probably only gives a partial picture of the potential variability of the compositions of the glasses used. In order to identify the production and distribution networks of windowpanes during that period, a more extensive study of Scandinavian glass finds should be carried out.

The identification of finds of window glass at pre-Christian cult sites in Scandinavia appears to be too numerous to be merely coincidental. It was previously assumed that the earliest window glass in Scandinavia was used in the construction of churches during the Middle Ages. It was also thought that windows with glass panes did not become common in the buildings of the king and nobility until the Middle Ages. Even though windowpanes were not common, this does not necessarily mean that they were not used as early as in the elite residences of the Viking Age and pre-Christian temple buildings. Could the lack of windowpanes amongst pre-Christian finds in Scandinavia simply be a misinterpretation of finds of early plane glass because it was just presumed that this was window glass of a more recent date? It is therefore thought-provoking that fragments of window glass are found both at pre-Christian cult sites (where there was no intensive production of glass beads), as well as at the trading centres of the Viking Age as shown in the study, Haithabu and Birka, as well as Ribe (see Barfod et al. 2022 for a thorough analysis of both raw material and bead production processes at the Ribe glass workshops). Why are fragments of window glass found at the elite sites, long before it is thought that glass panes are archaeologically and historically represented? Why is window glass associated with the residences of magnates at Tissø, Strøby Toftegård, Uppåkra, and Sorte Muld, which are all located in areas where window glass was not previously regarded as having been utilised in buildings until modern times?

The evolution of windowpanes

From the beginning of the 1st century, glass panes were made in the Near East and at Roman glassworks in Europe. Early windows containing glass are known from excavations in Rome, and at Pompeii and Herculaneum, where they are, for instance, found in public buildings, upper-class homes, greenhouses, and thermae. There are also several early Roman buildings with glass windows in Switzerland, France, Germany, and Britain (Balcon et al. 2009; Foy 2005; Harden 1961; Whitehouse 2001). The glass panes were mounted in window frames of wood or metal, which in some cases could be opened to ventilate the buildings.

The earliest window glass in Europe could have been made by placing the red-hot, malleable glass onto a flat, polished marble slab. After this, the glass could be shaped and pulled with various types of tongs and tools of iron; tool marks can often be seen in the corners and along the edges of these so-called cast, square pieces of window glass. These glass panes are always smooth on the top side, and matte and uneven on the back.

In the middle of the 1st century at the latest, Roman glass workshops began to produce window glass using the cylinder method (see also Foy 2005). In this technique, the glassmakers began by blowing a large glass cylinder, which was subsequently cut up and folded out on a tabletop – hence the name table glass. This produced a flat piece of glass, which was characterised by a straight, slightly rounded edge, and elongated, parallel blisters in the glass.

The cylinder glass was also matt and uneven on the side that was folded out onto the flat tabletop. Remains of glass panes made using the cylinder method have been recovered from excavations in Rome, Pompeii, and Herculaneum. In Europe, in both Antiquity and the Middle Ages, this was the most widely used method for making glass panes, and window glass made by using the cylinder method was common until the end of the 19th century. In the 1950s, the British archaeologist and glass specialist Donald B. Harden examined and analysed a large number of finds of Roman window glass from Britain, which were described as cast, although he proposed that they may have been made as cylinder glass (Harden 1961).

The third type of window glass, the crown glass, involved the production of round glass discs of variable diameter. This method apparently originated in the eastern Mediterranean during the 1st century, where small, flat, round glass panes measuring between 8 and 25 cm in diameter were made. These round glass panes were often mounted in pairs in cast plaster windows. Archaeological finds of crown glass dating at the latest from the 4th century have also been made in Italy, France, Germany, and Britain. However, it seems that it was not until coloured glass was produced for mosaic panes in church buildings, that window glass made by using the crown glass method became common in western Europe. During the Middle Ages, crown glass with a diameter of up to 1.5 m could be made. Crown glass is characterised by a curved, slightly thickened, rounded edge and concentric blisters and impurities in the glass itself. After cooling, the glass disc is divided into two halves – hence the nick-name half-moon glass. These halves were subsequently cut into smaller pieces, which were then fitted into the leaded windows. There was a thickening of the glass disc in the centre, where the glassmaker's puntel was placed. When the finished crown glass was knocked off the puntel, the puntel mark was left behind, which was popularly known as a bullseye. This bullseye was regarded as waste glass but was in historical times often used in round or oval door windows. Crown glass panes always have smooth and shiny surfaces on both sides (*idem,* see Foy 2005).

Illumination for God and for King

Glass windows are found in the earliest Christian churches dating from the beginning of the 4th century when, for instance, churches were built in Rome and Ravenna. In 540, Ravenna was conquered by the Eastern Roman emperor Justinian I (482-565) and direct relations with the Christian, Byzantine Empire lasted for several centuries; close cultural connections were also established, involving Eastern Roman glassmaking and architecture. During the reconstruction of the dome of the Hagia Sophia cathedral in Constantinople, which had collapsed due to an earthquake in 558, Emperor Justinian had a new dome constructed with 40 large glass windows. These windows were placed all around the base of the dome so that the sun's rays could be reflected off the golden glass mosaics inside the church (Trowbridge 1930).

Archaeological excavations of the Cathedral of Santa Maria Assunta on the island of Torcello, in the lagoon just north of Venice, uncovered a glass workshop dating to the 7th century, which produced both window glass and glass tesserae (Leciejewiez et al. 1977).

During investigations of the monastery of San Vincenzo al Volturno in Italy, several workshops associated with the monastery's private quarters were excavated, including glassworks with remains of glass furnaces, along with crucible fragments and production waste. The finds included green panes in various shades made by using the cylinder method and coloured panes of crown glass. A glazier's workshop for the preparation of window glass was also identified in the workshop areas. Here, H-shaped lead cames and cut-out blue panes were recovered, showing that leaded windows had been produced. The workshops operated during three phases, from the early 9th to the 11th century (Balzer 1999; Moreland 1985).

Early Roman windows have also been found, with the cut panes held together by various types of lead strips, but it seems that it is not until the 8th century that H-shaped lead cames started to be used in the assembly of glass mosaic windows. The use of H-shaped lead cames became common during the 9th century and examples are known from Italy, France, Germany, and Britain (Whitehouse 2001). At the abbey of Saint-Denis, north of Paris, limestone moulds for making H-shaped lead cames, dating to the Carolingian period, have been found (Balzer 1999).

In Britain, glass panes are present in both Roman and Anglo-Saxon buildings (West 1931). Archaeological excavations, however, indicate that window glass is only rarely found in the centuries after the collapse of the Western Roman Empire, and there is no evidence that glass windows were found in the buildings of Britain or northern Europe at this time. The earliest archaeological discoveries of glass furnaces from Anglo-Saxon England date to the late 7th century, when Bishop Benedict had a stone church and monastery erected in Wearmouth, in the Anglo-Saxon kingdom of Northumbria in northern England. Contemporary written sources indicate that in the year 675 Benedict had French glassmakers brought in to produce windows for the church, the cloister, and the monastery refectory (Harden 1961; Trowbridge 1930). In 688, the West Saxon king Ine established the abbey at Glastonbury. Here, the remains of four glass furnaces have been excavated, where window glass was produced using cylinder methods (Bayley 2000; Evison 2000; Willmott and Welham 2013).

During the archaeological excavations of the monastery at Fulda, which was established in 744, glass was found, which had been made by melting together Roman natron glass and European potash glass. Similar mixed glass was also retrieved at Lorsch Abbey from the Carolingian period, as well as at the Viking Age emporium of Haithabu (Kronz, Hilberg, Simon and Wedepohl 2015, 39 ff.). At some point in the 12th century, western European glassworks apparently stopped using natron glass.

The written sources and archaeological excavations both show that window glass is only rarely found in the period after the collapse of the Western Roman Empire. Even if there are glass windows present from 5-6th century France, there may have been a loss of technological knowledge (as was the case with the manufacture of cement and the construction of brick-built houses), and a decline in the need for glass windows caused by changes in building traditions. During the 8th century, however, there was a significant change in western European glass technology. Increased demand for window glass, especially for churches but likewise for large aristocratic buildings, apparently led to the development and production of potash glass in Europe, with potash in the form of woodash (potassium) used as a flux instead of natron (soda) (Wedepohl, Winkelmann and Hartmann 1997). Various types of early potash glass are known, depending on where in Europe they were made. This early potash glass was often very unstable. Most early church windows consist of varying light, greenish-coloured potash glass, where the colouration was caused by the iron oxide naturally present in the sand used for making the glass. Some coloured window glass was, however, made from melted-down Roman natron glass (van Wersch et al. 2014). The monk Theophilus Presbyter writes in *De Diversis Artibus* around 1100 how glass can be made from beech woodash, but also that blue window glass can be produced by melting down old Roman glass. In addition, he describes the making of stained-glass mosaic windows with lead cames (Theophilus 1979).

A similar development can be seen in the use of glassed windows in the aristocratic and royal palaces of the Continent. Particularly so for the early Carolingian representational *Aula Regia* that not only incorporated, mimicked, and developed ecclesiastical architecture but also were placed in close vicinity – as a sort of twin building – to the large basilicas and chapels of the Continental palaces. During the Carolingian period, these *pfalzen* more or less filled the same function and were almost all physical extensions of earlier Merovingian *villae*, thus continuing the traditions of both the Roman and Merovingian courts where kingly and churchly obligations were tightly interrelated (Wamers 2017, 150-152). In that sense, the house of God and the house of the King made use of very similar physical expression and symbolic architecture, and among these the use of glassed windows and coloured light figured prominently. The main *pfalz* of Charlemagne, found in Aachen, even has clear archaeological traces from local production of glass at the exact same location where the chapel and *Aula Regia* can be found (Giertz and Ristow 2013; Ristow 2016). Accordingly, since the same persons or families controlled both royal as well as ecclesiastical construction works, at least from the late 8th century onward the aristocratic seats of the Continent would have had access to and most likely used glassed windows in their palaces. A telling example of the coupling between aristocracy, technological knowledge and glass windows can be found in *The Lives of The Holy Abbots of Weremouth and Jarrow*, by the venerable Bede. He mentions that (sometime after 674) Bishop Benedict sent message to Gaul (*i.e.* the Merovingian kingdom) to fetch makers of glass so that they could help with the finishing touches of his church and "… they might glaze the windows of his church …" (Bede, chapter 5, after Giles 1910). This bears witness to the detailed knowledge about how to manufacture and use glass held by the continental craftsmen.

The situation in southern Scandinavia

In almost all excavations of the Danish parish churches, remains of window glass, which is often painted, have been found, and the conspicuous use of special light and windows can also be observed already in the earliest Danish church buildings (Hansen 1974, see also Melin 2022 for a thorough examination). Here, it is important to point out that this also applies to the wooden churches, and it is not a phenomenon that was only introduced with the stone buildings. The reused stave planks found in Framlev Church (*Danmarks Kirker*, Framlev Kirke) can, for example, be mentioned in this respect; here, window sections from an earlier stave-built structure were reused in the ensuing stone-built church.

Unfortunately, the wood could not be dated[2], but as the existing stone church was built around 1100, the plank must have belonged to a building from the later Viking Age or the very early Middle Ages – church or profane building. Grooves and tongues from the mortising into the wooden wall are still preserved on the best-preserved plank, and the plank has then been secondarily cut around the window section. Inside the window groove, small nails are still preserved, which held the window section in place, and was assembled with lead cames (Grinder-Hansen 2009; Koch 1898). The curved window opening measures *c.*85 x 35 cm, and the windows were therefore quite large; these could both provide a significant amount of light, and it would also have been possible to insert quite large and detailed sections with leaded glass panes. There is also a similar find from Dybe Church, a preserved stave plank (dendrochronologically dated to the last decade of the 11th century) with a cut-out rounded arch with grooves for holding the lead-framed glass window (*Danmarks Kirker,* Dybe Kirke). Importantly, this mounting technique, which can be observed on both the Framlev and Dybe planks, could very easily have been used in all types of timbered buildings and therefore may stretch way back in time.

At Lilleborg on Bornholm, which was a royal castle from around 1190 and is believed to have been destroyed in 1259, fragments of glass panes and glass mounted in H-shaped lead cames have been found, as is the case at other early royal Danish castles. This underlines the fact that also the earliest profane, stone-built structures in Scandinavia, such as Lilleborg, made use of the newest technology available for installing glassed windows. Obviously, exchange between building categories is inevitable and has been for millennia, and telling the individual parts apart is virtually impossible – not least with regard to (fragments of) windows (Qviström 2020, 247 ff.).

In a similar vein, the exchange (or inspiration) across borders is just as frequent a phenomenon. For example, the organisation of the buildings as it can be seen during the Fugledegård-phase at Tissø (*c.*800-1050), might quite well rest on the concept of Carolingian manorialism. Here, the large hall-building can perhaps be equated with the Carolingian *Aula Regia* mentioned above, whereas the small fenced-in area attached to the hall-building could be a mirroring of the chapel of the *pfalz*. In this way the two buildings would provide room for both representational as well as religious requirements. Encircling the central areas of both types of aristocratic settlements, several secondary buildings connected with production and everyday life can be seen (Jørgensen 2004, 245-247, fig. 7,9, and 16). Kings and magnates were especially important to the missionary activity of the Roman Church, and the presence of temples or cult buildings at the pre-Christian cult sites demonstrates that it was the elite of the society who were in charge of many of the religious activities.

From the historical sources, we know that Scandinavian royalty, and presumably also other persons from the top echelon of society, visited the Carolingian palaces (for example Harald Halfdansson Klak; Wamers 2017), and here they would have witnessed the large aulas with glassed windows. Imitating the structure of the Carolingian manor would quite possibly also include transferring specific architectural features of the aula, such as glassed windows.

Together with the obvious presence of woodash-lime windowglass at the pre-Christian cult sites, royal residences, and Viking Age trading centres, this could indicate that there were actual glass windows in prominent buildings as early as the Viking Age. Even if the exact contexts are lacking, the finds pattern is also interesting: Were glass panes perhaps used in the hall-buildings and temples of pre-Christian Scandinavia, like they were in contemporary Frankish and Anglo-Saxon palaces and churches?

The glass in the church windows was perceived as a special, magical material, which could let in the sunlight and illuminate the room, whilst also keeping the cold, wind, and rain out, whereas windows in aulas would underline the well-connected and exclusive character of the royalty residing there. This suggests that there possibly were one or more small windows with glass panes in the pagan cult buildings, like in the stave churches and the early stone churches in Jutland, just as the hall-buildings would be illuminated through glassed windows as were the aulas of the continental palaces.

Discussion

The strikingly large number of fragments of window glass from the pre-Christian cult sites, trading centres of the Viking Age and graves paint an interesting new picture. The finds of this early window glass seem too numerous to be merely coincidental and quite likely, in pre-Christian Scandinavia, windows with glass panes were already used in Viking Age magnate residences and cult houses in the same way as they were in contemporary Frankish and Anglo-Saxon palaces and churches.

An interesting question is why early northern European woodash-lime glass is found at the pre-Christian cult sites, trading centres and in graves from the Viking Age? Most of these sites are located where archaeologists would not expect to find remains of glass panes. Even though glassed windows were not common, this does not necessarily mean that they were not already used in the magnate residences and temples of the Viking Age. Several other archaeological finds show that the magnates and kings of southern Scandinavia were very much inspired and influenced by fine art and craftsmanship, from both the Frankish, Anglo-Saxon, and Byzantine areas. The present study shows that the notion that there are no glassed windows amongst pre-Christian finds is a result of archaeologists having been misled by their historically biased preconception. Consequently, it has wrongly been presumed that these must be window glass of a more recent date.

Other evidence suggests that glass was regarded as a magical material in the Iron Age and Viking Age. The Elder Edda tells of a magical glass sky (*glerhiminn*), and that stones, placed on an altar, would be turned into glass when they have the blood of sacrificial animals poured over them. In Old Norse literature, it is also stated that glass is a material onto which runes that have a magical effect can be carved (Nyrop 1879, 434). Therefore, it seems reasonable to agree with Arbman's interpretation of the window glass fragments from burials at Birka as amulets.

Veneration of the magical powers of glass can be identified at an earlier date in Scandinavia. It can, for example, be observed in late Roman Iron Age graves, in which small pieces of glass have been placed in the mouths of the deceased instead of a coin presumably intended to pay Charon when crossing the river Styx. This practice suggests that glass was thought to have special value and magical attributes (Boye 2002, 203 ff.). This is such a widespread phenomenon that glass fragments are the most common type of object recorded in the mouths of the deceased, and are more common than coins, which are found in the original version of this custom in continental graves (Dyhrfjeld-Johnsen 2009).

Moreover, glass occupies a special position at an early date in more tangible and use-orientated ways: Iron Age pottery with small fragments of glass inserted in the vessel, the so-called window vessels, also point towards a special and conspicuous use of glass (Oldenburger 2017a, 397-401). Experimental archaeology and the reconstruction of window vessels have clearly shown that these were not just objects for show, but such vessels with an inserted piece of glass would have been waterproof and could be used as drinking cups (Oldenburger 2017b). As such vessel types could function as drinking cups, they obviously were to be displayed and:

> many of the window vessels were of types presumably used for serving and drinking liquids during social gatherings. Therefore, they were meant to be seen and could be used to impress guests and visitors by showing that the owner was in possession of glass (Oldenburger 2017a, 401).

In South Scandinavia, the presumably high value of the glass probably also contributed to it being an especially sought-after commodity, which its owner could use to emphasise their own particularly privileged position. Glass is also found purely as a commodity in special contexts, and a piece of melted glass deposited in a posthole at Tietgenbyen, Funen, is an example of the secondary and deliberate ritual use of a glass fragment. This has been interpreted as a type of house offering upon the foundation of a building, which was erected at the transition between the Late Roman and the Early Germanic Iron Age (Lundø 2019).

Besides being used as adornment, glass can also be seen as part of personal equipment as far back as the Late Roman Iron Age. In the Illerup Ådal weapon deposits, glassbeads and even fragments of melted glass have been kept as part of the personal equipment (Ilkjær 1993, 51-52), thus underlining the special status of glass. There is therefore a considerable amount of evidence from Scandinavia suggesting that glass not only had a potential mercantile value but also was believed to have various magical attributes.

Concluding remarks

Numerous fragments of plane glass, *i.e.* windowpanes, have been found at several Viking Age sites, but often been overlooked in the research of the period and at large regarded as modern waste. However, the distribution and composition of the analysed corpus indicate two different approaches to the acquisition of windowpanes. In the proto-urban settings at Birka and to some extent also Haithabu, the imported glass has a recognisable oriental/Egyptian fingerprint, while the pre-Christian cult-sites of southern Scandinavia mainly show continental origins. To some extent the latter finds can be classified as belonging to more advanced forms of window glass production (*i.e.* of wood-ash-lime glass), but also a more diverse, perhaps experimental, range of glass manufacture. Furthermore, the heterogeneous constellation of the different types of glass that show similarities with the early woodash types as defined by Wedepohl in connection with their appearance at sites that show very limited activity post-1050 leads to the conclusion that they must form part of the primary activities of the localities in question. Accordingly, the use-frame of the analysed windowpanes should most likely be placed between the beginning of the 9th and the end of the 11th centuries. As the sites that have been characterised as aristocratic also are strongly characterised by the politico-ritual use of conspicuous architecture and at times very large and imposing aristocratic buildings, we suggest the actual use of glassed windows in these buildings – for magical as well as for status-marking reasons. In conclusion, the presence of recognisable (visually and chemically) fragments of windowpanes leads us to suggest that the use of glassed windows should not be regarded as introduced as part of the early medieval (*i.e.* post-1100) construction of Christian churches, but very likely is a feature already known as part of the magnificent halls and temples of the Viking Age.

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Notes

1 Four finds of window glass were made in the early excavations at Kaupang in Norway (Hougen 1969, 121) and 19 fragments have been recovered during the most recent excavations, five of which came from undisturbed Viking Age layers (Gaut 2011, 225). Unfortunately these were not available for the present study, but will form part of future analysis by the current group of authors.

2 The Framlev plank was examined a few years ago, both visually and with a CT scan. The annual growth rings were unfortunately very disturbed, with narrow growth rings and 'wild growth' (wavy growth rings), which means that the plank cannot be dated using dendrochronology (Niels Bonde, dendrochronologist, personal communication).

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Supplementary

Supplements see .docx-attachment

Sukow Ware at Vester Egesborg, Denmark?

The Question of Import, Inspiration or Coincidence in Viking Age Pottery Style

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ABSTRACT

During archaeological excavations at Vester Egesborg, a landing site from the Late Germanic Iron Age and Viking Age was found. The find material at the site was large and varied, providing proof of contacts with other places in the southern Baltic Sea area. This includes a significant number of sherds looking like Early Slavic Sukow pottery, which suggests contacts between Slavs in Mecklenburg and the Scandinavian population in the Early Viking Age. It is difficult to distinguish between Sukow Ware and contemporary South Scandinavian pottery in terms of shape and fabric, but the relatively large portion of rim sherds looking like the Slavic pottery type in the ceramic assemblage from Vester Egesborg posed the question of whether Sukow Ware has been imported to the site. ICP-MA/ES analyses of a sample of ceramic sherds suggest the existence of a network including the regions of Scania, Holstein and Schleswig. Evidence for the production of Sukow Ware at Vester Egesborg or in southern Zealand cannot be provided unambiguously.

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Introduction

In its broadest sense, 'Baltic Ware' is a term covering pottery found in Viking Age South Scandinavian context manufactured in shapes and decoration styles originating in the Slavonic territories south of the Baltic Sea. From the 11th century, Baltic Ware of Late Slavonic pottery style played an important role in the ceramic assemblage of the eastern part of the Danish kingdom during the Viking Age and Medieval Period, i.e., Bornholm, Falster, Scania, Lolland, Møn, Zealand, leading some scholars to only use the term for those particular groups of pottery (Naum 2008; Roslund 2001). However, the introduction of Baltic Ware commenced at an earlier point in time. Coil-made and customarily comb-decorated Early and Middle Slavonic pottery types like Feldberg, Fresendorf, and Menkendorf are occasionally present in burials and settlements of various sorts in Zealand, Denmark, and Scania, Sweden, during the 9th and 10th century (Brorsson 2003a, 2003b; Callmer 1988; Ulriksen 2018, 202-210). Late Slavonic pottery made on a potter's wheel and decorated with single horizontal grooves and wavy lines seems to have been introduced in the later part of the 10th century and are far more frequent than Early and Middle Slavonic types (Ulriksen 2018, 209).

Missing a local South Scandinavian chronology for Baltic Ware, the ceramic phases developed in Northeast Germany are used as a rough dating frame in Denmark and Scania (Brorsson 2003a; Larsen 2010; Liebgott 1977, 131-155, 1980, 136-152). According to the development of the Slavonic pottery south of the Baltic, the Early Slavonic types date to the 7th-9th centuries, the Middle Slavonic types primarily belong to the 10th century and the Late Slavonic types are dated to the 11th-14th centuries (overview in Kempke 2010). In Denmark and Scania, the identification of Baltic Ware relies on the decorative elements, the rims made with a template and the use of a cavalet (slow-wheel) or a potter's wheel. All these elements are contrasting the partly concurrent, local undecorated coiled flat-based South Scandinavian pottery type produced between the 6th century and the early 11th century (Brorsson 2003a; Madsen 1991; Selling 1955; Ulriksen 2018, 188-201) (Figure 1).

Figure 1. Example of a flat-based South Scandinavian ceramic vessel from Vester Egesborg (A2428x32) (Photo: Jens Olsen/Museum Southeast Denmark).

Interestingly, among this poorly dated pottery type are vessels, which have shapes and rim profiles similar to the Early Slavonic Sukow Ware and Undecorated Feldberg Ware (Brorsson 2010, 24; Madsen 1991; Nielsen 1985; Ulriksen 1998, 16 with further references; Wietrzichowski 1990). However, as these sherds are retrieved by excavating various types of settlement sites in Zealand and Scania and as their colour, tempering and firing are not particularly distinctive, they are typically catalogued as locally produced pottery either labelled 'settlement pottery' or 'South Scandinavian pottery'. Accordingly, for years it has been an almost neglected question whether pottery of Sukow Ware and Undecorated Feldberg Ware may have been imported to or produced in Viking Age South Scandinavia. Lately, excavations at a landing site in South Zealand have provided a collection of rim sherds similar to Sukow Ware and Undecorated Feldberg Ware in an unusual quantity, thus posing the question if these pottery styles spread across the Baltic Sea at an earlier date and in larger numbers than previously believed.

Sukow Ware and Undecorated Feldberg Ware

The Sukow Ware and the Undecorated Feldberg Ware have been discussed since the 1960s as regards to their origin, their relative chronological and typological position within the Slavonic pottery types, their date and the question of their interrelations (Donat 1984; Kempke 2010, 235; Schuldt 1964; Wietrzichowski 1990, 37-40 with further references).

In 1990 the German archaeologist Frank Wietrzichowski published an article analysing the Early Slavonic ceramics of the Sukow type and Undecorated Feldberg type. The large assemblage of sherds had been found in settlement pits within the borders of present-day Mecklenburg-Vorpommern, and Wietrzichowski defined four shape-groups based on the profiles of the rims and the bodies of the vessels (Wietrzichowski 1990, 40-44) (Figure 2).

Shape-group 1 is Sukow Ware and is characterised by short everted or vertical rounded rims and a slightly S-shaped body profile with a vaguely pronounced shoulder on the upper third of the body. The sherds have a crude or medium coarse tempering and are relatively poorly fired.

Shape-group 2 is also Sukow Ware looking more or less like Shape-group 1, but the rims are wiped flat and without the use of a template. Both tempering and firing are quite varied.

Shape-group 3 is ascribed to the Undecorated Feldberg Ware. The rims are sharply everted, typically with a jutted lip. The body is tending towards a biconical shape, while the tempering and firing mostly resemble the Sukow Ware.

Shape-group 4 is also Undecorated Feldberg Ware with short, sharp-profiled and everted rims. The tempering is medium-coarse to fine, while the firing is described as good or very good.

It ought to be added that some Sukow vessels have been decorated with circular stamps or crudely incised lines (Wietrzichowski 1990, 54-59).

According to Frank Wietrzichowski (1990, 77-78), the dating frame of the Sukow pottery in Mecklenburg-Vorpommern is *c.*AD 650-750, mostly relying on the connection between a brooch of Fenno-Scandinavian origin and Sukow sherds in a settlement pit from Benzin (cf. Gralow and Parschau 1984). However, the time of settling of the

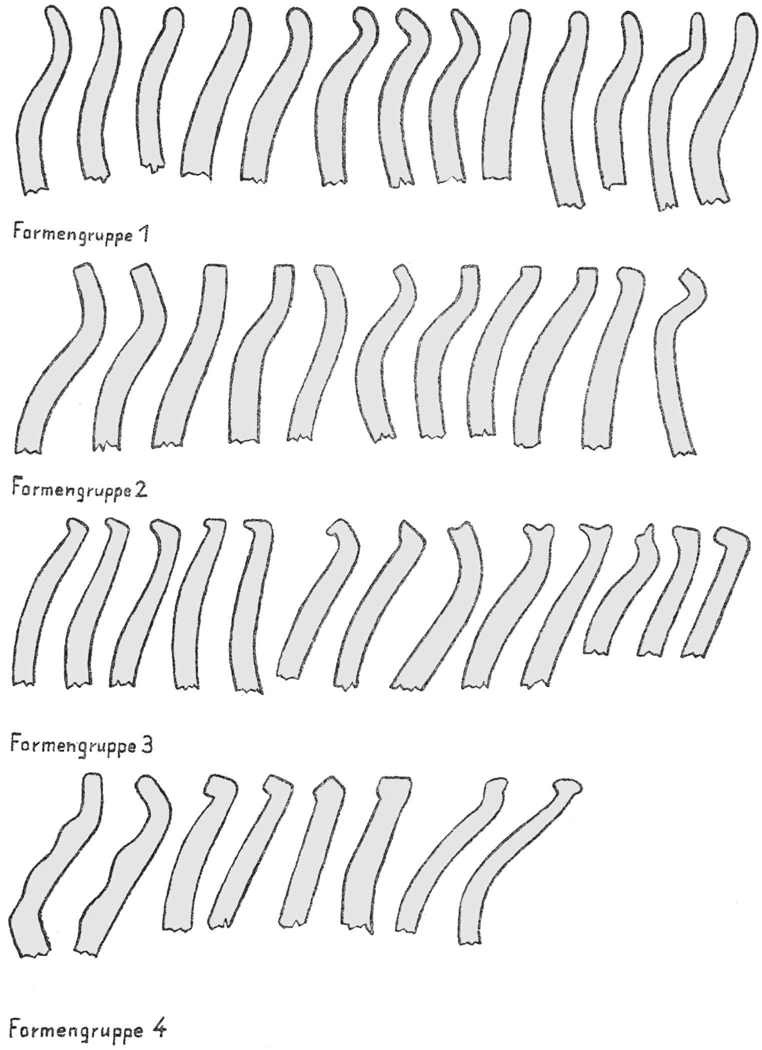

Figure 2. *Formengruppe* 1 and 2 are Sukow Ware, and *Formengruppe* 3 and 4 are Undecorated Feldberg Ware. After Wietrzichowski 1990, Abb. 1.

Slavonic people along the South Baltic coast of present-day Northeast Germany has more recently been estimated to the last third of the 7th century, even though dendro-chronology of settlement sites do not reach further back in time than the early part of the 8th century (Biermann 2019, 22-23; Biermann et al. 1999, 236-240; Brather 1996, 14-17). Dendrodatings from four locations in Holstein belong to the first half of the 9th century (Brather 1996, 15; Kempke 2010, 247). In Wolin, on the Polish coast, Sukow Ware is scarce and belongs to the period between the end of the 8th century and the beginning of the 9th century (Stanisławski 2012, 153). At Szczecin, on the river Oder, a few sherds of Sukow Ware have been retrieved from the Schlosshügel Phase I, dendro-dated between the early 8th century and the middle of the 9th century (Dworazyk 2003, 258). Located outside the Slavic homelands, Hamburg holds Sukow pottery in a 9th century context (Kempke 2014).

Generally, the chronology of Slavonic pottery types is somewhat imprecise. Counting sherds, the heyday of a particular type can be deduced, but both the time of introduction and the time of fading-out may be blurred for periods of 50-100 years (cf. Gabriel and Kempke 1991, Abb. 14-15; Wietrzichowski 1990, 74). The estimated introduction of the Sukow Ware in the decennia shortly before AD 700 appears to be fairly probable, while there seems to be regional differences considering the durability of the type resulting in considerably overlapping sequences between types that basically constitute different chronological phases (Kempke 2001, Abb. 2, Abb. 3; Ulriksen 2018, 202).

It has been suggested that the Undecorated Feldberg Ware was introduced in Mecklenburg-Vorpommern in the second half of the 7th century (Wietrzichowski 1990, 77). This date relies on a context where the pottery was found together with a South Scandinavian bird-shaped brooch dating

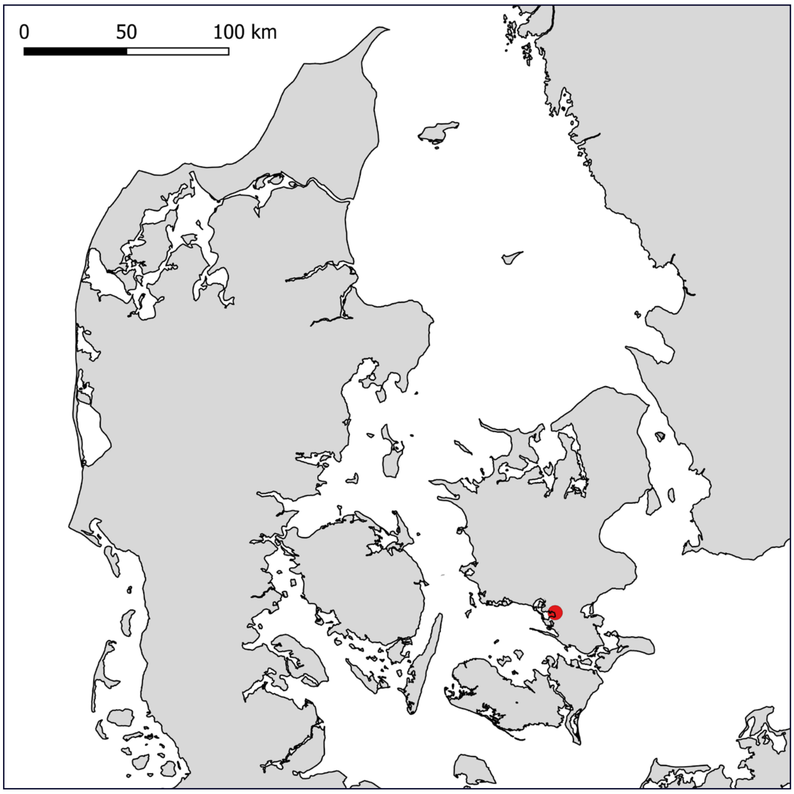

Figure 3. The location of Vester Egesborg, Denmark, is marked with a red dot.

from *c.*AD 650-725 and the fact that Sukow Ware always is found in layers stratigraphically earlier than the Undecorated Feldberg Ware. Even though dendro-dating of contexts with Feldberg pottery has been published, it is not pointed out if there are Undecorated Feldberg Ware among the sherds (Biermann 2019, 22-23; Brather 1996, 143-144). Nevertheless, an introduction before AD 700 is not likely for this pottery type, and the contextual dating relying on Scandinavian brooches are not in conflict with a date of introduction during the early 8th century. The Undecorated Feldberg Ware develops into the decorated Feldberg type belonging to the 8th and 9th century (Wietrzichowski 1990, 38), but it has been found in 10th century contexts too (Brather 1996, 145, Abb. 111).

The Landing Site at Vester Egesborg

The question of the presence of Sukow Ware and Undecorated Feldberg Ware in a South Scandinavian context was re-vitalised when analysing pottery from the landing site of Vester Egesborg in southern Zealand (Ulriksen 2018, 186-215). Here, 151 rim sherds of a total of 1250 rim sherds are comparable to rims of the Sukow type. Hitherto, the possible presence of Undecorated Feldberg Ware in South Scandinavia has been overlooked, but in the pottery assemblage from Vester Egesborg there are 51 rim sherds comparable to Undecorated Feldberg Ware.

The landing site at Vester Egesborg is situated on the innermost coast of the *c.*5 km long and very shallow Dybsø Fjord (Figure 3). Through a narrow passage with a strong current, the fjord is connected to more open and deeper waters of Smålandshavet and from here, the fairway to The Seven Seas is open. Vester Egesborg was established in the late 6th century AD and abandoned in the second part of the 10th century. It operated as a production site for textile and iron and as an assembly site for mustering ships and crews for expeditions (Ulriksen 2006, 2018). The excavation campaigns have revealed 120 pit houses and 28 three-aisled houses as well as a large number of artefacts – *c.*18,500, dating from the era of the landing place. They were retrieved mainly when excavating the pit houses and the rubbish pits. A cultural layer covering parts of the site proved to contain objects too. Due to limited economic resources, it was not possible to excavate the cultural layer as thoroughly as the features, and only partial dry sieving of selected areas were conducted.

The preservation conditions were good and many artefacts made of bone, antler, iron, copper

Figure 4. Stamp-decorated sherds from Vester Egesborg. a) A1645x2 and b) A3055x25 (Photo: Jens Olsen/Museum Southeast Denmark).

alloy and silver were recovered. However, the overwhelming part of the find material was sherds of pottery with more than *c.*13,500 individual pieces. Usually, the sherds were rather small but also larger parts of vessels were present.

The Pottery Assemblage

In the regions of Scania, Zealand and the other East Danish islands, the typical flat-based, South Scandinavian pottery type is actually rather uncharacteristic, often with an inaccurately manufactured inverted rim and without any kind of decoration (cf. Figure 1). Consequently, it offers no obvious opportunity for a detailed chronology.

The tempering of the clay, the firing temperature and the look and 'feel' of the surface of the South Scandinavian pottery can be very much like that of Early and Middle Slavonic types of pottery. Accordingly, it can be almost impossible to identify an undecorated sherd from the body of a vessel as either South Scandinavian or Baltic Ware of Early/Middle Slavonic types, which has not been worked on a cavalet or a potter's wheel. At Vester Egesborg, a focus on rim sherds provides a more reasonable representation of the relative number of South Scandinavian pottery (85 %) and Early and Middle Slavonic pottery (15 %). The spatial distribution of the Early and Middle Slavonic pottery types covers most of the site, but 50 % of the 524 sherds were found in only five pit houses of which four were located quite close to each other (Ulriksen 2018, Fig. 357).

Limited in number but easily recognizable are 17 sherds of stamp-decorated pottery. In South Scandinavia stamped decoration is known from the 6th century AD, probably inspired from Anglo-Saxon England, Saxony and Frisia. From the 8th century, however, stamped pottery most likely is either Slavonic or inspired by Slavonic potters (Ulriksen 2018, 210-213 with references). Large, stamped circles on sherds from Vester Egesborg are associated with Sukow Ware and Feldberg Ware while circle-with-cross stamps are found on Middle Slavonic Menkendorf type vessels (Figure 4).

Within the 1,250 rim sherds initially identified as South Scandinavian pottery, inverted rims clearly dominate. Amongst the vertical or short everted rims there are sherds looking very much like Sukow Ware (151 sherds) and Undecorated Feldberg Ware (51 sherds). If these sherds originate from the Slavonic areas or if they belong to vessels manufactured at Vester Egesborg by Slavonic potters, it would prove the presence of Baltic Ware in Denmark at an earlier point in time than previously realised. But as the surfaces, tempering and firing are almost indistinguishable from the South Scandinavian sherds, a sample of 14 rim sherds were chosen to be scrutinized further using the chemical ICP-MA/ES analysis in an attempt to point out the origin of the clays of the sherds (Figure 5).


A
0 1 2 3 4 5 cm
B
C
D
E
F
G
H
I
J
K
L
M
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0 1 2 3 4 5 cm

Figure 5 (previous page). The sampled sherds. South Scandinavian pottery: a) A21x33, b) A21x75, c) A245x41, d) A817x8, e) A1320x5). Sukow-like sherds: f) A4x12, g) A4x13, h) A4x27, i) A2749x116b, j) A2750x9d, k) A3071x18. Undecorated Feldberg-like sherds: l) A2749x114b, m) A3063x43. Feldberg-like sherd: n) A1320x24 (Photo: Jens Olsen/Museum Southeast Denmark).

ICP-MA/ES Analyses of the possible Sukow and Feldberg Sherds

During the last decades, ICP-MA/ES (Inductively Coupled Plasma-Mass Atomic Emission Spectrometry) analysis of pottery sherds have been increasingly used to determine the origin of ceramics (e.g. Brorsson 2013; Little et al. 2004). ICP-MA/ES is a chemical analysis that examines the ceramic sherds' chemical identity by measuring a vast spectrum of elements down to extremely low concentrations (Golitko and Dussubieux 2016).

The trace elements in particular (Al, Ca, Ce, Co, Cr, Ga, La, Mg, Mn, Ma, Sr and V) were measured from the sample of 14 sherds from Vester Egesborg, and the results are used to point out the geographical origin of the clay from which each pot was made. The selection was based on previous experience of reliable discriminating processing (e.g. Thompson and Walsh 1989). It is fundamental to stress that this technique produces data about the frequency of chemical and trace elements from both the clay and the temper that have been used to produce the ceramics; it does not allow specialists to distinguish between the temper and the clay (e.g. Brorsson 2013, 61).

To carry out the analysis, samples of only about 0.3 g of material from the chosen sherd are necessary. Thus, even if the method is destructive it is not particularly intrusive, especially if the studied pieces are from fragmentary and non-diagnostic fragments. In order to perform the analysis, the samples are ground into a powder, which is then screened by mass spectrometry. The ICP-MA/ES analyses provide a large amount of data, which is statistically processed. The data is therefore sorted out in a factor and a cluster analysis, which combine samples of the same chemical composition. Reference data enables interpretations of likely geological and geographical origins (e.g. Little et al. 2004) and the samples from Vester Egesborg have been compared with clays and ceramics from the Ceramic Studies' proprietary database, which contains information for *c*.14,000 samples from mainly northern Europe. Ceramics of different chemical composition are not made using raw material collected in the same region. Furthermore, it is important to consider that the ICP-MA/ES analysis is not biased by the treatment of the clay. In other words, a coarse or finely worked clay collected from the same place will be placed into the same ICP group, while two fine clays from different places will be separated.

ICP-MA/ES analyses have been carried out on 14 different sherds/vessels of which six are suggested to be of Sukow type, two of suggested Undecorated Feldberg type, while one sherd is of Decorated Feldberg type and five are from South Scandinavian pots (Figure 6). Of primary interest in the study is to determine if the likely Sukow type vessels and the Feldberg type sherd were made locally at Vester Egesborg or at sites in the Slavonic region of the southern Baltic coast. As a reference material for local ceramics, sherds from South Scandinavian-type vessels from Vester Egesborg were also analysed.

The ICP-analyses show that the majority of the vessels are similar to each other (Figure 7), i.e., they are made from raw materials with the same chemical composition. This means that the clays and rocks were collected in the same region, which is most likely within a radius of maximum *c*.20 km from Vester Egesborg. Since 11 out of 14 sherds have been made from similar material, it is also most likely that the vessels were produced by raw materials collected somewhere in the vicinity of the landing site. Theoretically, the vessels may have had another origin, but in that case the 11 vessels of Sukow-like, Undecorated Feldberg-like, and South Scandinavian types would all have been made at another site and subsequently also have been transported to Vester Egesborg. The latter interpretation is rather unlikely since most Viking Age pottery is considered to have been made locally (Brorsson 2010). However, the dendrogram in Figure 7 shows that there are several different ware groups within the Vester Egesborg pottery. Samples nos. 6, 9, 10 and 14 in the upper part of the dendrogram are very similar, and these vessels were most likely made out of raw materials from the

Sample no.	Ceramic type	Feature ID	Context	Date of context
Vegesborg1	Sukow	A4x12	Pit house	8th-10th century
Vegesborg2	Sukow	A4x13	Pit house	8th-10th century
Vegesborg3	Sukow	A4x27	Pit house	8th-10th century
Vegesborg4	Sukow	A2749x116B	Pit house	6th-10th century
Vegesborg5	Sukow	A2750x9D	Pit house	9th-10th century
Vegesborg6	Sukow	A3071x18	Well	*c*.AD 1500 *)
Vegesborg7	Feldberg decorated	A1320x24	Pit house	9th-10th century
Vegesborg8	Feldberg undecorated	A2749x114B	Pit house	6th-10th century
Vegesborg9	Feldberg undecorated	A3063x43	Pit house	8th-10th century
Vegesborg10	South Scandinavian	A21x33	Pit house	8th-10th century
Vegesborg11	South Scandinavian	A21x75	Pit house	8th-10th century
Vegesborg12	South Scandinavian	A245x41	Pit house	8th-9th century
Vegesborg13	South Scandinavian	A817x8	Pit house	9th century
Vegesborg14	South Scandinavian	A1320x5	Pit house	9th-10th century

Figure 6. ICP-analyses were carried out on 14 sherds from different vessels found at Vester Egesborg. *) The find material in the fill of the well A3071 were of 6th-10th century types, while the remains of a wooden barrel in the bottom of the well were dendro-dated to *c*.AD 1500.

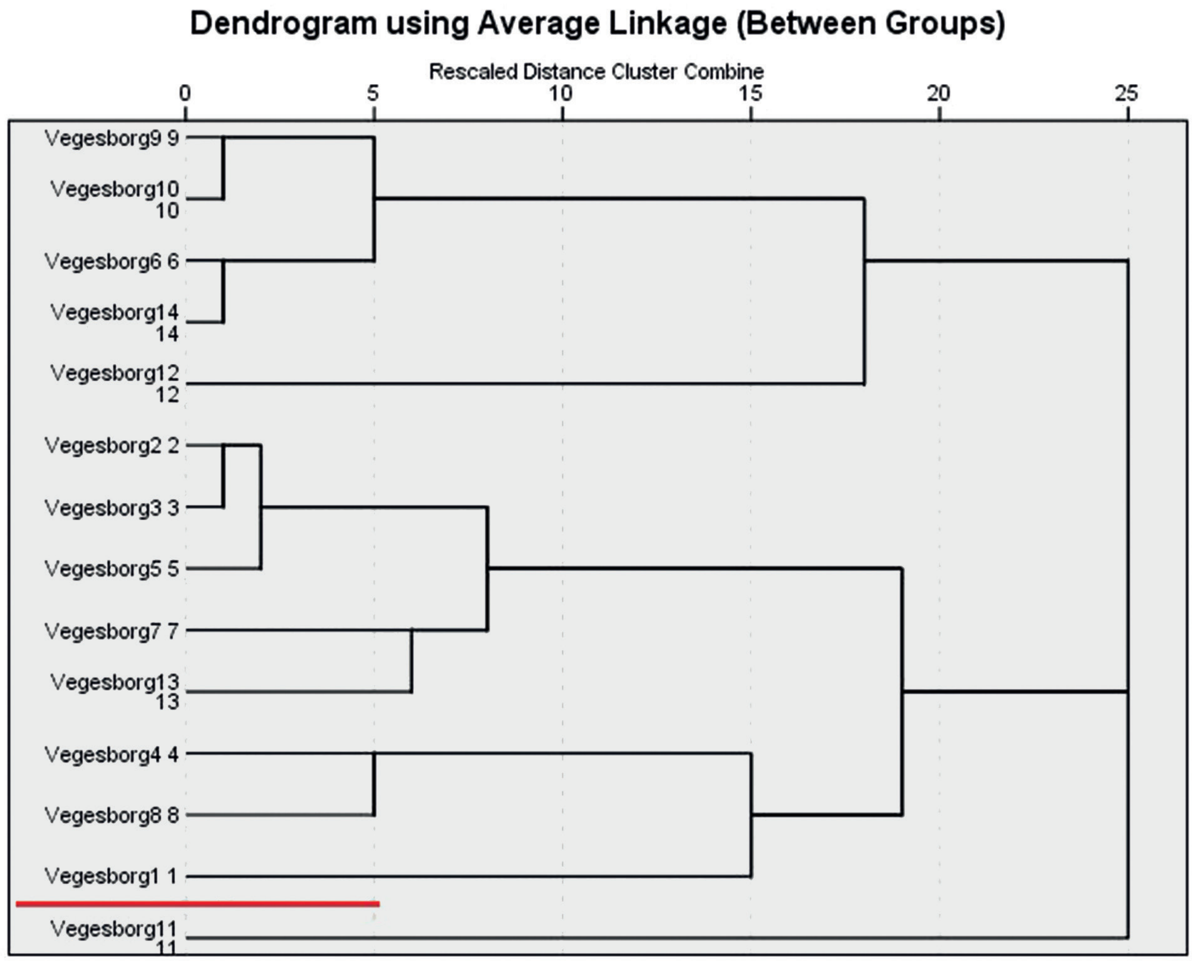

Figure 7. ICP1. The sample that differs most from the others is sample Vegesborg11, a South Scandinavian vessel, which seems to be from Scania, southern Sweden.

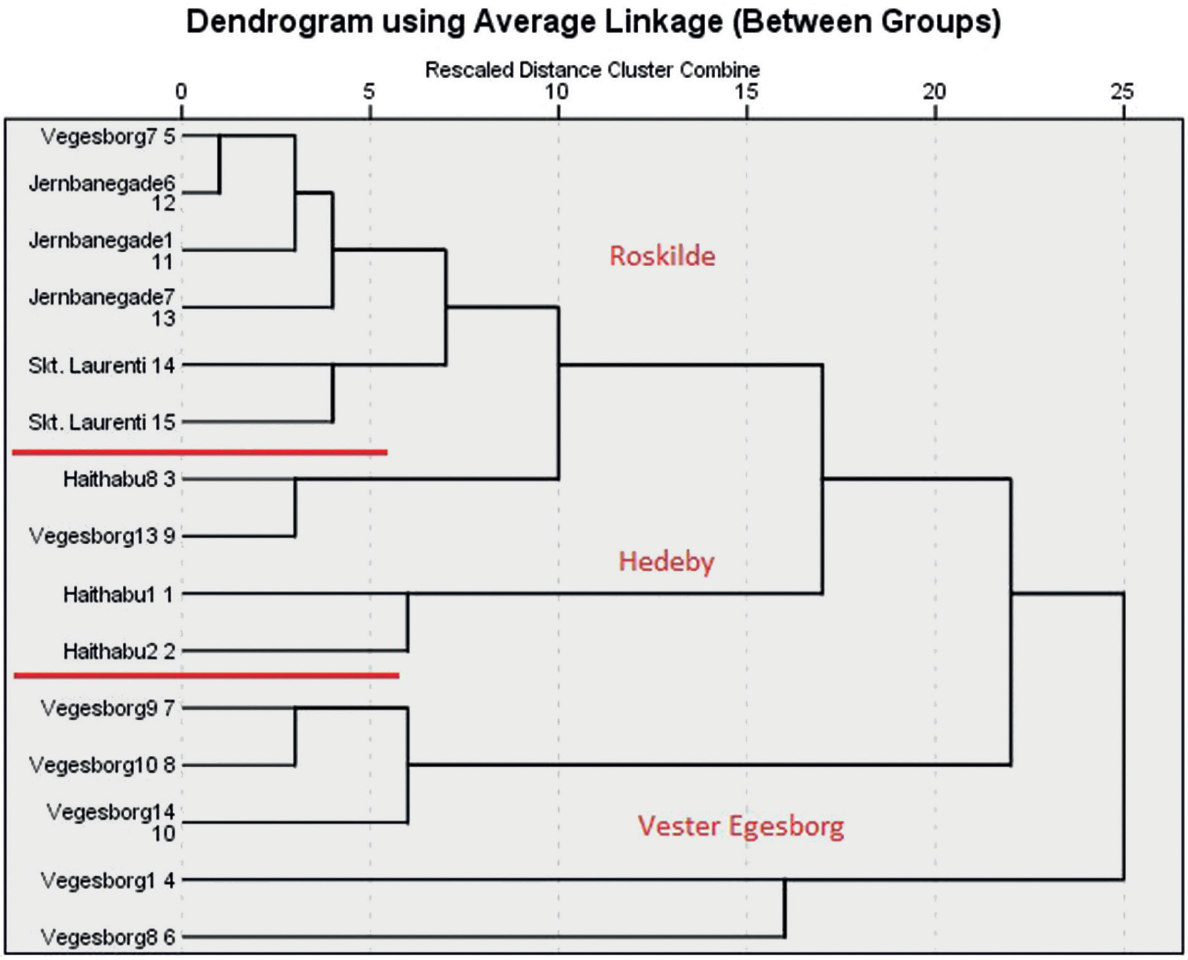

Figure 8. ICP2. A Feldberg vessel from Vester Egesborg (sample Vegesborg 7) is most similar to ceramics from the Roskilde region on Zealand. A Scandinavian pot (sample Vegesborg13) is made of the same fabric as ceramics from Hedeby.

same clay source. Another group consists of samples nos. 2, 3 and 5, indicating that these vessels were made out of clays from another clay source. Thus, the vessels can be regarded as locally made when compared with contemporary vessels from southern Denmark, Bornholm, southern Sweden and northern Germany.

In contrast, three finds are probably non-local. Sample Vegesborg 11, belonging to a South Scandinavian vessel, differs markedly from the other finds with a completely different fabric (cf. Figure 7). Chemically, this pot closely resembles pottery and clays from the Ystad region in southern Scania. Also, a Decorated Feldberg vessel, sample Vegesborg7, has most similarities with pots and brick from the Roskilde area in central Zealand (Figure 8). The distance from here to Vester Egesborg is only 70 km and, during the Viking Age, it is very likely that people from different places on Zealand travelled that distance rather frequently (Ulriksen et al. 2020, 5-8). The fabric of one of the South Scandinavian vessels, sample Vegesborg13, has more similarities with ceramics found in Hedeby than with the locally made from Vester Egesborg (cf. Figure 8). The distance between the two sites is about 170 km by sea route and, considering the overall find material from Vester Egesborg, contacts between the two during the 9th and 10th century are rather likely (Ulriksen 2018, 409-411).

Discussion

The ICP-MA/ES analyses of the pottery from Vester Egesborg indicate that 11 of the 14 sampled sherds were made of local clay and thus manufactured on site or more likely in one or more settlements in the vicinity. Nevertheless, they do not consist of exactly the same type of clay and they form different groups showing that the local fabrics were not identical according to its chemical composition. Beforehand, it was expected that the five rims of South Scandinavian type pottery were more or less local. The analyses confirmed this for three of them, while two sherds seem to have different origins: One from the area around Hedeby and one from the Ystad region in southern Scania. The six sherds with Sukow-like rims are all among the apparently local production and so are the two sherds of Undecorated Feldberg type. The only Decorated Feldberg type sherd in the sample was anticipated to come from the Slavonic areas on the southern Baltic coast, but surprisingly it turned out to originate from the Roskilde region on Zealand. It indicates that vessels of Slavonic-type could have been made at a settlement outside the Slavonic core area and transported to another non-Slavonic settlement.

The results raise further questions regarding pottery use and cultural exchange in the Viking Age. The landing site of Vester Egesborg sits in a location with easy access to the Baltic Sea and in a relatively short distance – less than 24 hours of sailing in fair wind – from the Slavonic coastal areas of modern-day north-eastern Germany and western Poland. The proximity and the tradition of cross-Baltic relations through centuries between south-eastern Scandinavia and Eastern Europe do support the possibility of the exchange of goods, ideas and people (Bogucki 2013; Callmer 1992; Hedeager 2011, 191; Lund Hansen 1995, 413, 2011; Näsman 1984, 99; Ulriksen 2018, 385-391). Thus, contacts between the West Slavonic area and Zealand in the 8th and 9th century are very likely, and it is not surprising that connections to the Hedeby area from the 9th century onwards can be witnessed too (Ulriksen 2018, 384-391). Additionally, the sherd of South Scandinavian type, which chemically is comparable to pottery from Scania, indicates an expected regional network during the Viking Age. Scandinavian ships naturally travelled within the Danish kingdom and mustering at the landing site of Vester Egesborg may be one of the reasons why we find pottery from Scania there.

Concerning the overall ceramics assemblage at Vester Egesborg, the identification of the rim sherds of the Sukow-like type and Undecorated Feldberg-like type considerably affects the balance between the rim sherds of South Scandinavian type and Baltic Ware. Before sorting out the assumed Sukow Ware and Undecorated Feldberg Ware, the South Scandinavian type dominated by 85 % of the identified rims, while the Early and Middle Slavonic types constituted 15 % of the rim sherds. Pottery assemblages from Moesgård, Øm-Foldager, Selsø-Vestby, Gershøj, Gevninge-Nødager and Kirke Hyllinge-Stensgård, which are all Viking Age settlements with pit houses on Zealand comprise between 1 and 9 % of Middle Slavonic-like types. This demonstrates that the amount of Middle Slavonic-type pottery at Vester Egesborg is significant compared to the other sites mentioned (Ulriksen 2018, 209). This is also the case when extracting the rims that may belong to Sukow Ware and Undecorated Feldberg Ware. Together they constitute 16 % of the total assemblage of rim sherds, further reducing the percentage of clearly South Scandinavian rim sherds to 69 %.

To investigate the possible presence of the Sukow type and the Undecorated Feldberg type at other comparable locations, samples of ceramic rim sherds from five Viking Age settlement sites on Zealand have been surveyed visually. The survey includes the residential sites of Tissø and Strøby-Toftegård, the settlement at Gevninge-Nødager, affiliated to the residential site of Lejre, the production site at Kirke Hyllinge-Stensgård and the coastal landing site of Vedbæk-Stationsvej, all being active during the 7th-10th century. At all sites, rim sherds comparable to Sukow Ware and Undecorated Feldberg Ware were present, though in small numbers (Ulriksen 2018, Ch. 6, note 568).

Following the analyses arises the question of whether the size of the apparent Slavonic footprint on the pottery assemblage of the 8th century to the first half of the 10th century may imply the presence of Slavs in South Scandinavia. Such a situation has been proposed relating to Late Slavonic pottery types being introduced to the region during the second part of the 10th century and already in the 11th century constituting a significant portion of the pottery assemblages in all types of settlements in south-eastern Scandinavia (Brorsson 2000, 2003b; Liebgott 1980; Madsen 1991; Ulriksen 2000, 157-163, 2018, 209). It has been suggested that this change reflects that Slavonic potters moved – freely or forced – from their homelands to South Scandinavia and started a pottery production in Late Slavonic ceramic styles. This may be true in some areas such as Scania (Roslund 2001) and not least on the island of Bornholm in the Baltic Sea where the characteristic pottery was accompanied by jewellery of Slavonic tradition indicating the presence of Slav people (Ingvardson 2019; Naum 2008; Wagnkilde 2001).

Comparing the situation of the 11th century to the 8th, 9th and early 10th century there are some essential differences to consider. Late Slavonic pottery was made on a potter's wheel, it was well-fired and it was decorated, thus quite different from the handmade South Scandinavian ceramics. Consequently, the Late Slavonic pots were more attractive, both from a practical point of view and aesthetically. Regarding the Early Slavonic pottery like the Sukow Ware and Undecorated Feldberg Ware it was manufactured in the same way as the South Scandinavian pottery and was visually similar. As it is difficult to distinguish between the two pottery types in the first place, it is equally difficult to argue that the Sukow Ware and the Undecorated Feldberg Ware should be favoured over the South Scandinavian pots. In the 8th-9th century ceramics had not had any significance as identity markers for several hundred years in South Scandinavia. During the 4th and 5th century AD, some pots were carefully finished and decorated, but since the 6th century the pottery was negligently manufactured and presents itself as more or less uncharacteristic with only the rare stamp decorated vases of the 6th and 7th century as exceptions (Ulriksen 2018, 186-197, 210-213 with further references). The gradually increasing number of decorated Slavonic pottery, beginning with a limited presence of the decorated Early Slavonic Feldberg type typically at coastal settlements (Brorsson 2003a) and growing towards the more frequent occurrence of Middle Slavonic Ware at different types of settlements through the 9th and 10th century, indicates that Slavonic pottery only slowly was adopted by the communities of south-eastern Scandinavia. The desire for Baltic Ware from a broader spectrum of society did not happen until the late 10th or more likely the early 11th century.

Furthermore, it is worth noticing that the rim profiles comparable to those from Sukow Ware and Undecorated Feldberg Ware are not only a south-eastern Scandinavian issue. Similar rims are known in settlements from south-western Scandinavia, i.e. Funen and Jutland (Henriksen 1997, 32-34; Madsen 1991, 220-222; Madsen, with Sindbæk 2014, 271-273; Steuer 1974). This indicates that the rim shapes are used widely because they are just very easy to form and, thus, they may not be as diagnostic as believed in the first place. This is supported by the ICP-MA/ES analysis reflecting that most of the rims have been produced in South Scandinavia. Rather than indicating a more widespread ceramic influence from the Slavonic area, it is more likely that the rim shapes must be acknowledged as straightforward to make and therefore 'universal' to the potters using the same basic techniques.

Exchange of Pottery or People? – or none of the above

Previously, studies of ceramic vessels from Viking Age graves at several cemeteries across the Baltic region have shown that the cultural origin of the pot was not important. Slavonic, Saxon or Frisian pots were for instance used as grave goods in Scandinavian graves and South Scandinavian vessels have been found in Slavonic graves (Brorsson 2004).

Archaeological excavations carried out at Groβ Strömkendorf on the coast of Mecklenburg north of Wismar have revealed a large international trading site and an adjoining cemetery containing nearly 350 graves, dated mainly to the 8th century (Gerds and Wolf 2015). Culturally, the site was established in a West-Slavonic region. Cremation deposits in urns were common, but there were also several other types of cremation graves, as well as inhumation graves, boat graves, a chamber grave and animal burials. The pottery from the graves primarily consisted of West Slavonic and Scandinavian vessels, but also some Frisian and West European pottery from the Eifel and the Rhine area were present (Brorsson 2010). Most of the inhumation graves at Groβ Strömkendorf contained only Slavonic vessels and often more than one. Only one grave contained both Slavonic and South Scandinavian pottery.

Of a total of six boat graves at Groβ Strömkendorf five of them contained pottery (Brorsson

2010, 11). The structure of the graves is similar to Scandinavian burial tradition, but only one contained Scandinavian pottery. In this particular grave, there was a Slavonic vessel too. One boat grave contained a complete Frisian vessel as well as a complete Slavonic vessel. The remaining boat graves contained only Slavonic pottery. The study of a sample of graves from Groβ Strömkendorf shows that there is no apparent correlation between the burial form and type or origin of the pottery.

The example above shows that the cultural interpretation of ceramic pots and the interpretation of the grave types in different parts of South Scandinavia and the Baltic Sea region do not always correlate. Further, it indicates that neither the cultural origin or the shape or decoration of the ceramics had deep rooted influence on the identity of communities in South Scandinavia. This observation is in agreement with the tradition of South Scandinavian pottery from the 6th to the 10th century: Not much effort or cultural markers were invested in the production of pots. This makes way for the possibility that Slavonic potters could have lived in South Scandinavia, manufacturing vessels in Slavonic tradition to the local people. However, the undecorated Early Slavonic Ware did not offer a higher functional quality, or a greater visual value compared to the South Scandinavian pottery. If we assume, for the sake of argument, that Slavonic potters migrated, they have not left any other traces in the archaeological record of the 8th to 10th century South Scandinavia. In the large assemblage of metal objects from the Viking Age retrieved by using metal detectors, Slavonic items are almost non-existing. This may be due to the fact that brooches or pins of metal were not a representative part of Slavonic dress tradition (Gabriel and Kempke 1991, 142), but neither distinctive silver beads, earrings, belt hooks or decorative objects from head dresses occur in any noticeable number despite intensive metal detecting activity on Zealand, Lolland, Falster and Møn. Neither have excavations of settlements identified the typical 'Hausgrube' representing the Slavonic type of house (e.g. Brather 2001, 103-116; Krüger 2011, 51-53; Segschneider 2001), or have typical Slavonic artefacts like a crude bone awl (Corpus 1979, 41/181:43-45 and 41/272:73; Ulriksen 2000, Fig. 26) or biconical spindle-whorls (Matthey 1991, Fig. 3; Thomsen 2018, 254) been found in numbers that indicate the presence of Slav people carrying a Slavonic material culture with them.

Contrasting this is the evidence from Bornholm in the Baltic Sea. Here, hoards dated to the late 10th century and the 11th century include typical Slavonic jewellery, as well as characteristic cut melt of Slavic/Scandinavian type (Ingvardson 2019, Fig. 2.5, Fig. 2.11). Additionally, inhumation graves from Nordre Grødbygård in south-eastern Bornholm dating from the 11th century contained both Baltic Ware and jewellery of Slavonic origin (Wagnkilde 2001). The evidence from Bornholm is significant but attests a local phenomenon to the island. In the rest of South Scandinavia, however, it is not until the 11th century that (Late) Slavonic type pottery is joined more frequently by other artefacts of Slavonic type.

Conclusion

The study of the ceramic material from Vester Egesborg initially indicated that Early Slavonic pottery of the Sukow type and Undecorated Feldberg type are present in a relatively significant number. The ICP-MA/ES analyses showed that the sherds visually identified as probable Early Slavonic vessels were made from local clay. Regarding pottery of the Sukow type and the Undecorated Feldberg type, it is important to bear in mind that there are no technological differences between the South Scandinavian and Slavonic Sukow vessels and the quality of the fabrics are the same. As mentioned above, the profile of the rims, the shape and size of the body are all rather similar; the design of the rims were used in Funen and Jutland too. Consequently, it is difficult to establish as a fact that Slavonic potters have been producing Sukow-type ceramics in South Scandinavia.

As to the Decorated Feldberg pottery, it has a higher technological quality than both the South Scandinavian and Sukow types, indicating that this type of ceramic most likely was made by Slavonic potters. The analysed Decorated Feldberg sherd from Vester Egesborg originate from the Roskilde area, and contacts across Zealand are likely.

Further, the ICP-MA/ES analyses have pointed in the direction of a Baltic region network including Vester Egesborg. An eastern leg is found in the Ystad-area in southern Scania from where a vessel of South Scandinavian type originates. The distance between Vester Egesborg and the Viking Age landing site of Ystad-Tankbåten is *c.*190 km by ship. This is more or less the same distance as to Hedeby in a westbound direction, from where the clay of another Scandinavian-type pot originates. It is surprising, though, that the ICP-MA/ES analyses did not establish a knot in the network in the coastal zone of the Slavonic homelands in East Holstein, Mecklenburg-Vorpommern and Poland. In the Viking Age find material from Vester Egesborg, there are indications that connections were established probably involving trading sites on the Slavonic coast, as well as Menzlin on the Peene River (Ulriksen 2018, 390, 409-412).

With no explicit evidence of any rim sherds from Vester Egesborg made from clays originating in the Slavonic area, it is not possible to conclude that rim sherds comparable to Sukow and Undecorated Feldberg ceramics actually have been produced by Slavonic potters. It is equally likely that the sherds belong to South Scandinavian pots.

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The Garbage, the Castle, its Lord and the Queen.

A New View of Boringholm as the Home of a Failed Parvenu

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ABSTRACT

This paper seeks to explore an alternative approach to the interpretation of paradoxal evidence by comparing finds and contexts. It is based upon the theorems of garbology, developed by the archaeologist William Rathje (1945-2012) in the Tucson Garbage Project. While Rathje used archaeological methods for research in garbage reflecting modern consumerism, this paper takes the opposite approach, applying the theorems of garbology to late medieval garbage practices. A case study focusing on Boringholm Castle (lifespan between 1369 and the early 15th century) discusses the paradox of finding artefacts reflecting an outstanding elite culture in a modest environment that resembles a farmstead rather than a late medieval castle. The range of finds at Boringholm is very broad, demonstrating that this was the household of a parvenu who tried to imitate a courtly lifestyle.

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Introduction: Social Mobility in the Late Middle Ages

Wernher der Gaertnere wrote his epic poem 'Meier Helmbrecht' around 1250. Its eponymous protagonist is a rich peasant's son. He is not interested in working on a farm and succeeding his father as a rural mayor, but wants to become a knight instead. His family equips him with fashionable clothing and a horse, which enables him to start a career as a robber knight. When he returns home, proud of his stolen wealth, he has developed a pretentious upper-class accent and despises his family's lifestyle. His sister decides to join him. Helmbrecht arranges her marriage with a member of his gang, but the bailiff's intervention ends the celebration, as all the robbers are caught: Nine of them are hanged, and Helmbrecht is blinded and loses a hand and a foot. He tries to take refuge at his father's farm, but his father brokenheartedly rejects his son. Wandering alone through the countryside, Helmbrecht is recognised by peasants as a former robber and is finally hanged (Honemann 2001, 33-39; Wernher der Gaertnere).

This poem is a story of a parvenu's failure to achieve higher social status, and is typical of the 13th or 14th centuries. A parvenu is defined as a person from a humble background who has rapidly gained wealth or an influential social position, but who chooses to behave according to the social norms of their origins in preference to those of more elevated levels of society (OED 2022). This paper uses archaeology to trace the life of a failed social climber who tried to join the upper aristocratic class by imitating their way of life. This is a phenomenon we encounter frequently in late medieval society, which was characterised by a high degree of vertical mobility: In Central Europe, the nobility consisted of several layers with a clear differentiation between the old, upper nobility and the lower nobility. The former comprised princes, counts and free noblemen owning estates and holding a lord's fief. The latter is much more diverse and comprised knights, their families and a lord's unfree *ministeriales* (=servants). Both layers shared a similar military lifestyle and belonged to the court culture. Talented lower noblemen could even assume the roles of the upper nobility in war or at the royal court. However, a hard glass ceiling separated the upper free nobility from lower noblemen, since intermarriages were rare between these two groups.

A classic example of vertical mobility starting in a rural retainer context is the originally unfree *ministeriales* of Hagen-Arnsburg-Münzenberg, who succeeded as fighters and counsellors in royal service. The pay-off in return for this service enabled Kuno of Münzenberg (who is mentioned in documents in 1155-1207) to build the most impressive castle in Hesse, Münzenberg. His granddaughter Adelheid married Ulrich, Count of Hanau, who made King Rudolf I free his wife and children in 1273 to ensure that the comital heritage remained in the hands of his otherwise unfree sons. Now the heirs of Münzenberg belonged to the upper nobility (Atzbach 2018, 188-192; Spieß 1992). While Münzenberg's ancestors might have shared Meier Helmbrecht's rural upper-class background, the urban elite also strove to adopt elements of noble lifestyle to increase their chance of becoming a knight and a member of the aristocracy. One example of this is the Vintler family's history: Niklaus Vintler was a successful merchant and burgher who became a bailiff in Bozen, Tyrol. In 1385, he bought Runkelstein Castle close to Bozen, which he formally received as a fief from the Bishop of Trient. During its extensive renovation, Niklaus rebuilt and decorated the castle with one of the most famous series of late medieval paintings, showing classic topics of courtly love, tournaments and knightly lifestyle. His brother Hans translated an Italian poem, 'Fiore di Virtu', praising the nobility of virtue instead of the nobility of ancestry. His grandson and his granddaughter were accepted in the noble sphere and married members of the lower aristocracy in Tyrol. Research has misinterpreted Runkelstein Castle's paintings as a classic example of knightly court culture, but in reality they are the result of a civic self-made man's systematic, visual ascension strategy (Pfeifer 2011; Siller 2011; Wetzel 2000).

Late medieval Denmark resembled the Holy Roman Empire in terms of society and social advancement, but there were also differences: Although no legal differentiation between free noblemen and unfree servants or peasants existed, society was far from being equal. Apart from the large number of (free) peasants and the few urban communities, a new military class of retainers and knights arose, after chivalry and horses had become important in warfare following the Battle of Fotevig in 1134. This new aristocratic group might have been rooted in the early *hirde* or *herremænd* (=herres mænd, a lord's men), who followed their lord into war and were freed of tax in return. Moreover, the upper social sphere of magnates owning large estates (for instance the Hvide or Brok family) took part in Danish rule in conflict or in cooperation with the kingdom. With the central power's decline since 1250, but especially since King Erik Menved's reign (1286-1319), military conflicts had grown in number with a severe impact on everyday life. The Danish kings tried to retain control using expensive mercenary troops, but this policy led to an erosion of royal property and destroyed central power. As a result, local leaders started to fortify their houses in this 'Age of the Castle', which did not end until Queen Margaret I's restoration of central power in the late 14th century (Atzbach 2021; Etting 2004, 2010, 11-20, 29-38; Ingesman et al. 1999, 82-86).

During this period of conflicts and warfare, many people lost their lives or property, while others managed to ascend socially to the status of being a lord's retainer or counsellor – similar to the aforementioned *ministeriales* in the Holy Roman Empire. These self-made men might have been regarded as parvenus by the established magnates and their retainers. We do not hear explicitly about failed parvenus like Meier Helmbrecht in Danish written sources. However, it is possible to spot corresponding biographies: The later Renaissance manor house of Rosenholm in Central Jutland was originally founded as the manor 'Holm' by the magnate Anders Peetz, who was Queen Margaret I's retainer and had his seat there. His sons were fortuneless and sold major parts of this estate. The house finally fell to the Aarhus Bishopric and was let to a peasant as a simple farm (Danske herregårde 2022; Hansen 1909).

This study seeks to explore the potential of archaeology for approaching vertical mobility in the high and late Middle Ages. It proposes that the site of Boringholm Castle (Figure 1) was the home of such a parvenu due to the paradoxal character of the archaeological evidence. The castle was in

Figure 1. Sites mentioned in the text (Graphics: Katrin Atzbach).

use between 1369 (dendrochronology, shortened thereafter as (d)) and the early 15th century and was completely excavated between 1905 and 1916. The excavation results were published in 2005 (Kock and Roesdahl 2005).

Theoretical Framework: Artefacts and Interpretation

Archaeology aims to reconstruct or at least understand past societies and their internal processes. The central basis for this approach is contexts (building structures, layers, graves, cuts etc.) and the finds which are (ideally) embedded in them. Traditionally, finds are regarded as a more or less precise mirror of past life. For instance, a concentration of tools or production waste signifies the presence of a workshop, luxury items such as precious metal, imported cloth or stoneware are regarded as reflecting an upper-class lifestyle with access to trade, and weapons are associated with a military way of life. Since the early days of archaeology, scholars have regarded the selection of objects and formation processes as the most important filter between historical reality and the excavated finds. The key assumption has been that archaeological finds represent past everyday culture proportionally: Hans Jürgen Eggers proposed that source criticism should be applied to archaeological contexts and finds in order to differentiate between 'living culture', 'dying culture' and 'buried culture' (Eggers 1959, 255-267). Michael B. Schiffer, Pär Karlsson and Göran Tagesson contributed the important identification of de facto, primary, secondary and tertiary contexts reflecting the location and relocation of objects after they go out of use (Schiffer 1987; Tagesson 2003). Recent interpretations of archaeological finds regard materiality as an interaction between an object and its user. Object biographies reveal the changing role of an object in its lifespan and in the hands of different users (Burström 2014; Gosden and Marshall 1999; Hahn 2005). This immediate or proportional relationship, especially between a quantitative presence of objects and past everyday life, has been a central paradigm in research and in archaeological textbooks until the present (cf. Renfrew and Bahn 1996, 195-196, 201; Scholkmann 1998; Scholkmann, Kenzler and Schreg 2016, 101-119; White and Beaudry 2009).

In contrast to prehistory, medieval and later/historical archaeology has largely benefitted from written and pictorial sources that have shed a second and a third light on archaeological contexts. On the one hand, upper-class contexts identified by such additional sources often contain imported tableware, drinking or window glass, precious weapons and luxury items such as jewellery and elaborate riding gear, or simply an exceptionally wide range of objects. Sometimes, however, high-status sites do not contain any remarkable finds. For instance, the imperial palace in Seligenstadt did not provide any object that could have been attributed to a high-status household (Atzbach 2020). This could be explained by erosion or the later removal of occupation layers. On the other hand, a few paradoxal contexts have appeared: One famous example is the golden brooch from Schleswig that was excavated in a fisherman's hut and has been interpreted as booty from the murder of King Eric IV Plovpenning in this town (Atzbach 2010; Radtke 2007). In general, the contrast between a site with modest architecture and a large number of valuable finds needs an additional interpretative framework that goes beyond the paradigm of proportion.

Our theoretical approach will take its point of departure in William Rathje's ideas of '*Garbology*'. William Rathje (1945-2012) was an American archaeologist teaching anthropology at the University of Arizona and Stanford University. Originally working as a Mayanist, in 1973 he started the Tucson Garbage Project, which studied consumerism by applying archaeological methods to the excavation of modern landfills (Rathje and Murphy 2000; Schiffer and Riecker 2015). His innovative *Garbology* approach compared consumer interviews to excavated landfill finds that originated from these consumers' districts. Some results were expected, while others were surprising and contradictory. This new method provided objective data about modern consumer behaviour – on a huge data basis of more than 1,342 m^3 of excavated stratified material (Rathje and Murphy 2000, 11, 16). Rathje's archaeological results have primarily been used for demoscopic market research in today's society. However, it is also possible to turn his approach around, using his results and principles to explain the relationship between historical waste management and everyday life. This approach has not been used in archaeology before and will be applied in our case study.

The Tucson Garbage Project's results can be condensed into five theorems that characterise general anthropological traits in human behaviour:

1) What we say is not what we do. It is no surprise that people tend to be less than honest in interviews regarding their alcohol or drug consumption and their sexual behaviour (Rathje and Murphy 2000, 53-54).
2) There is no immediate or proportional relationship between garbage and a household inventory: Some valuables or objects with personal value, e.g. an encyclopaedia or a volume of National Geographic, rarely end up in the dustbin because they are handed to followers, friends or relatives as a gift or legacy (Rathje and Murphy 2000, 58).
3) First principle of food waste: The more repetitive your diet – the more you eat the same things day after day, the less food you waste. While ordinary daily meals are scarcely visible in the waste, exotic meals and strange objects with which the members of a household are not familiar tend to be overrepresented in the household waste (Rathje and Murphy 2000, 62). This fact is also reflected by the German saying 'Was der Bauer nicht kennt, frisst er nicht' (What a peasant does not know, he will not guzzle). The project led to the extremely counterintuitive result that in times of shortage the proportion of scarce (and

therefore expensive) goods actually increased in garbage and landfills: Both the sugar shortage and the beef shortage in the USA during the 1970s increased the proportion of discarded sugar and beef (packages) (Rathje and Murphy 2000, 59-60). This was proven once again during the recent covid-19 crisis in 2020: It was almost impossible to buy yeast in Denmark – guess where all the hoarded yeast ended up…

4) First principle of household hazardous waste. This principle is closely related to the previous principle: Cleansers and detergents which are used daily rarely appear in waste, whereas special products bought for a single purpose, e.g. glues and sealants, account for a disproportionately large share of hazardous household waste (Rathje and Murphy 2000, 76).
5) A high proportion of branded goods in waste indicates eagerness to follow a role model. The Garbology Project called this theorem 'the Hollywood Hypothesis': Middle-class families climbing the social ladder tend to discard more branded goods than affluent people do. Latin American immigrants in the USA quickly adopted American consumer patterns buying and discarding even more typical US-American products - such as red meat or expensive toys – than their Anglo-American neighbours. Rathje's team interpreted this phenomenon as an act of integration that imitated the everyday culture visible in American soap operas or Hollywood movies (Rathje and Murphy 2000, 135, 147). From an anthropological point of view, this phenomenon reflects the interest of the lower class in status symbols used by the upper class. It is also known as conspicuous consumption (Veblen 1899, chapter IV) or trickle-down effect: The upper class are constantly forced to change their status symbols in order to distinguish themselves from their lower-class imitators (Durkheim 1887, 57).

The application of this model, albeit rooted in recent consumerism theory, to late medieval society is legitimate because recent studies have revealed the diachronic character of human consumption behaviour that is not driven by a western, medieval or modern mentality: Of course, the consumption patterns of the medieval elite were vastly different from the majority of the population. The latter were mostly limited to consuming goods produced in their local area, and the selection of goods was generally quite confined. In contrast, the elite had wider access to luxury goods fabricated in distant regions. While former economic research discussed a "consumer revolution" not before 1700, today, "modern" consumerism patterns seem to develop already from the 14th century onwards (Dyer 1989, 2005). This transition generated a structure comparable to the upper and middle class in the American society scrutinized by Rathje. Thus, modern consumerism theory provides a framework for understanding how people in the past acquired, consumed, and disposed of goods and materials. Additionally, it allows for the examination of the creation and maintenance of social status through the acquisition, display and consumption of goods, as well as the impact of economic changes on consumption patterns. On the one hand, consumption is primarily ruled by the limits of supply and demand on a given market or in a trading network. Beyond subsistence, acquiring things aims to construct or to maintain status and social relationships throughout all periods and cultures (Jervis 2017; Trentmann 2004). The aforementioned trickle-down effect originates from the 'Reagonomics' of the 1990s but has become an integral part of archaeological theory (Aghion and Bolton 1997; recently e.g. Frieman and Lewis 2021). Thus, it is worth trying to apply Garbology theorems to medieval waste. On the other hand, *nouveau riche* wealth has never been the key to entering the upper class, who uses a distinctive set of symbols, marital networks and (in medieval times) ties of fidelity, honour and hierarchy: Owning a fancy horse and a magnificent armour did not qualify you for access to an aristocratic feast (Hørby 1980, 271).

The application of this model to the archaeological source material excavated in medieval castles presents one particular issue: In an ideal world, we would work with objects that had been carefully excavated by specialists with detailed documentation. However, the site selected here, Boringholm, was not excavated according to modern standards. Nevertheless, it is possible to regard its finds as the relics of one household that existed in a period of two generations. In settlements, households rather than individuals constitute the smallest archaeologically observable social unit.

The analysis of an old excavation on a castle site is a methodological challenge. Find complexes without contexts – not only from castles, but also from urban sites – are one of the most critical issues in modern archaeology. We could choose a radical solution by ignoring this material, which is typically excavated under challenging conditions, usually on the initiative of early enthusiasts. However, a more promising method involves developing new approaches to giving this material a voice. Schmid (2020) demonstrated the possibility of reconstructing even functional contexts on the basis of such finds. Moreover, the special character of castles offers one opportunity: In contrast to a town or village plot, a castle site is less subject to contamination. Castles are usually built in remote areas, on the top of a hill or in a bog, which reduces the impact of any neighbouring households. Agricultural use might have freighted dung containing sherds from farms into the plough layer, but this is not the case at Boringholm, which was located in muddy lowland that was not appropriate for husbandry. All archaeological contexts at this site are assigned to its household, even if besides primary and secondary deposition contexts there may be contexts for which a tertiary origin cannot be completely ruled out. The archaeological record then represents a fragmented picture of all the people of this time who lived here, while internal differentiation of the households, for instance between the owner's family and their servants, and the allocation of archaeological material to certain members, is generally difficult to achieve. In the future, more elaborate, detailed analysis of zones of activity based on archaeological context and the access analysis of rooms may make it possible to identify links to specific groups of the castle household (Friedrich 2006; Handzel and Kühtreiber 2015; Meyer 2006). This means that we have to accept that the material culture of this time might have belonged to different households that had lived on the site within its useful life. Moreover, it is a fact that the temporal resolution of archaeological sources, due to their very nature and available dating methods, remains generally rough – there are only a few cases in which the time span is shorter than one generation/30 years. As a result, we are studying an 'average household' comprising objects both from the master's and servants' householdings that were deposited on this site in a period of one or two generations.

Case Study: Boringholm

The castle was situated north of the small village of Boring in Hvirring Parish, the historical Nim Shire (Danish: *herred*), today Skanderborg Municipality. Christian Axel Jensen, curator at the National Museum of Denmark and a specialist in castle research, excavated the site entirely in 1906-12 according to the standards of the time, only exposing apparent features like wooden beams. Almost one hundred years later, the finds and documentation were analysed in a multidisciplinary research project at Aarhus University (Kock and Roesdahl 2005). The castle is situated close to the borders of the shires Nim, Vrads and Nørvang in wet lowlands far from country roads on a remote site. Such a hidden 'mud castle' was a typical humble fortified house of a rich peasant and his family during the uncertain times in the 14th century (Atzbach et al. 2018, 200 chart 2) (Figure 2). We do not know the site's original owner. According to written sources, Knight Iver Lykke's heirs transferred all of their rights in Boring including holm, house and buildings to Queen Margaret I of Denmark in 1400. Moreover, Knight Mogens Munk assigned his property in Boring, which he had received from Iver Lykke's heirs, to her in 1406, because he was aware that 'my gracious Lady Queen Margaret and the Kingdom are entitled to it' (after Ulsig 2005, 268, original text in *Diplomatarium Danicum* 1406). A few years before, in 1396, the royal law court decided that 'three parts of Boring, Boringholm and its belongings are to be distributed amongst the local peasants, while the fourth part, which was formerly owned by Peder Brok, was conveyed to King Valdemar earlier'. Erik Ulsig interprets this distribution as a restitution of misgotten property. The Brok family had already held some property in Boring since 1323 (Ulsig 2005, 267). It is not clear if this property comprised Boringholm Castle. Taking into consideration that the castle was not built before 1369, this transaction could concern a different site. Nor is it clear how Knight Iver Lykke, who was Queen Margaret I's retainer and counsellor, obtained the site. The cas-

Figure 2. Boringholm on the Royal Danish Academy of Sciences and Letters' map (*Videnskabernes Selskab Kort*, 1787). The castle was not visible on the original map, but was situated in the lake (Rasksø, blue markup) north of the village of Boring. Boring was situated at the dead end of a back road, while the trunk road connecting the market town of Ribe and the royal residence of Skanderborg crosses the map extract from Uldum to Nim (Markup and scaling: Katrin Atzbach; map: Geodatastyrelsen, downloaded from *Historiske kort på nettet*, https://hkpn.gst.dk/ [accessed 20 December 2021]).

tle was probably deserted on the Queen's order, which would fit well with her policy of suppressing adversaries and razing minor fortifications to the ground, because they were regarded as a risk to public peace (Atzbach 2021a; Etting 2004).

The Buildings

In the first construction phase, the castle was erected on a flat, natural mound in the former shallow Rasksø Lake in 1369 (d). This mound was only slightly above the water level, making the site very muddy especially in rainy periods. The inner castle with the main buildings measured about 40 x 40 m (Figure 3). A wooden bridge to the southeast connected the inner castle to the mainland (all subsequent descriptions following Johansen and Nielsen 2005). The central castle mound bore a pile foundation framed by bulkheads. Several layers of timber, branches and soil framed by two bulkheads expanded the natural mound to the north. Four wings surrounded a central courtyard: The north wing was the best preserved, measuring about 30 x 6 m. It consisted of a one-aisled building subdivided into three rooms, erected in 1371 (d). Wooden planks or sections of wattle and daub were notched into sill beams that also bore the posts forming the walls. There is no evidence for Heidi Maria Møller Nielsen's reconstruction of a rafter roof (Danish: *spærtag*) (Johansen and Nielsen 2005, fig. 6.13), since reversed assembly (Danish: *højremskonstruktion*) was widespread in late medieval Denmark, while no rafter roofs are documented on profane buildings in Denmark in the Middle Ages. The building construction documented during the excavation and interpreted by Christian Axel Jensen as well as Johansen and Nielsen (2005) needs to be revised. The floor consisted of planks and clay. A simple fireplace or oven heated the western room, while the central room contained a more elaborated fireplace built in ashlars from a ruined church. One single rim sherd of a vessel tile is documented (Andersen 2005a, 115 fig. 8.20), but this is not enough to conclude that there was a tile stove at this site. The northern building burnt down and was redressed in a similar way around 1374. The western wing measured about

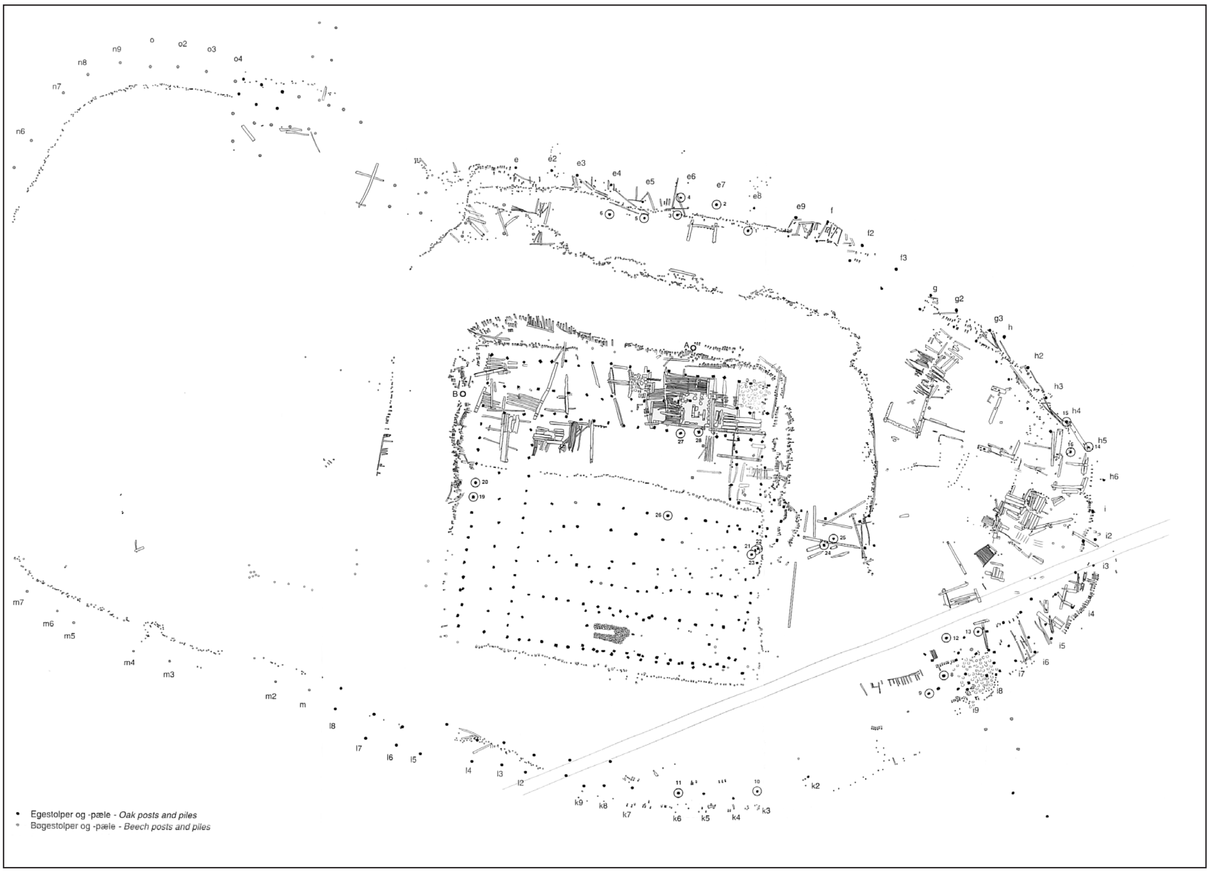

Figure 3. General plan of the Boringholm Castle excavation. The inner castle was built between 1369 and about 1372 on a shallow natural mound in the former Rasksø Lake. Originally, a wooden bridge to the southeast provided access from the mainland. Around 1380, the mound was artificially expanded to the northeast with an outer bailey and some outbuildings, and to the west, where no traces of buildings were found, but a newer bridge provided access to the mainland (Map: Ulla Johansen in Koch and Roesdahl 2005, Folding Plan).

23 x 5.50 m. It seems to be constructed as a two-aisled building with a purlin roof, built around 1370/72, but there is little information about its structure. The southern wing measured about 24 x 5 m; its construction matched the western building. To the east, a small wooden annex in the northern wing enclosed the courtyard. Evidently, the northern building was the main dwelling; the other wings housed the stable or barn.

In the second period, the castle mound was artificially expanded to the north, east and west, comprising about 10,000 m^2, in 1380. Around the central mound, a channel of about 6-7 m in width was not filled up, forming a wet moat between the older inner castle and the outer areas. The western area did not seem to have any buildings, and a younger wooden bridge to the north connected the castle to the mainland. The northern and eastern expansion might be regarded as an outer bailey with several half-timbered outbuildings. A bridge over the wet moat connected this area to the central mound. A palisade or even a rampart probably enclosed the castle, at least in its second period. The last repairs were made in 1401, before the castle was abandoned and torn down in the early 15th century.

The Finds

The wet ground preserved a large number of organic and inorganic finds at Boringholm: The excavations brought 1,407 objects to light, of which 42 % were organic. Else Østergård and Penelope Walter Rogers have analysed textiles, ropes and cords (Østergård and Rogers 2005), and Hanne Dahlerup Koch has analysed shoes (Koch 2005), while most of the finds have been scrutinised by Charlotte Boje H. Andersen in her PhD dissertation (Andersen 2003, 2005a). In an additional study based on Andersen's first registration, Boringholm's wide range of objects has been quantified by means of the *number of artefact types* (NAT), which was compared to twelve Danish medieval castles (Atzbach 2021c; Atzbach and Radohs 2021; summarized here in Appendix 1). This method was originally developed as a measurement for the wealth of grave goods: Instead of counting the number of *objects*, the number of *types* is registered, e.g. five sherds of greyware, two sherds of stoneware and a knife are not counted as eight *objects*, but as three *artefact types*, generating a NAT value of 3. The castles in that study were excavated between 1887 and 2000 with different methods following different collection strategies, which is not without problems. Lilleborg, Næsholm, Boringholm, Lykkesholm and Hedegård were excavated entirely more or less according to contemporary or modern standards. Ravnsborg was completely exposed by his owner without any archaeological supervision. Gurre, Nørrevold and Sandgravvold were excavated to a large extent. Thus, the absolute number of finds does not correlate to the degree of excavation but reflects the collection strategy. Interestingly, the NAT value is independent of the sheer number of objects. Evidently, the NAT method reduces the excavation or collection bias since even a single collected sherd/vessel of redware gives a count and documents the presence of this artefact type at a site: At Ravnsborg Castle, the excavator was scarcely interested in finds and collected only 562 objects; he barely wanted to expose his castle's walls. However, these objects make a NAT of 43, matching the range from Næsholm that was entirely excavated by professionals with the threefold number of finds. Hedegård Castle was completely excavated and generated more than 3.000 objects, which represent only 25 number of artefact types. Consequently, NAT is an effective way of sampling the range of objects even on a partially excavated site.

Another issue is differences in preservation conditions across the sites. To reduce the bias created by the favourable impact of wetland conditions on preserving organic objects that would not have survived in dry contexts, only the NAT of inorganic finds ought to be considered. The former study had two significant results: The number of artefact types is independent of the overall number of collected finds, but tends to correlate with the status of the castle's owner. For instance, the royal castle of Gurre has only been excavated partly but has a NAT value of 44 based on a total of 364 objects; whereas the knightly castle of Egholm has been fully excavated but only reaches a NAT value of 15 despite producing a larger number of objects (560). In other words, even partially excavated sites can be used as a sample. However, this hypothesis needs confirmation based on modern excavations with clear standards of context recording, sieving and controlled metal detecting.

Applying this method to Boringholm, all the inorganic artefact types totalled a NAT value of 42. 245 objects belonged to 23 artefact types that characterise an upper-status household, i.e. riding gear, precious weapons, jewellery, imported tableware or gaming pieces (Andersen 2004, 16; Atzbach and Radohs 2021; Goßler 2005, 2009, 2015; Krauskopf 2006, 2021, 230). Instead of presenting all finds again, a few exquisite objects will serve to illustrate the high standard of material culture at Boringholm: Imported pottery demonstrates the presence of widespread contacts, with the Italian Archaic Maiolica that served as a spice container perhaps documenting that the inhabitants enjoyed refined meals (Blake 2021, 31, fig. 2.4.2; formerly identified as Saintonge in Andersen 2005a, 116, fig. 8.23). There is also a remarkably large number of Rhenish stoneware artefacts (Andersen 2005a, 116-118, fig. 8.26). A brass-damascened sword from Passau with a discoid pommel and triangle guards, found in its scabbard 'in deep layers' to the west of the western fireplace, is an outstanding weapon (Andersen 2005a, 141-143, fig. 8.80). Its quality matches the bronze spur with engravings and the quatrefoil-decorated bronze stirrup (Andersen 2005a, 156-158, fig. 8.104, 155, fig. 8.101). Two small wooden shields with a coat of arms (which looks rather like a house mark, Andersen 2005a, 152, fig. 8.97) are also rare, and were probably used for decorative purposes in the hall in the main building. A set of chessmen documents that there was also time for courtly leisure activity (Andersen 2005a, 176, fig. 8.142) (Figure 4).

The majority of the objects found can be associated with ordinary householding activities such as cooking and farming, and there is a broad range of tools and equipment (Andersen 2005a, 158-162). Moreover, there are finds with a clear military character documented by 106 parts of weapons or

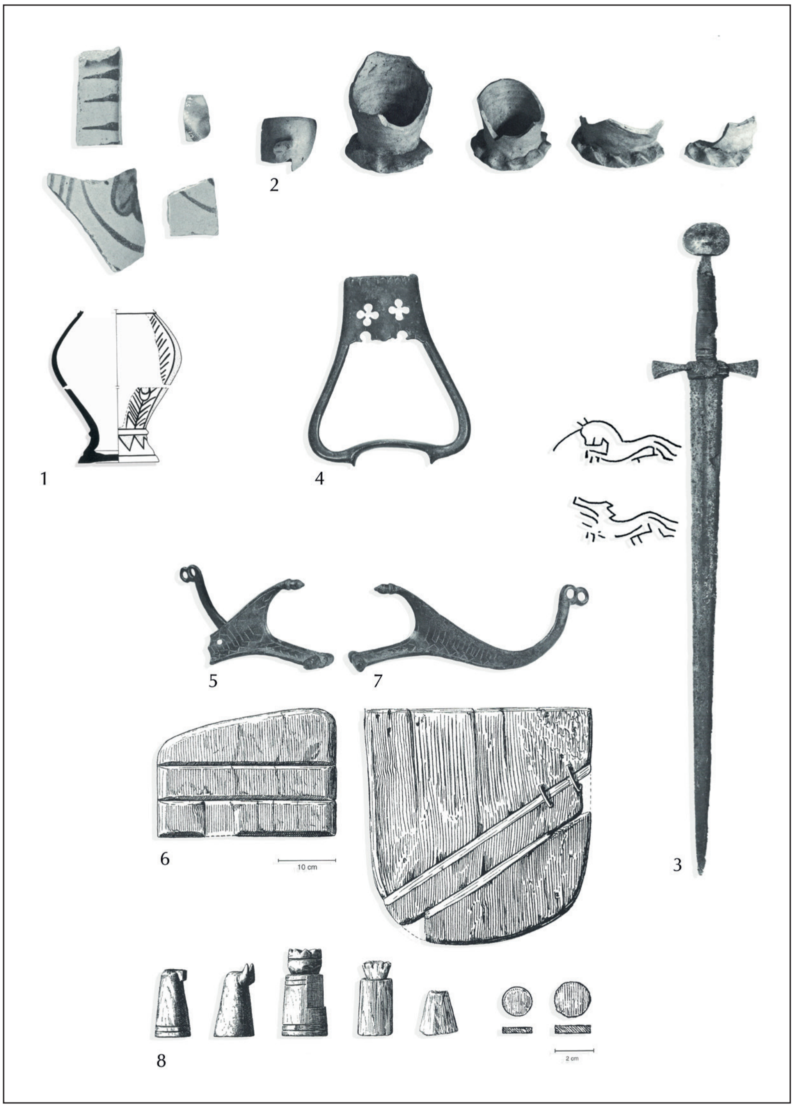

Figure 4. Outstanding single objects illustrate the elite culture at Boringholm:

1) Italian Archaic Maiolica (Blake 2021, fig. 2.4.2 and 2.6).
2) Rhenish stoneware (117, fig. 8.26).
3) A sword from Passau (141, fig. 8.80).
4) A bronze stirrup (155, fig. 8.101, NM).
5) A bronze spur with engravings (158, fig. 8.104).
6) Two shields with a coat of arms (or more likely a house mark, 151, fig. 8.97).
7) An engraved spur (155-158, fig. 8.104).
8) A set of chessmen (176, fig. 8.142).

(Graphic composition: Katrin Atzbach, drawings: Peter Linde, photographs: National Museum of Denmark).

armour. 83 items are associated with horses (horse gear, horseshoes, currycombs, spurs, stirrups) and signify chivalry. The aforementioned outstanding objects reflect an affluent way of life with international connections and the time for leisure and gaming. Thus, Boringholm resembles an aristocratic household rather than a peasant household. This fact is also supported by the castle's demography, which can be identified based on the leather shoes that were found here. Willy Groenman-van Waateringe (1978, 1984) developed a graphical-statistical method based on the phenomenon that each collection of shoe soles shows two characteristic peaks for women and men (in today's Denmark 43 in French stitches for men and 40 for women, TV-Østjylland 2021) (Figure 5). Hanne Dahlerup Koch's data about Boringholm's shoes provide a proxy for the residents at this castle (Figure 6): 113 of the 192 soles could be identified as adult men's (Koch 1990, 33-55, fig. 15 and 26). Only 79 soles belong to the small-sized groups, i.e. children, adolescents and women. 'Male shoes' constitute 59%, which is an astonishingly large proportion in comparison with other late medieval sites, where children's soles usually represent the biggest proportion (Atzbach 2012, fig. 10). This demonstrates that Boringholm housed not only its owner's family, but also a group of male individuals, probably retainers (Andersen 2005a, 167, fig. 8.126; Koch 2005, 217-218, fig. 217, 10.23).

Discussion

According to the written sources, Boringholm was involved in the conflict between Queen Margaret and the Jutlandic aristocracy. We do not know its former owner, but it is clear that the castle was handed over to Queen Margaret via her retainer Iver Lykke and his heirs. Shortly afterwards, it was

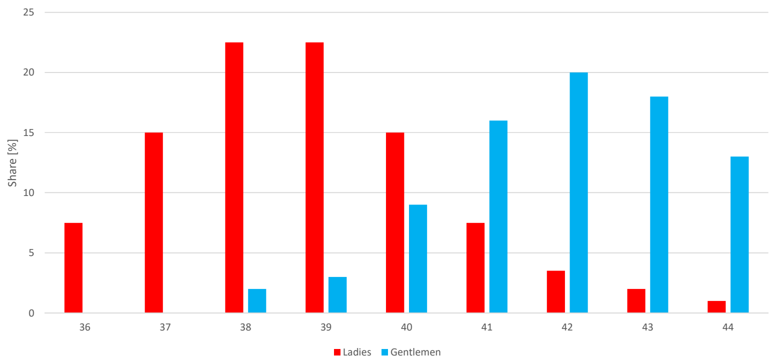

Figure 5. Distribution of shoe sizes in Germany in French stitches (2017). The female peak is located at size 38, the male peak at size 42 (Graphics: Rainer Atzbach, data: Neumann 2022).

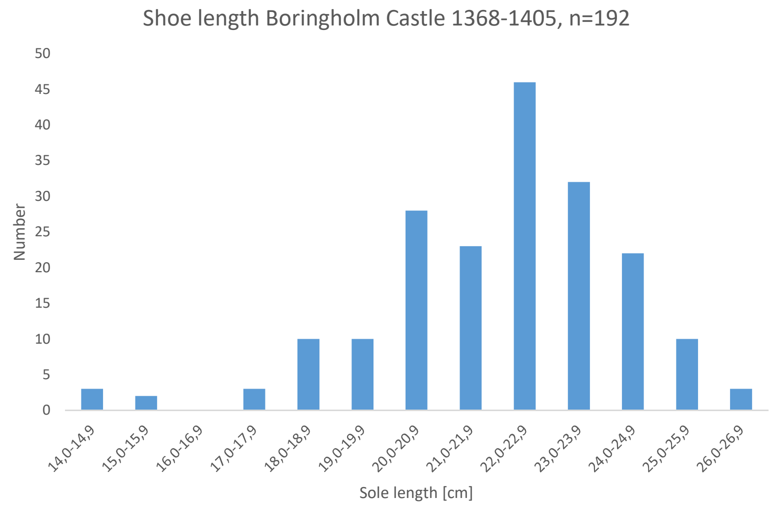

Figure 6. Distribution of shoe lengths at Boringholm: 113 of 192 soles seem to belong to the male peak, while 79 soles are left for children, adolescents and women (Graphics: Rainer Atzbach, based upon data from Koch 1990, 33-55, fig. 15 and 26).

deserted. Moreover, all former possessions of the Brok family – who had been an opponent to the Danish Kingdom – in Boring were distributed among the local peasants in the late 14th century. This supports the hypothesis that Boringholm was one of the illegal fortifications that were the 'origin of injustice' banned by the Queen in 1396 (Kroman 1971, 334-344, No. 35, article 3).

Boringholm was situated close to the border with the neighbouring shire, a typical position for Danish castles. One previous study showed a relationship between the view that a castle provided and its owner's rank. Boringholm occupies a middle position between royal and ducal castles, which tend to take central positions as a landmark and even more remote fortified refuges of peasants (Atzbach et al. 2018, 200-201). Boringholm was not able to control the important trunk roads drawn on *Videnskabernes Selskab*'s map in 1787 because of its remote position at the dead end of a back road that only accessed Boring (Figure 2). This humble and hidden type of fortified farm is described in *Chronica Sialandie* in the year 1359, when the Jutlanders started their uprising against King Valdemar Atterdag, who had built 'castles of mud and tile, and they did not even have straw left' (*in luto et latere castra edificarunt, nec palea eis dabatur*, translated by the author after *Chronica Sialandie* 1359, 141 = 51v), a reference to *Vulgata*, Exodus 5,7, where bricks had to be produced by the Israelites in Egypt, who even had to provide their own straw. Stefan Magnussen identified such a remote position as characteristic of minor private castles in Southern Jutland, while important ducal or royal fortifications were typically located in the vicinity of centres of communication (Magnussen 2019, 147). A study of King Erik Menved's fortifications in Jutland supports this hypothesis: His strongholds were always erected close to transport nodal points (Atzbach 2021b, 171-172). Its remote position puts Boringholm in the group of minor private castles built during the 14th century. Its architectural layout, a three- or four-wing set of half-timbered buildings without any evidence of a second storey or even a tower, resembles a farmstead far more than a castle. Our knowledge about late medieval farms is limited, but known examples like Tårnby and Store Valby on Zealand and Kyrkheddinge or Ilstorp in Scania show dimensions similar to Boringholm's inner

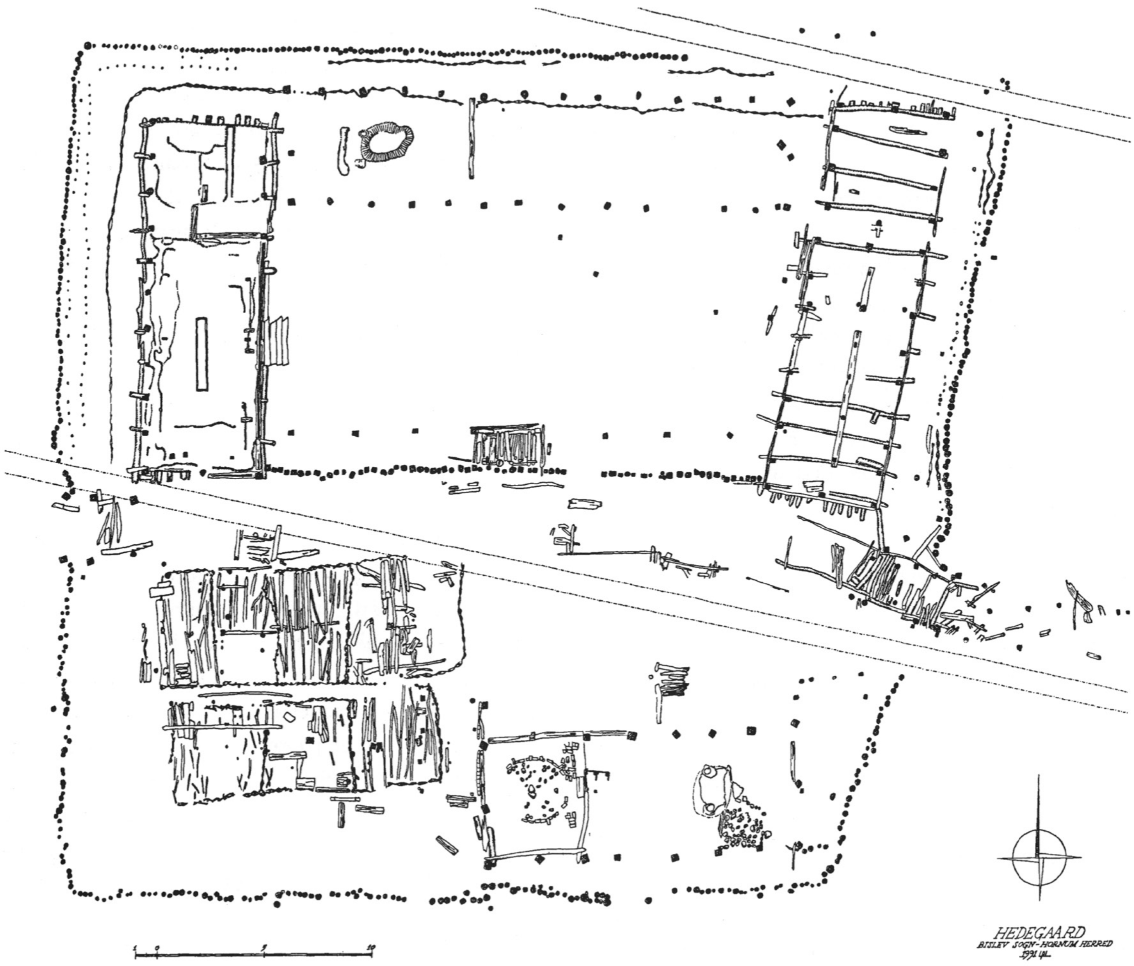

Figure 7. Hedegård Castle in Himmerland, Northern Jutland. It looks like Boringholm's twin. The castle existed between 1363 and 1390, was erected in wet lowlands and consisted of three half-timbered buildings (Reproduced after Nielsen and Johansen 2005, 282 fig. 15.6).

castle. They also comprise a main building with at least two fireplaces (Tårnby: Kristiansen 2005, 175-185; Kristiansen and Roland 2005, 132-135; Store Valby: Kristiansen 2006, 157, 163; Kyrkheddinge: Sabo 2001, 19-21; Ilstorp: Tesch 1996). However, Boringholm's compact and enclosed structure differs from the more open farmsteads and corresponds to its function as a castle. Wooden castles are known in 14th-century Denmark: The minor castle of Hedegård in Himmerland (1363-90) looks like Boringholm's twin and is similar in topography, dating, construction, size and shape, but its material culture bears witness to a corresponding agricultural lifestyle rather than an aristocratic one (Figure 7) (Hyldgård 1988; Nielsen and Johansen 2005, 282-283). Egholm or Nørre Kongerslev, for example, were also positioned in wet lowlands on natural or artificial mounds like Boringholm, but have a wooden tower (discussion of further examples, cf. Nielsen and Johansen 2005, 280-283). There is no doubt that wood was a less prestigious building material than stone or brick: The small royal Bygholm Castle was built in a hurry by King Erik Menved on a mound of about 35 m in diameter west of Horsens during the Jutlandic uprising in 1313/14. It consisted of three (or four?) small wings – but was completely erected in brick (Atzbach 2021b, 169-170 with further references). In the 14th century, all castles built by the crown or magnates were erected (at least in the central parts) in brick or stone, frequently equipped with a donjon or at least a keep (Etting 2010, 67-79, 111-189). Nørrevold alias Arnsholm Castle close to Arrild in Southern Jutland has a more or less similar range of prestigious and aristocratic objects. Valdemar Sappi, who belonged to the ducal family of Schleswig, built his seat on three mounds between 1351 and 1368. Although its dimensions are only slightly larger than Boringholm's, a central brick tower outclasses Boringholm's architecture (Atzbach and Radohs 2021, 143-144).

Overall, Boringholm Castle provides only a few fortification elements: Its remote position in a muddy wetland, its compact layout enclosed by a wooden palisade and a structure reminiscent of an "outer bailey". If we want to argue for military relevance, we will have to put Boringholm on the lower end of the scale between a fenced farmstead in a village and a stone-built royal castle on a hill.

On the European level, there are various examples of the prestigious character of stone-built castles: In Switzerland, the wooden castle of Rouelbeau close to Genève was erected between 1334 and 1339, but replaced by a stone version only ten years later (Terrier and Regelin 2009). In Hesse, Münzenberg Castle north of Frankfurt am Main and Romrod Castle were protected by a prestigious and impressive stone wall facing the country road, while the other side was only enclosed by a fence (Atzbach 2018, 190-192; Friedrich 2008). In England, Bodiam Castle, Sussex, also had doubtful military value. Its excellent preservation has made it one of the best-researched fortifications in Europe. Apart from its masonry, it shares some traits with Boringholm: Located in low wetlands close to a regional border, it was erected by a parvenu in the last quarter of the 14th century. However, its patron, Sir Edward Dallinridge, managed to keep his seat and to make his family part of the English aristocracy (Johnson 2002).

The finds from Boringholm demonstrate the presence of a high-status lifestyle that is characterised by typical 'barometer objects' such as imported pottery, precious personal items and weapons, armour and riding gear as well as unique building elements – in this case a fireplace made of ashlars, perhaps a tile stove that was torn down (Goßler 2015, 355; Hundsbichler et al. 1982, 53). Andersen's qualitative analysis attributed a knightly status to the castle's inhabitants (Andersen 2003, 69, 2004, 2005b, 2012, 7). Kasper Terp Høgsberg reviewed the finds and confirmed the presence of an aristocratic culture at Boringholm (Høgsberg 2014). He identified a broad range of standard equipment (keys, lockers, furnishings, greyware and redware pottery, kitchen equipment, ordinary linen and wool textiles, shoes, knives, scabbards, combs, riding gear and tools). Moreover, he classified some objects as luxury items (ashlars, imported pottery, brass jars, jewellery, a sword, a specially decorated spur and stirrup, hunting equipment, coins and toys) (Høgsberg 2014, 24-29). A comprehensive analysis of material culture comparing 13 Danish medieval castles revealed that Boringholm with its NAT value of 48 belongs to the group with the widest range of objects (Figure 8 and Appendix 1). Disregarding organic finds – which might be biased due to different preservation conditions – Boringholm still comprises 42 artefact types, which is only outmatched by the royal castles of Lilleborg (53), Gurre (44) and Næsholm – which is ascribed to the king or one of his retainers – and the comital Ravnsborg (43). Variety matters as an indicator of affluence in the Middle Ages: Boringholm's twin, Hedegård, provided only 25 artefact types (Atzbach and Radohs 2021, 148, Tab. 10), although it contained twice the number of finds (3,505 objects). Boringholm clearly represents an aristocratic lifestyle in terms of both the quality of its single objects and the range of its material culture. Goßler identified riding gear as a central signal of an aristocratic lifestyle, and the strong presence of objects related to horse keeping underlines the aristocratic character of Boringholm (Goßler 2005, 141-142). If we only look at the number of artefact types that fall into the category of barometer objects, Boringholm belongs to the top group together with Lilleborg, Gurre and Ravnsborg.

A further strong aristocratic signal is visible in the use of stoneware. Recently, the relevance of stoneware as an indicator of upper-class contexts has been confirmed for the Baltic region: Boringholm's proportion of stoneware (12 %) is higher than the most scrutinised Danish private castles including the ducal Nørrevold. Moreover, this proportion outmatches all Danish towns. Only the upper-class castles (Gurre, Næsholm, Ravnsborg) outnumber Boringholm with a proportion of up to 82 %, whereas Boringholm's twin, Hedegård, only contains 2 % (Atzbach and Radohs 2021, 152-155). The supply of Rhenish and Saxon stoneware depends on access to the Hanseatic market – and in Hanseatic towns such stoneware is ubiquitous with a proportion of about 17-36 % (Atzbach and Radohs 2021, 155, fig. 15;

Castle	Number all finds	NAT all	Number inorganic finds	NAT inorganic	NAT barometer	Stone-ware (%)	Status after Andersen
Lilleborg	4000	55	3998	53	26	3	royal
Gurre	364	48	334	44	23	53	royal
Næsholm	1531	46	1510	43	19	17	royal (?)
Ravnsborg	562	43	562	43	23	82	comital
Boringholm	1407	48	814	42	23	12	knightly
Nørrevold	1961	45	1502	39	17	6	ducal family
Lykkesholm	398	30	397	29	9	4	peasant
Sandgravvold	517	28	513	26	12	1	knightly
Hedegård	3505	31	3270	25	12	2	peasant
Absalons Skanse	372	20	365	19	9	8	watch tower
Heigned	171	18	171	18	5	5	peasant
Egholm	560	22	478	15	5	0	knightly
Nørre Kongerslev	262	14	259	12	6	2	unknown

Figure 8. Number of all finds, number of all artefact types (NAT), number of inorganic finds, number of inorganic artefact types, number of object types regarded as barometer objects, and the proportion of stoneware pottery at selected Danish castles. Status according to Charlotte Boje Andersen's qualitative analysis (Graphics: Rainer Atzbach, compiled from Atzbach and Radohs 2021, table 9-11. Data basis: Andersen 2003).

Müller 1996, 131). However, the supply in the hinterland seems to be limited, with Demuth's study of Hanseatic pottery in Norway revealing its restriction to the coastal region, especially in harbours. Ben Jervis discussed a similar phenomenon in relation to imported pottery in the coastal region in medieval Southern England. Both studies identified the use of imported tableware as an expression of a certain lifestyle, i.e. a conscious decision to acquire – or not to acquire – imported pottery (Demuth 2019; Jervis 2017). Further studies are required to find an explanation of why stoneware is only represented in Danish towns on a limited scale: Even the important harbours of Ribe, Aarhus, Holbæk and Næstved do not contain more than 6% (Atzbach and Radohs 2021, 154 f.). Consequently, the strong presence of stoneware at Boringholm, 17 km (half a day's journey) from the sea, is clearly indicative of an affluent way of life.

Christof Krauskopf's study of noble culture in Central Europe showed that all castles contained standard equipment, while luxury items, hunting equipment, toys and specially decorated personal items belong to an upper-class lifestyle, which is also characterised by the absence of agricultural tools (Krauskopf 2006, 2021). In other words, Boringholm's strong agricultural element places it on the lower level of the aristocratic social echelon.

Its affluent material culture is in complete contradiction with the modest type of architecture. Boringholm has almost the same NAT value as the castles of Ravnsborg and Næsholm (both have a NAT value of 43); but these two castles had an elaborate and differentiated stone architecture with a massive keep and a curtain wall. This becomes clearer when looking at the architecture of castles that have a significantly lower NAT value than Boringholm. Lykkesholm on Langeland (NAT 29) comprised two half-timbered buildings as well as a central brick tower. We have no building evidence from Sandgravvold (26); but as mentioned above, Hedegård in Northern Jutland (25) features a similar structure. Absalons Skanse (19) had only a wooden watchtower, Heigned on Langeland (18) was a brick-built towerhouse, and Egholm in Northern Jutland (15) consisted of a wooden tower surrounded by a palisade. Nørre Kongerslev in Northern Jutland featured a wooden main tower on the inner castle and a second one in the outer bailey (Atzbach and Radohs 2021, 140-144 with further references).

What is the explanation of this obvious contrast between modest wooden architecture and an affluent material culture representing an aristocratic lifestyle?

Such a mismatch between the social status according to written documents and the excavated material culture did not become visible until the excavations of 19th-century poorhouses. Firgårde poorhouse (1880-1916), close to Skanderborg, brought a surprising range of finds to light, resembling a manor's household rather than an almshouse, comprising e.g. gilded porcelain plates, ice-skates, crystal glass, porcelain tobacco pipes and a porcelain doll (Mauritzen et al. 2007, 49-52; Nielsen and Hansen 2017, 80-84). The poor and criminal Olof Petterson lived in a forest in the Swedish countryside, in a humble dugout cabin that was in use in the first half of the 19th century. Its excavation revealed horseshoes, porcelain sherds and a range of objects that were similar to a quite well-off nearby croft (Svensson et al. 2020, 173). Both examples reveal the attempts of the poor to follow contemporary consumption patterns, which is a link to William Rathje's garbology. Theorem (1), '*What we say is not what we do*', cannot be applied to Boringholm, as we lack certain evidence about the founder's social status apart from the fact that he – and it was probably a man – belonged to the medieval group of *bellatores*, as proven by the site's clear military character. Theorem (2), *There is no immediate relationship between garbage and a household inventory*, argues that valuables or valued personal objects were absent in a household's garbage because they had been given to friends and relatives. One possible explanation for the broad range of valuable or at least symbolic objects discarded at Boringholm is the lack of potential gift receivers: Marcel Mauss's theory about gifts from 1925 (new translation 2016) introduces the idea that each gift is meant to impose an obligation on the receiver. In particular, the precious sword from Passau which was buried might have been a highly symbolic object that the castle founder received himself as a pledge for some kind of feudal or military loyalty. Discarding or simply leaving this object (and the other valuables) on the site seems to indicate a lack of appropriate followers who would be pleased to receive such an object. Theorem (3), *First principle of food waste*, and theorem (4), *First principle of hazardous waste*, paraphrase the fact that rare, expensive or exotic objects tend to be overrepresented in a household's garbage. Applying these theorems to Boringholm, the mismatching upper-class garbage was *not* part of the inhabitants' traditional daily life. Together with theorem (5), *Branded goods in waste indicate eagerness to follow a role model*, the presence of excellent aristocratic objects belonging to the contemporary military elite's lifestyle, but ending in this household's garbage, underlines that the inhabitants originally were not accustomed to noble courtly culture. Naturally, the objects were owned by the inhabitants; their sheer number gives the lie to the interpretation that they were stolen goods like the golden brooch in the Schleswig fisherman's hut. Theorem (5) is driven by the interest of the middle class in imitating upper-class culture. Consequently, the luxury items might have been used to emulate a courtly way of living, as documented by the prestigious, big fireplace made of ashlars.

Building a castle is always a large investment. Boringholm's building process took at least three years: It started with the pile foundation, whose trees were cut in winter 1368/69, i.e. used in summer 1369. The main building's first phase was erected in summer 1371, but the western and southern wings were not built until 1372. Taking into consideration the bellicose period in the second third of the 14th century, this surprisingly slow process reflects a lack of resources. Its modest result ended up with neither a tower nor at least one brick building or even timber frames filled with bricks. Boringholm's builder was a man who had the power to fortify his home and was experienced in military service. He gathered horses and armoured retainers on this site, where his family also lived, and where the only female inhabitants were members of this family, striving to achieve an upper-class lifestyle. The clear military character made Charlotte Boje H. Andersen ascribe this castle to a knight (Andersen 2003, 69, 2012, 7), who evidently strove to achieve aristocratic status, but was not affluent enough to create the appropriate high-class framework to display his objects. Late medieval Denmark is characterised by the crisis of the lower aristocracy: Individuals who had once been successful social climbers in the service of the king or a magnate did not manage to compete with the more powerful and richer magnates who profited both from the ox trade and their allegiance to the king/queen. The new organisation of land use, characterised by the presence of a small number of manors, destroyed the lower nobility's economic basis and limited the opportunities for social climbers. These minor aristocratic landowners had to become the retainers of a magnate – otherwise their fortunes declined, and they became ordinary peasants. This phenomenon has been described as 'the Fall of the Danish gentry' (Dahlerup 1969; Hørby 1980, 243 f.).

Modern sociology has shown that individuals who strive for a certain status try to compensate for a lack of knowledge, experience, position or power by using prestigious goods and status symbols. The weakest students of economics wear the most expensive shoes and watches, and have the most expensive briefcases (Stihler 1998, 58-59; Wicklund and Gollwitzer 1981, 89-90). This kind of self-promotion by means of objects is also known from traditional societies in the Global South, where ethnological research on the one hand has found that strange or exotic objects are assigned the role of status symbols. On the other hand, these mismatching objects tend to go into oblivion or are discarded if they are not integrated into the daily household processes (Hahn 2005, 76). Objects and their owners act interdependently: Single, special, exotic objects might acquire a special meaning for their owner. But this meaning cannot be transferred to a new owner, so they end up as waste when their owner has to leave them behind (Hahn 2015, 11-12).

Conclusion

A rose is a rose is a rose, but no castle is like another one. Each castle, manor or fortification ought to be studied as a single case and not as an example for a type or a function. In this sense, Boringholm is also an exceptional site that should not be regarded only as a wealthy peasant's temporal refuge during a time of crisis. Its construction began in 1369, in the 'Age of the Castle', when several waves of warfare hit Denmark. Without doubt, its founder belonged to the military aristocracy of this period. He was able to equip his building with the necessary attributes to show off his aristocratic rank, emulating some elements of courtly culture. What we see here is an ambitious knight rather than a settled nobleman: Formally free, experienced in military service, wearing a coat of arms and a sword, enjoying luxury items and living in a castle. However, his seat resembles more a moated farm than a fortress. William Rathje's garbology helps to explain and to understand the contradiction between the presence of affluent finds and modest buildings: This man was a social climber who was not yet able to leave his peasant background behind. Boringholm was probably inhabited by a dedicated retainer of the Brok family, a parvenu on his way upwards, who simply chose the wrong side during the fight between the Kingdom of Denmark and the Jutlandic opposition. He lost at least his property, maybe even his life, and his castle was subsequently handed over to the Queen's followers, the Lykke family, in the late 14th century, before it was torn down at the Queen's command. Robber knight Meier Helmbrecht was executed for his deeds by his former victims. Our anonymous knight was punished for his uprising against the royal vision of public peace. His castle was destroyed – we do not know what happened to him but, probably, his social climbing ended with his aristocratic householding in Boringholm.

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Supplement:

Castle	Number of all finds	Number of inorganic finds	NAT all finds	NAT only inorganic	Extent of excavation	Status	Dating
Lilleborg	4000	3998	55	53	The majority of walls exposed	royal	1100-1300
Gurre	364	334	48	44	Partially exposed and excavated.	royal	*c.*1365- before 1534
Næsholm	1531	1510	46	43	Completely exposed walls	royal (?)	1278-1340
Ravnsborg	562	562	43	43	Completely exposed	comital/royal	1334-1510
Boringholm	1407	814	48	42	Completely exposed	knightly/unknown	1368-1401
Nørrevold	1961	1502	45	39	Partly excavated in trenches and fields	ducal family	1351-68
Lykkesholm	398	397	30	29	Partially excavated	peasant	2nd h. 13.-mid 15th c.
Sandgravvold	517	513	28	26	Destroyed. Partially excavated	knightly	13th/14th c.
Hedegård	3505	3270	31	25	Completely exposed	"not a knight", peasant	1362-1406
Absalons Skanse	372	365	20	19	Partially excavated	watch tower	1st h. 14th c.
Heigned	171	171	18	18	Partially excavated	peasant	14th/15th c.
Egholm	560	478	22	15	Completely excavated	knightly	1335-1340/50
Nørre Kongerslev	262	259	14	12	Poor preservation, completely excavated.	unknown	2nd h. 14th c.
Sum	**15610**	**14173**					

Appendix 1. Distribution of finds at 13 Danish castles. 'NAT'= Number of artefact types; excavation method: 'Excavated'= modern, stratigraphical excavation; 'exposed'= digging out obvious contexts such as walls and wooden beams without documentation of soil contexts and the relationship between finds and contexts. Extent of excavation and status according to Charlotte B.H. Andersen (2003), data compiled from Atzbach and Radohs 2021, table 7 and 9 with further sources and references.

Dietary Stories: A Multi-proxy Study of Food Remains Recovered from Dominikonų St. 11 in Vilnius Between the 15th-18th Centuries

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ABSTRACT

This article presents research results from an archaeological excavation in the area of Dominikonų St. 11 in Vilnius Old Town using four groups of evidence: archaeological artefacts, historical records and zooarchaeological and archaeobotanical research results. The analysed material covers a wide chronological range (between 15th and 18th century) allowing us to observe dietary changes in relation to architectural development and spatial distribution. This research shows changes in human diet over time from the pre-Palace period when human diet consisted of grain and cattle to imported oysters, veal, game, and wines during the Palace period.

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Introduction

The consumption of food and drinks is tightly intertwined with social status of people, their ethnicity, religious beliefs, environment or social factors (Valenzuela-Lamas et al. 2014). Understanding what plant and animal species were consumed in the past and how their consumption varied over time can significantly contribute to the knowledge about the daily lives of the local population (Twiss 2012; Karg 2007). While studying archaeological material from the historical periods it is important to combine both historical sources of past diets as well as recovered ecofactual and artefactual material for a better reconstruction of past diets.

The historical datasets of past food consumption in Lithuania can be found in various account books of different households, estate inventories, recipe books, shopping lists, shop inventories (e.g., Antanavičius 2012; Jablonskis 1934; Jurginis and Šidlauskas 1988; Valikonytė et al. 2001). In addition, various estate record books provide information on what foods were purchased, sold or collected as taxes, what was cultivated, harvested, and what was consumed by people or used as animal fodder. This does not necessarily reveal the nutritional spectrum of the general population, as the food supplies to the residents of a higher status were mostly documented. It is possible to track information about many food sources in various law books, metricas (e.g., Lithuanian Metrica) from the 15th century onwards. However, sometimes not all purchased foods or those obtained in other ways are documented in detail due to the author's subjective approach. Especially, when food is not purchased but rather locally grown and collected or wild animals were hunted down, one can find evidence of past foodways only from archaeological datasets. A broad picture of historical cuisine can be drawn from the works of historians, but again, it is often based on historical sources, like, account books where food sources of monarch or nobility are presented (Dambrauskaitė 2021; Laužikas 2014, Margienė-Zarankaitė 2018), thus lacking the information about the commoner's diet or the extent of certain food consumption among various levels of society. On the other hand, some spic-

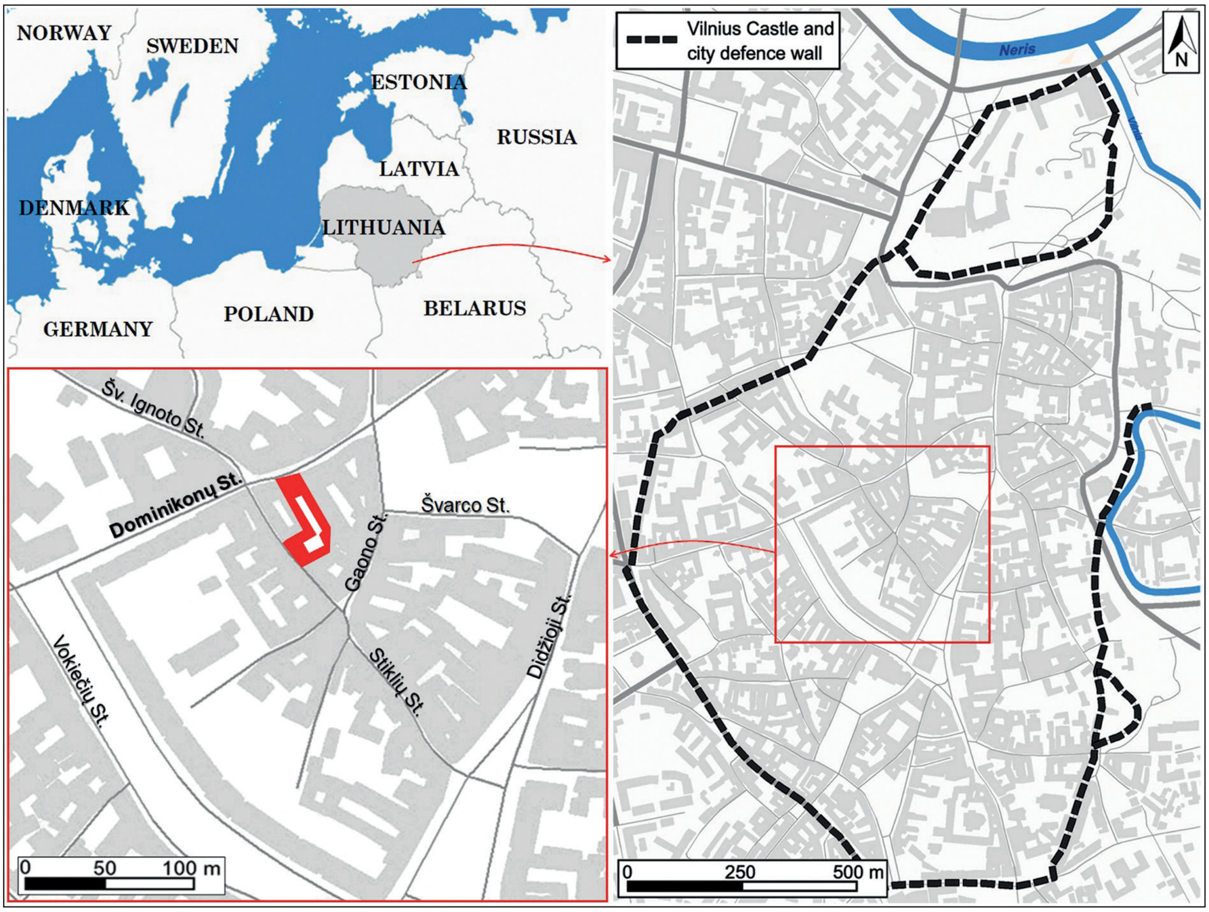


Figure 1. Location of Dominikonų St. 11 complex (Graphics: R. Karaliūtė).

es or herbs, fragile saffron stigmas are unlikely to preserve archaeologically, thereby we almost have no records of them, while historical information hold records about their use (Hjelle 2007, 173). Therefore, if possible, combined archaeobotanical, zooarchaeological, and historical data should be used for a better understanding of past foodways and diets.

Currently there are no combined bioarchaeological studies from Vilnius city. Complex analyses of zooarchaeological and archaeobotanical data are still very rare, and if conducted, results are never published together, despite the fact that combined they represent a much fuller picture of past foodways. The best-known case of bioarchaeological research in Vilnius is from the Upper and Lower Castles. Several articles based on archaeobotanical material (pollen and macrofossils) have been written (e.g., Motuzaitė Matuzevičiūtė et al. 2020; Stančikaitė et al. 2008), while a monograph of zooarchaeological data has been published separately (Blaževičius 2018). Unfortunately, a combined overview of past diet based on these fine results has not been provided yet.

The aim of this paper is to evaluate the dietary habits and the dietary changes through time of the population that lived in the area of Dominikonų Street 11 between 15th-18th centuries in Vilnius. We apply a multiproxy approach using archaeological, zooarchaeological, archaeobotanical and historical data to better understand the dietary habits and changes. Finally, we aim to foster further discussions of the pros and cons of focusing on a single type of data, and how the dietary picture can unfold when multiple sets of evidence are used together.

A Historical Overview of the Households of Dominikonų St. 11

The building and the courtyard located at Dominikonų St. 11 represents the former Pociej Palace in Vilnius Old Town (Figure 1) that was

Figure 2. Dominikonų Street (1850) by Jean Baptiste Arnout and Adolphe Jean-Baptiste Bayot (Album de Wilna, 2e Série 3e Liv.). A building of Dominikonų St. 11 is the middle of street on the right side.

built during the 17th-18th centuries. There is relatively little information about the previous development of this area. The land plot is located on the south-eastern side of Dominikonų St., next to the well-known road from Vilnius Lower Castle to Trakai, established in the 14th century. It has been speculated that during the 15th century there may had been two households with buildings along the street, but by the 17th century they were merged into one under the same owner (Čaplinskas 2008, 119; Zilinskas and Blinstrubienė 2018, 2).

A historical document dated July 18 in 1600 mentions a large luxury house that Eustachy Wołłowicz sold to the Vilnius Royal goldsmith Mikołaj Bretszneider (Paknys 2006, 157). According to the 1636 census of Vilnius city residents and their houses, the same house belongs to the city jurisdiction and is reported to have had three rooms, one of which was heated. It also contained a goldsmith's shop, a small room, one storage room, two cellar units, a distillery, a stable for two horses and a large courtyard.

In 1668, the land plot belonged to Alexander Jasienski-Wojna and it contained three masonry houses with cellars. 30 years later, the property inventory of A. Jasienski-Wojna mentions not three separate houses, but a representative palace. The main entrance is believed to have been from the Dominikonų St. side (high street), while the representative gate was on Stiklių St. (side street) (Čaplinskas 2008, 119-120; Drėma 1991, 37-38; Zilinskas and Blinstrubienė 2018, 1-3). From 1668 to 1698, major changes took place in this land plot. During the Russo-Polish War in 1654-1667, buildings were damaged, and large-scale reconstruction works started after the war. This has been confirmed during archaeological excavation (Žvirblys 2021, 563).

In 1700, the palace was inherited by the owner's daughter Teresa Wojna-Brzostowska. Soon she became a widow, but not for long as she married Alexander Pociej, a voivode of Trakai and passed on the palace to the Pociej family. On June 11 in 1748, a huge fire started in Vilnius. The palace was badly damaged again. After the conflagration, the palace was not only repaired but also expanded.

Chronology	Period of Early Residents	Period of Commoners from Masonry Houses	Royal Goldsmith Workshop and a Period of New Constructions	Palace Period
	15th c.	15-17th c.	late 16-17th c.	18th c.
Number of archaeological contexts[1]	1 : 1	10 : 2	8 : 1	5 : 2
Total (fauna)[2]	58 (+58)	180 (+3301)	184 (+87)	535 (+38)
Total (flora)	41	249	76	726

1 Since the number of contexts varies according to the archaeological material, the exact number of each of them is given here - (number of zooarchaeological contexts) : (number of archaeobotanical contexts).
2 Number of bones collected from the heavy residue of the sediment samples is given in brackets.

Table 1. Main information of analyzed contexts from Dominikonų St. 11.

Facades acquired the features of Classicism style; a gallery was built above the main entrance gate from the yard side. In the 19th century, the palace lost its representative purpose and was converted into apartments, and its current condition reflects this layout (Figure 2) (Čaplinskas 2008, 120-123; Drėma 1991, 37-38, 228-229; Zilinskas and Blinstrubienė 2018, 1-3).

Materials and Methods

In 2019-2020, an archaeological survey (*c*.435 m²) and excavation (288 m²) were conducted at Dominikonų St. 11 in Vilnius. Archaeological excavation took place in rooms, cellars, and courtyards of the building complex (Žvirblys 2021, 566). The samples for zooarchaeological and archaeobotanical analyses were collected from various features including kitchen waste pits, fireplaces, or waste dumps in the basement areas dated between 15th-18th centuries (Table 1).

The area of the archaeological excavation had been disturbed in 1968–1973 during the installation of underground-centralized heating and other utility pipes. Despite this, some of the trenches and test pits revealed undisturbed cultural layers (Žvirblys 2021, 563). Historically recorded events, such as reconstruction of buildings, traces left by fire, change of household owners etc., enabled accurate dating of the investigated structures and explained their formation. Certain structures, specifically inside the building, dated by historical architects (Zilinskas and Blinstrubienė 2018, 1-3). Some contexts were also dated not only by architectural affiliations, but also by established typological chronologies of household pottery, stove tiles and glassware (e.g., Katalynas 2015; Vaitkevičius 2004). For the purpose of this article, we divide the material into four periods: 1) Period of Early Residence (15th century), 2) Period of Commoners from Masonry Houses (15th-17th centuries), 3) Royal Goldsmith Workshop and a Period of New Constructions (late 16th-17th centuries), 4) Palace Period (18th century).

Zooarchaeological material was collected during the archaeological excavation by carefully selecting visible bone remains out of the sediments. Sieving was not possible due to the high quantity of construction rubble and other waste deposits, although we recognize that hand-collecting bones favour the larger sized mammals over the smaller sized animal species. Nevertheless, smaller fragments of bones, fish scales or eggshells were collected from the heavy residue of the sediment sample collated from flotation that in turn showed a huge advantage of wet sieving method for the collection of a more complete picture of human diet (Table 2, marked by *). Those bones contained ribs, phalanges, vertebrae, facies articulares of long bones belonging to e.g., small rodents or fish that would otherwise have been left unnoticed during the hand-collecting process. However, majority of collected bones were too fragmentary preventing their attribution to species level, therefore, these bones were not included into the general statistics.

	Taxa	15th c.		15-17th c.		late 16-17th c.		18th c.	
		NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
Domesticated	**Mammals**								
	Bos taurus L.	17	2	56	5	58	4	132	4
	Canis lupus familiaris L.							1	1
	Capra hircus L.	1	1	2					
	Capra hircus/Ovis aries			5	5	6	1	9	3
	Capra hircus/Ovis aries /Capreolus capreolus			1					
	Equus caballus L.	2	1			41	2		
	Sus domestica Erxleben	6	1	7	2	3	1	9	2
	Sus domestica/Sus scrofa	3				1		3	
	Birds								
	cf. *Anser* sp.			2	2			2	2
	Gallus gallus domesticus L.			1	1			2	2
	Egg shells*	6		57				5	
Wild	**Mammals**								
	Alces alces L.							3	1
	Lepus sp.			1	1				
	Fishes								
	cf. *Abramis brama* L.			1	1				
	*Pisces**	12		91		12		3	
	Fish scales*	191		+500		67		6	
	Molluscas								
	Ostrea edulis L.							29	15
Unknown	**Birds**								
	Anser/Anas sp.							1	1
	Anser/Cygnus sp.					1	1	1	1
	Aves			1	1			9	9
Unidentified	Indeterminate	4		12		8		32	
	Large mammal	19		85		60		270	
	Medium mammal	6		5		6		32	
	Small mammal			1					
	Indeterminate *	30		~3000		59		21	
	Small mammal*	16		210		16		14	

Table 2. Summary information on the taxa identified during the zooarchaeological analysis.

All zooarchaeological data was recorded by number of identified specimens (NISP) and minimum number of individuals (MNI). In the text, the abbreviation 'n' refers to a number for both faunal and floral fragments.

In total, 955 animal skeletal remains were submitted for zooarchaeological analysis covering the 15th-18th centuries. The species identification was carried out with the use of bone atlases (Adams and Crabtree 2011; Cohen and Serjeantson 1996; France 2009; Gilbert 1973; Prehn et al. 2018; Schmid 1972) and the bone reference collection at the Bioarchaeology Research Centre of Vilnius University. Skeletal elements of sheep and goat, same as for pig and boar, were considered as one group respectively, due to well-known difficulties distinguishing these because of morphological similarities. 540 animal bones were either too small and fragmented or lacked characteristic diagnostic features and, thus, were not identified. Skeletal remains that identified at the elemental level, but not attributed to species, were grouped according to the size of an animal. The fragments could belong to small mammal, medium mammal, or large mammal. The age of the animals was determined based on epiphyseal fusion data and teeth (Hillson, 2005; Payne 1973; Silver, 1969). Butchery marks, such as cut or chop marks, helical fractures, were recorded whenever observed. The zooarchaeological remains in Table 2 were divided into two main groups of animals: domesticated and wild, and then subdivided into Vertebrate subgroups: mammals, birds, and fishes.

Archaeobotanical analysis were carried out on sediment samples from six contexts within the Dominikonų St. 11 (15^{th}-18^{th} centuries), consisting mainly of pits, fireplace, and cultural layers (in total, 110 l). In order to extract carbonized or mineralized macrofossil remains a flotation method was used (Greig 1989). Sediment samples were floated through 300 μm mesh sieves, while heavy residues were wet sieved through 2000 μm mesh sieves. All dried samples were sorted under the microscope OLYMPUS SZX10. Macrobotanical remains were photographed using an Axiocam Erc 5s camera and ZEN 2.6 lite software. Collected and assorted plant macrofossils (mostly charred and carbonated) were identified with the aid of specialized botanical atlases (Anderberg 1994; Berggren 1981; Cappers et al. 2012; Grigas 1987) and reference collection of modern plants stored at Bioarchaeology Research Centre of Vilnius University. Subsequently the botanical samples were divided into two main groups: domesticated and wild, and then subdivided into smaller groups by habitats (Table 3).

Results

The Period of Early Residence (15^{th} century)

The earliest context of the Dominikonų St. 11 is a fireplace pit placed inside the courtyard and dated to the 15^{th} century. Archaeological analysis has revealed that the fireplace was used at least twice. The date of this context is defined by the characteristic affiliated material consisted of various household pottery remains including unglazed and unornamented pottery, black earthenware, tapered roof tile. Some pottery fragments were secondary burnt, likely indicating that they were used for cooking directly on the fire. It is also worth mentioning that the fireplace contained a flat and burnt stone measuring 7-10 cm x 25 cm that may have been used to place vessels on for cooking.

More than 116 bones were collected from this pit, of which 58 were picked by hand and 58 during wet sieving. Only 41 were successfully identified and belonged to the following domestic animal taxa: cattle (*Bos taurus*; n=17), pig and pig/boar (*Sus domesticus*/*Sus scrofa*; n=6+3), horse (*Equus caballus*; n=2) and goat (*Capra hircus*; n=1). 12 unidentified fish bones were also found during sediment flotation.

The majority of identified bones belonged to cattle. Based on the epiphyseal fusion data, which were available for 10 fragments, eight individuals were mature. Only two thoracic vertebrae demonstrated incomplete epiphyseal fusion belonging to juvenile individuals (Silver 1969). Evidence of butchery and bone modification include chop marks (n=1), disarticulation (n=1), and helical fracture (n=1), which can be suggestive of bone marrow removal (Outram 2001). Most of the skeletal remains were badly preserved, sun bleached or had been exposed to heat. In addition, 191 fish scales and six eggshells were collected within the context, some of which were burnt. During initial examination of fish scales shape, most likely they belonged to three species: common roach (*Rutilus rutilus*), European perch (*Perca fluviatilis*) and northern pike (*Esox lucius*), which have all been detected at other archaeological sites in Vilnius (e.g., Tetereva et al. 2018, 180).

From the sediment sample, 41 plant remains were collected. About half of the identified plants belonged to raspberries (*Rubus idaeus;* n=19). Meanwhile, only one charred grain of barley (*Hordeum vulgare*) was found. Considering that the fireplace was mostly used for cooking, the minimum number of crops can be explained by the fact that direct fire destroyed the rest of the grains under the oxygen-rich charring conditions.

	Taxa	Plant part[1]	Context			
			15th c.	15-17th c.	late 16-17th c.	18th c.
Domesticated	**Cereal and pulse**					
	Avena sativa L.	Fruit, charred		4		
	cf. *Camelina sativa* (L.) Crantz	Fruit, charred			4	
	Cerealia sp.	Fruit, charred		2		
	Fagopyrum esculentum Moench	Fruit, charred		1		+500
	Fagopyrum esculentum Moench	Lemma, charred		2		
	Hordeum vulgare L.	Fruit, charred	1			
	Hordeum vulgare var. *vulgare*	Fruit, charred		1	1	
	Pisum sativum L.	Fruit, charred		2	3	1
	Secale cereale L.	Fruit, charred		8	2	1
	Triticum aestivum L.	Fruit, charred		1		
	Vegetables and spices					
	Allium cepa L.	Seed				1
	Brassica cf. *nigra* L.	Seed			1	
	Fruit					
	Juglans regia L.	Endocarp		1		
Wild	**Fruit**					
	Corylus avellana L.	Endocarp			2	3
	Fragaria sp.	Fruit, charred		1		1
	Rubus idaeus L.	Fruit	19	27	2	1
	Weeds and ruderals					
	Atriplex patula L.	Fruit		14		
	Centaurea cyanus L.	Fruit			1	
	Chenopodium album L.	Fruit	8	111	23	5
	Chenopodium hybridum L.	Fruit		1		
	Euphorbia sp.	Seed, charred	1			
	cf. *Galeopsis ladanum* Neck	Fruit, charred			1	
	Galium aparine L.	Fruit, charred		5	8	2
	Lamium sp.	Fruit, charred				2
	Polygonum lapathifolia (L.) Delarbre	Fruit, charred			8	1
	Setaria viridis (L.) Beauv.	Fruit, charred		2		1
	Silene dioica (L.) Clairv	Seed, charred		2		
	Silene vulgaris (Moench) Garcke	Seed, charred			1	
	Stellaria graminea L.	Seed		1		
	Meadow plants					
	Galium cf. *verum* L.	Fruit, charred	1	4		
	Malva sylvestris L.	Seed	1			
	Melilotus cf. *officinalis* (L.) Pall.	Seed, charred		1		
	Melissa officinalis L.	Fruit, charred				1
	Prunella vulgaris L.	Fruit, charred				1
	Taraxacum officinale (L.) Weber ex F.H.Wigg.	Fruit			1	
	Thymus sp.	Fruit, charred				1
	Trifolium repens L.	Seed, charred		1		
	Wetland plants					
	Carex spp.	Fruit, charred	3			50
	Carex spp.	Fruit		40	10	+150
	Juncus sp.	Fruit		6		
	Ranunculus sp.	Fruit, charred			1	
	Rhododendron sp.	Seed, charred			1	

[1] Botanical terms of plant parts: Endocarp – inner layer of the pericarp (wall of the mature ovary); Fruit – ripened ovary, the structure that bears the mature seed; Seed – a ripened ovule (in: http://conservationresearchinstitute.org/forms/CRI-FLORA-Glossary.pdf).

Table 3. Summary information on the taxa identified during the archaeobotanical and biological remains analysis (continued on the next side).

	Taxa	Plant part[1]	Context			
			15th c.	15-17th c.	late 16-17th c.	18th c.
	Coastal plants					
	cf. *Salsola kali* L.	Fruit, charred		1		
	Habitat unknown					
	Potentilla sp.	Fruit				1
	Vicia sp.	Seed, charred			1	
	Viola sp.	Seed, charred				1
	Amaranthaceae	Fruit		1		
	Apiaceae	Fruit, charred		1		
	Apiaceae	Fruit	1			
	Brassicaceae	Seed		3		
	Fabaceae	Seed, charred	2	1		
	Lamiaceae	Fruit			1	
	Poaceae	Fruit, charred	1	2		1
	Rosaceae	Fruit, charred			1	
	Polygonaceae	Fruit	2		1	
Other	Unidentified fragments		1	2	2	1
	Bread/food remains			1		

The Period of Commoners from Masonry Houses (15th-17th Centuries)

The investigated land plot were inhabited by the city commoners during a long period in the 15th-17th centuries. Most archaeological contexts from this period contained typical roof tiles of semi cylindrical form and so-called Gothic ceramics with polished black surface, tapered roof tiles, and fragments of various stove tiles. The zooarchaeological material from this period come from 10 different contexts such as waste pits and cultural layer, while the archaeobotanical samples were taken from two waste pits.

In total, 180 animal bones were collected by hand while about 3000 were sorted from the heavy residue during flotation. Only 168 of these were however identified while the remaining bones were too fragmented. Identified bones belong to cattle (n=56), pig (n=7), goat or goat/sheep (*Capra hircus/Ovis aries*; n=2 or 6), probably domesticated geese (cf. *Anser* sp.; n=2), chicken (*Gallus gallus domesticus*; n=1), unidentified bird (n=1), hare (*Lepus* sp.; n=1), and possibly common bream (*Abramis brama*; n=1). A surprisingly large number of fish bones (n=91) were collected from the sediment samples.

Epiphyseal fusion data available for 17 cattle bone fragments indicated that the majority (n=15) of them belonged to mature individuals, while one distal radius belonged to an individual that died before reaching 3,5-4 years, other thoracic vertebra belonged to an animal that died before reaching 5 years (Silver 1969). Yet, one very fragile bone, most likely of a juvenile calf, was also found. Butchery evidence included chop marks (n=2), cut marks (n=2), disarticulation (n=4), and helical fracture (n=1). Few bones (n=9) also had gnawing signs and one of them was sun bleached. At least three examples of bone working were noted (Figure 3).

Figure 3. Discarded bone working fragments of cattle (*Bos taurus*) (Photo: E. Ananyevskaya).

Out of the seven identified pig bones at least one of them belonged to individual that died before reaching 2 years of age (Silver 1969). Judging from the shape of the tusk, one mandible fragment was attributed to a male individual (Hillson 2005). Skeletal remains of goats/sheep contained mostly limb bones. However, because of the noticeably ambiguous shape it is possible that one bone belonged to a roe deer (*Capreolus capreolus*). All goats were identified by their horncores. Along with larger fish vertebra, possibly belonging to common bream, and small, yet unidentified, fish bones were also recovered in the flotation samples. In addition, over 500 fish scales were collected from the flotation samples. Most of them were about 5 mm in diameter and, in rare cases, 16 mm in diameter. The abovementioned three species of fish, common roach, European perch, and northern pike, were identified. All fish remains were found in the same context together with few gnawed cattle bones mentioned before. Lastly, 57 bird eggshells and one charred bread/mash fragment were found here as well.

249 plant macrofossils were extracted from two sediment samples, the majority of which belong to cultivated plants. The cultivars belong to rye (*Secale cereale*; n=8), oat (*Avena sativa*; n=4), buckwheat (*Fagopyrum esculentum*; n=3), hulled barley (*Hordeum vulgare* var. *vulgare*; n=1), bread wheat (*Triticum aestivum*; n=1), Cerealia (n=2), and pea (*Pisum sativum*; n=2) (Figure 4 a-e). In addition, a small fragment of walnut shell (*Juglans regia*) and even more raspberry fruits (n=27) were found as well.

Weeds and ruderals were the dominant plants (*c.*55%), including white goosefoots (*Chenopodium*

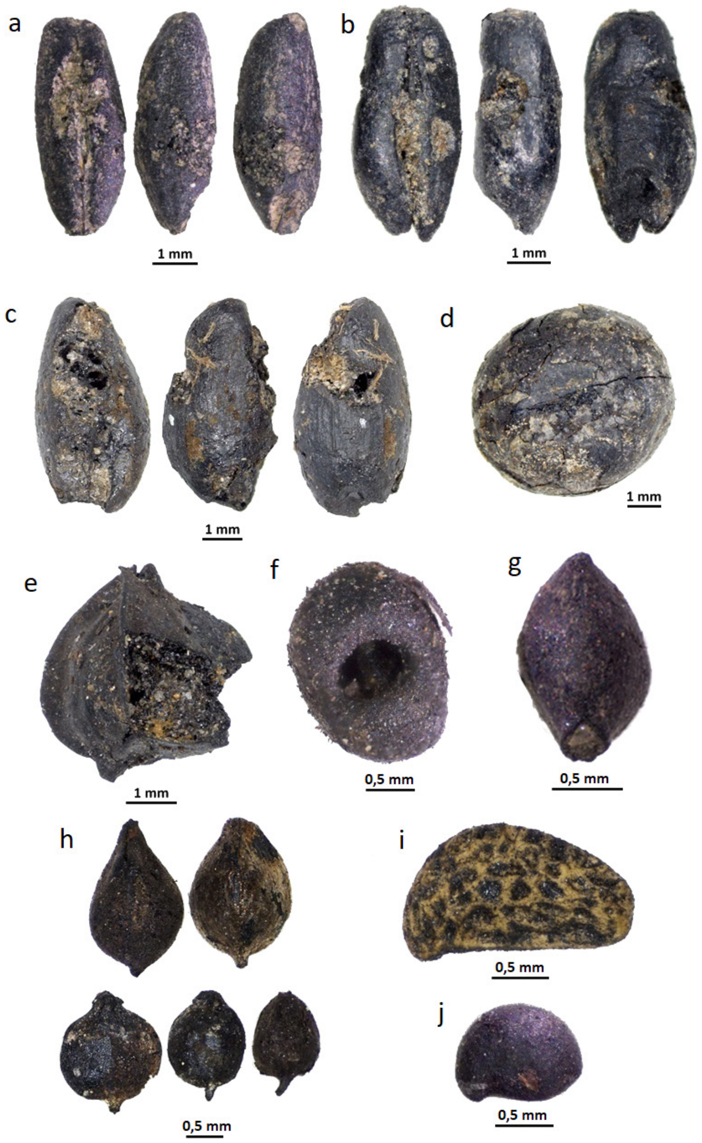


Figure 4. Photos of archaeobotanical remains from Dominikonų St. 11.
a – *Avena sativa*;
b – *Secale cereale*;
c – *Hordeum vulgare* var. *vulgare*;
d – *Pisum sativum*;
e – *Fagopyrum esculentum*;
f – *Galium aparine*;
g – *Thymus* sp.
h – *Carex* spp.;
i – *Rubus idaeus*;
j – *Fragaria* sp.
(Photos: R. Karaliūtė).

Figure 5. Crucibles discovered in the rubble above the early 17th century foundation (trench 9) (Photo: A. Žvirblys).

album; n=111) and spear saltbushes (*Atriplex patula*; n=14). Based on the number of identified plants the second most common group is wetland plants with mainly fruits of sedges (*Carex* sp.; n=40).

The Royal Goldsmith Workshop and a Period of New Constructions (Late 16th-17th Centuries)

This period is characterized by local and imported household pottery with yellow, light brown or green glaze. Furthermore, large quantities of the typical late 16th – mid. 17th century stove tiles were found as well. Several of the tiles were decorated with a single-headed eagle dating to 1585, which attribute them to the Royal goldsmith's sponsor, Polish-Lithuanian nobleman Krzysztof Radziwiłł II, who was born in 1585. Besides typical fragments of household pottery and stove tiles, crucibles for melting of non-ferrous metals (possibly gold) were also found (Figure 5), which may be connected with the activities of the aforementioned goldsmith M. Bretszneider. Parts of several stone pavings dating to the second half of the 17th century were discovered in the complex within the house and in the courtyard. One of these has been preserved *in-situ* for public presentation. The zooarchaeological material was collected from eight separate contexts including waste pits, cultural and rubble layers, whereas the material for archaeological analysis came from a single context within a waste pit.

Out of the 271 collected animal bones (184 collected by hand and 87 found in heavy residue), only 122 were identified to species, with cattle making up the majority of these (n=58). During the analysis of epiphyseal fusion data, it was noted that at least 23 individuals were mature, one died at age 3.5-4 years, while a second one before reaching 5 years (Silver 1969). Various vertebral elements (n=10) as well as proximal femur (n=6) make up the majority of the cattle skeletal remains. Butchery evidence on cattle skeletal fragments include chop marks (n=6), disarticulation (n=6), and saw marks (n=1). At least three examples of bone working were detected. The second most common species is horse (n=41) with at least two mature individuals (MNI=2). No evidence of butchery on fragments of horse bones was detected, but one thoracic vertebra had signs of abnormal bone growth, which might be suggestive of diseases related to hard labor or deformities occurring due to old age (Baker and Brothwell 1980). In addition, goat/sheep (n=6), pig and pig/boar (n=3+1), and one bird radius that likely belongs to swan (*Cygnus* sp.) or goose were identified. During archaeobotanical analysis, 67 fish scales and 12 fish bones were identified.

Layers dating to the 17th century contained 76 archaeobotanical macrofossils. In comparison to the 15th-17th centuries, the percentage of weeds and ruderals remained the same. White goosefoot (n=23) remained dominant, but during this period clevers (*Galium aparine*; n=8) and pale persicaria (*Polygonum lapathifolium*; n=8) increased as well. Based on the general distribution by habitats the second most abundant group of plants belonged to wetland species (n=10; only sedges), while third belonged to crops and pulse (n=10). The former

Figure 6. Test pit 12 with the shards of cylindrical wine bottles (Photos: A. Žvirblys).

group includes peas (n=3), rye (n=2), hulled barley (n=1), and probably false-flaxes (*Camelina sativa*; n=4).

The Palace Period (18th century)

Cultural layers from the 18th century are distinguished by a large amount of various archaeological finds of household pottery, glass and metal artefacts, coins etc., that are all associated directly with a palace. The most typical finds of this period are faience and majolica bowls, plates, and other dishes that emphasize the high status of their owners. The beautiful porcelain dishes had floral patterns on the bottom, or be decorated with painted scenes or floral and geometrical patterns. It is important to make a note about the discovery of broken shards of wine bottles that were dumped in a single pit that is indicative of an imported wine consumption (Figure 6). From this period, the zooarchaeological data was assembled from five separate contexts belonging to waste pits and rubble layer while archaeobotanical material was taken from two different contexts: rubble layer and waste pit.

In total, 573 animal remains were found, 38 from a sediment sample during flotation, but only 204 of these were successfully identified. 65 % of the identified bones belonged to cattle, which were presented mostly by vertebral elements, although fragments of pelvic bone, scapula, cranium, and femur are also present in large quantities. The majority of bones are from mature individuals, however, at least seven fragments are from young individuals: juvenile calf (n=3; by metapodial bones), 6-15 month old (n=1; by pelvic bone), over 24 month old (n=1; mandible), 24-30 month old (n=1; by mandible), 28-30 month old (n=1; by mandible) (Silver 1969). No signs of butchery were detected

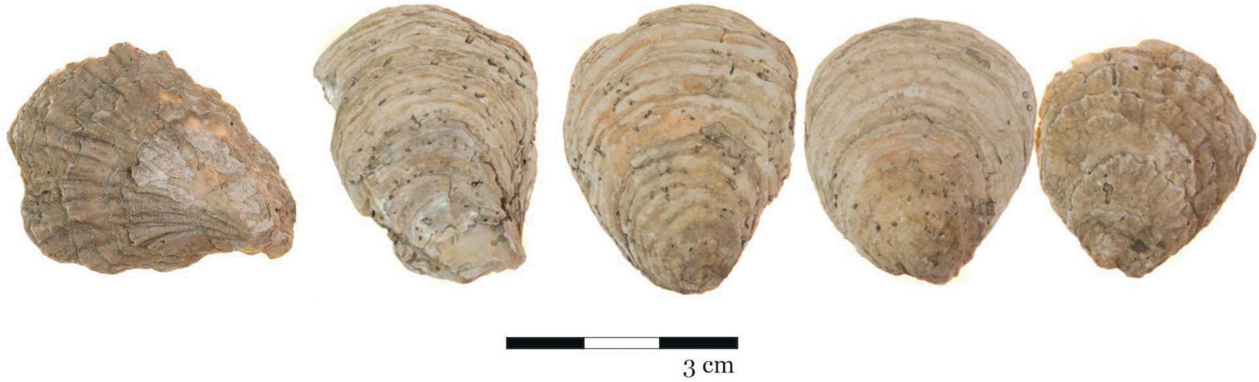


Figure 7. European flat oyster (*Ostrea edulis*) shells collected during the excavations from the 18th century contexts (pit 8) (Photo: A. Žvirblys).

on these animals, but there were plenty of them on mature animal bones: chop marks (n=16), cut marks (n=2), disarticulation (n=16), saw marks (n=1). At least five cases of bone working were found.

In comparison to the earlier contexts, there is a notable number of bones from pig (n=9) or pig/boar (n=3) and goat/sheep (n=8). In cases of pigs, mainly limb bones were observed, but no signs of butchery were recorded. One mandible of a goat/sheep belonging to a 6-8 years old individual was identified. It is worth noting that the only bone (femur) of a dog (*Canis lupus familiaris*) was found.

In contrast to the previous periods, fifteen bird bones were found, four of which possibly belonged to domestic birds, such as goose and chicken. There were also identified one bone of goose/duck (*Anser/Anas* sp.) and one bone from a goose/swan. Unfortunately, nine bird bones were not unidentifiable at the species level and it is thus unknown whether they belonged to domesticated or wild birds. Three skeletal remains of elk (*Alces alces*) were also present among faunal remains. Zooarchaeological analysis of 18th century period revealed that people at the Pociejai Palace used other non-local water resources, such as oysters. Shells of European flat oysters (*Ostrea edulis*; n=29) were also identified (Figure 7). Six fish scales and three fish bones were also recovered from the analysed flotation samples.

In a thick layer of ashes above a stone paving, a concentration of charred buckwheat (n=+500) was recovered, which is associated with the 1748 city fire in Vilnius. These had probably fell down from the storage area as a bag and burned during the palace fire (Figure 8). 226 plant macrofossils of 18 different plant taxa were collected for archaeobotanical analyses. Apart from the buckwheat concentration mentioned above, this period was clearly distinguished by predominance of wetland sedges (around 90 %) (Figure 4h, Figure 9). The second most abundant group of plants was weeds and ruderals (n=10). A few meadow plants were identified as well. All of them are considered as aromatic/medicinal plants belonging to lemon balm (*Melissa officinalis*), common self-heal (*Prunella vulgaris*), and thyme (T*hymus* sp.). In addition, only three macrofossils of domestic plants were identified: rye, pea, and onion (*Allium cepa*).

Discussion

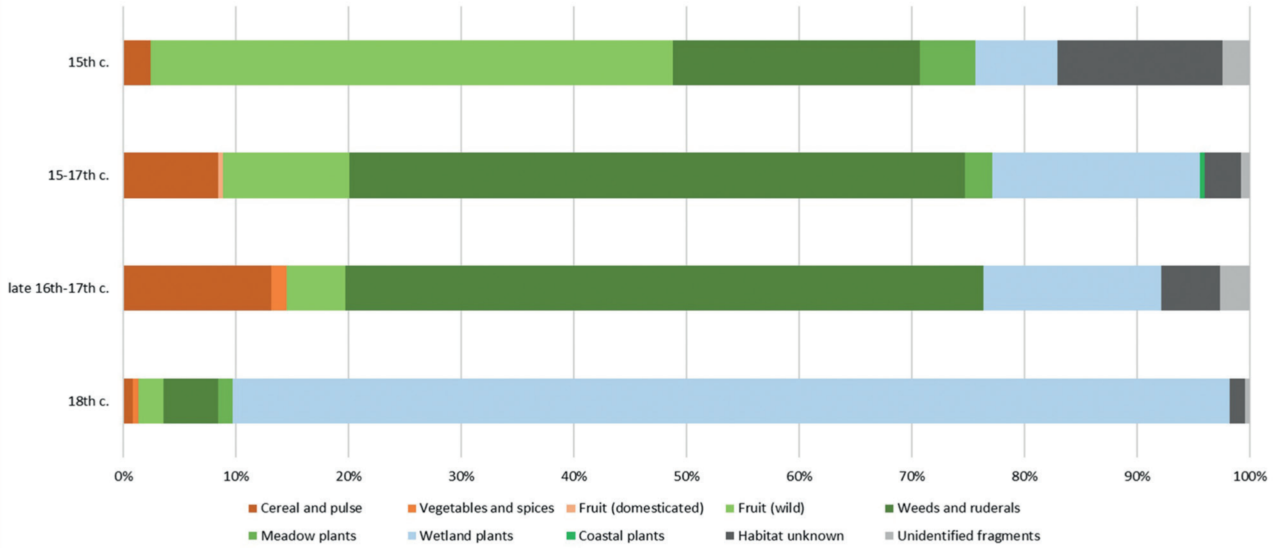
In the following, we discuss the findings of different food sources present at the Dominikonų St. 11. In order to avoid repetitions by discussing the same food source for each period, the diversity of each food product and its differences between periods will be highlighted instead. The food sources are discussed in the broader contexts of Vilnius and in the light of historical records.

Animal Food Sources

Beef and veal

Bones of domestic animals unambiguously dominate the assemblage from Dominikonų St. 11

Figure 8. The unearthed paving fragment of charred and disturbed stones and the burnt buckwheat grits collected above it in the SW part of the courtyard (Photos: A. Žvirblys).



[1] Bag of buckwheat detected in the context of 1748 is not presented here, because in the absence of a large number of cereal and pulse in the object, their introduction distorts the general tendency.

Figure 9. Distribution of archaeobotanical remains by centuries.

(80-100 %), of which cattle is the majority (15th century: 41.5 %; 15th-17th centuries: 51.9 %; 16th-17th centuries: 47.5%; 18th century: 65.3 %) (Table 2). A gradual increase in the number of cattle bones can be observed, with an exception in the 16th-17th centuries where there is a particular high number of horse bones (see below). A similar pattern of increasing beef consumption can be observed at other sites within Vilnius city that have been zooarchaeologically investigated (Piličiauskienė 2013; Piličiauskienė and Blaževičius 2018).

The popularity of beef can be explained by the multifunctionality of cattle. Cows are kept for meat and milk production, and the production of offspring. Agriculture was based on oxen power instead of horse power, thus oxen were kept for field work or transporting. Finally, the arable fields needed to be fertilized and the cattle were kept for the production of manure. Because of these advantages, it is not surprising that cattle have been raised in abundance (Piličiauskienė and Blaževičius 2018, 52-54).

Most cattle were already mature at the age of death, although at least 12 bones of from separate juvenile animals individuals (4.5%). In contrast to beef, veal or younger cattle meat were more highly valued (Holmes 2018, 164). Most bones of young individuals date back to the 18th century linking the consumption directly to high social status people.

Horse

In the layers of the 17th century, 41 horse bones were discovered. 37 of them were found in the same context, while the rest appeared as solitary finds. Based on MNI, they belong to two individuals. The horses might have died from natural causes and buried, based on the absence of any signs of butchery marks. Nevertheless, burying a horse on a land plot in the city appears unlikely because horses would usually have been buried outside the city (Holmes 2018, 117). According to zooarchaeological remains, there are known evidence that humans possibly ate horses (Piličiauskienė 2013, 125) even in Modern ages. Consumption of horse is usually linked to military disturbances or famines. In the 17th century Lithuania suffered from multiple military campaigns (Swedish Deluge, Russo–Polish War), and later a plague came to the country in 1711. There is a possibility that horses were actually eaten, but it remains an open question whether horse meat has been eaten by humans or as dog fodder (Holmes 2018, 146; Piličiauskienė and Blaževičius 2018, 70-72).

Pork

Pork may be considered as the second most popular type of meat (ca. 13% of all domestic animal bones). Pigs were usually kept for their meat and slaughtered when they reached optimum meat yield, having limited value for secondary production (Holmes 2018, 50; Sportman et al. 2007, 134). During the 15th-18th centuries, the number of pigs and pigs/boar bones decreased. Urbanization, the remoteness of pastures, centralized supply of meat (mostly beef) resulted in a decreasing number of domestic animals kept in the city (Piličiauskienė and Masiulienė 2011, 180). Due to the high consumption of beef, pork only makes up a small share of the total meat consumption. The same tendency can be observed at Vilnius Lower castle, Klaipėda Castle and Klaipėda Old Town (Žulkus and Daugnora 2009; Piličiauskienė and Masiulienė 2011; Piličiauskienė and Blaževičius 2018).

Poultry

In the Middle Ages and Early Modern Age chickens and geese are estimated to be the most frequently consumed type of poultry. Chicken is the dominant species, but it was overtaken by geese in the 16th century (Rumbutis et al. 2018, 111). Skeletal remains of both chickens (n=3) and geese (n=4) have been identified in the material from five different waste pits dating to the 15th-18th centuries. The eggshells are not identified to specific bird species, but it is likely that the eggshells belong to the domesticated birds, such as chicken or geese, as bones of these birds were also detected at the site. Despite the fact that eggshells have been detected in three periods out of four, relatively few bones of domestic birds has been discovered, potentially due to the bias of bone collection by hand, rather than fine sieving all sediments.

Noblemen, and on occasion commoners, consumed chickens and geese, although wealthy individuals had the privilege to consume meals of the wild birds. From the 18th century contexts, one bone from a goose/swan and from a goose/duck was identified, as well as nine unidentified bird bones. Another bone of goose/swan was identified in the waste pit dating to the 17th century. Unfortunately, due to fragmentation of fragile bones, it is difficult to recognize the amount, species and possible presence of wild birds. The fact that several bones could possibly belong to a swan suggest the presence of wealthy residents. As recorded in First Statute of the Grand Duchy of Lithuania (1529) domestic swans were priced three times higher than peacocks (Rumbutis et al. 2018, 125, 224).

According to account books and historical recorded menus (Antanavičius 2012; Laužikas 2014), bones of unidentified birds may have belonged to nobles' favorite grouse, capercaillie, partridge, bustard, quail, etc. These are wild birds that were purposely hunted only by the nobles or upon their request (Dambrauskaitė 2021, 96-99). Based on a statistical analysis of poultry consumption in post-medieval Southern England, the remains of wild birds were mostly found at ecclesiastical and high-status sites, while remains from lower status sites may be linked to poaching (Holmes 2018, 136, 169). Thus, the discovery of wild or captive-bred birds clearly distinguishes the palace period from the previous ones, when it was the home of craftsmen. We argue that a recognizable increase of consumption of birds should be linked to the status of the palace inhabitants.

Fish and mollusks

At least 180 fish bones (mostly small vertebrae) and 1,400 small fish scales (*c.*5 mm size) were found during the flotation of sediment samples dated to the 15th-18th centuries. Based on the shape of the scales, they most likely come from three fish species: common roach, European perch, and northern pike. One fish vertebra, most likely, belonging to common bream was found as well.

Archaeo-ichthyological material from the area of Vilnius Lower Castle dating to the 14th-15th centuries includes fish scales from pikes, pikes-perches, cyprinids, breams, catfishes, sturgeons, perches, tench, shubs, rudds, roaches, all of which may be caught in the nearby rivers of Neris and Vilnia (Piličiauskienė and Blaževičius 2019, 43). Fish was typically caught using nets, traps, and fishing rods although fish farming was also an option (Tetereva et al. 2018, 187). The Grand Dukes owned several fish breeding ponds in the city and around it in order to meet the needs of the monarch or other noble people. Around 1546, Viršupio Manor for example maintained 20 ponds for breeding of mostly pikes (Dambrauskaitė 2018, 170). It was also possible to purchase fish at the markets where a wider assortment was available. In Vilnius, the Hanseatic merchants usually traded in herring that was popular among commoners and, as noted in account books, herrings were bought for consumption by servants (Dambrauskaitė 2018, 171).

The majority of the fish remains are found in the contexts dating to the 15th-17th centuries when Dominikonų St. 11 was inhabited by commoners. It has been suggested that the identified breams, roaches and perches are lower quality fishes compared to carp, tench, pike, and salmon (Dambrauskaitė 2018, 173-174). Although only a few pike scales have been identified, these may indicate pike consumption at special occasions, such as fasting. Pikes were the favourite fish even by Lithuanian Royal Palace and were preferred over more valuable fish such as salmon or sturgeons (Dambrauskaitė 2018, 174). Considering the size of bones and scales that were found it is likely that fish was caught by small-meshed nets, which resulted in catches of both medium and small sized fishes.

Only in the contexts of the 18th century, 29 shells of European flat oysters were found. Oysters have previously been found at several other locations in Vilnius, such as at Šv. Ignoto Street at the Bernardine monastery and in the area of the Lower Castle (Luchtanienė 2005, 217; Piličiauskienė and Blaževičius 2019, 47). Oysters are mentioned in the lists of courses for monarch banquets or official receptions back to the 17th century, with notes that oysters must be served fresh. Despite the fact that oysters were known in Lithuania for quite some time, they only became a common delicacy of banquets in the 18th century (Laužikas 2014, 89).

Oyster is a native shellfish to the western European coastal waters, mostly at the North Sea coast, whereas the Baltic Sea is not suitable for them due excessively low salinity and large temperature fluctuation (Lõugas et al. 2022, 814). Like other countries that did not have a natural oyster source, Lithuanian nobles had to import them. Oysters are a perishable food often referred to as 'perishable luxury' due to the logistical challenges of transporting them deeper into the continent. Oysters may remain fresh for up to 10 days, or 8-12 weeks, if kept cool and tightly packed (Thomas et al. 2019; Lõugas et al. 2022, 823). One of the closest oyster centres was in Germany, on the coast of the Wadden Sea, where oyster trade had been conducted since the 13th century, though their organized oyster catching developed in the 16th century (Lõugas et al. 2022, 814). A valuable cargo could easily be transported by Hanseatic merchants.

Wild game

At least one bone of hare and three bones of elk were found in contexts dating to the 15th century and the 18th century. It should be noted that the simple number of wild animal bones is not abundant enough to establish a high status of the site owners, but in view of the entire zooarchaeological material from the 18th century, we consider the skeletal remains of wild animals as an indicator wealthy inhabitants.

By the 16th century, the declining importance of hunting as a source of food, changes in the law to guard against poaching and the highly priced killing of wild animals transformed hunting into a privileged activity (Holmes 2018, 146; Margienė-Zarankaitė 2018, 87-88). This trend is also observed in archaeological material from Vilnius Lower Castle where the number of skeletal remains of wild animals decline by almost half compared to material from the 14th-15th centuries (Margienė-Zarankaitė 2018, 88). Hunting was primarily an entertainment available only to a narrow circle of privileged nobles. Naturally, from time-to-time, game meat diversified the menus of the people of the high social status, especially at official banquets, or it was sent as a political gift, but beef was the predominant meat of the time (Margienė-Zarankaitė 2018, 94). According to historical records (Antanavičius 2012; Laužikas 2014; Valikonytė et al. 2001), in addition to elk and hare, at the same time European bison, aurochs, roe deer, wild horse, boar, beaver, lynx and bear were also hunted and served.

Plant Food Source

Cereals and pulses

Charred peas and cereal grains of oat, hulled barley, rye and bread wheat were found in most of the analysed domestic pits. Unfortunately, due to the small and varied number of grains, it is difficult to assess the changes and peculiarities of their consumption in 15th-18th centuries. All the crops have also been identified in other parts of Vilnius, for example at Vilnius Lower Castle (Stančikaitė et al. 2008), Upper Castle Hill (Motuzaite Matuzevičiūtė et al. 2020), Bokšto St. 6 (Motuzaitė Matuzevičiūtė et al. 2017), Liejyklos St. 8, Vilniaus St. 24 and 41 (unpublished). Usually, cereals are found in small numbers, except in unique cases when granaries or storehouses are found.

In Dominikonų St. 11, a notably high concentration of buckwheat fruits (nuts) was identified. Buckwheat originated from East Asia and spread across Central Asian into Europe during the Middle Ages (Hunt et al. 2018; de Klerk et al. 2015). It adapted to annual growth in colder regions at high altitude. It is grown not only as a source of food for humans and animals feed, but also plays a major part in honey production (Weisskopf and Fuller 2014, 1025-1028). Buckwheat is considered brought to Lithuania by the Mongols in 13th-14th centuries where it soon became widespread (Grikpėdis and Motuzaitė Matuzevičiūtė 2020, 228).

Buckwheat pollen recorded in contexts from 13th century Vilnius (Stančikaitė et al. 2008, 247), and charred macrofossils were detected at Upės St. 21 (Butkevičiūtė 2017), and Bokšto St. 6 (Motuzaitė Matuzevičiūtė et al. 2017). In the latter case, buckwheat was found mixed with unthreshed rye. Such storage of crops shows that they were kept for sowing (Motuzaitė Matuzevičiūtė et al. 2017, 226). Historical records often describe buckwheat as an important part of poor people's diet. Buckwheat was mentioned in 17th century documents from Gdańsk as being a component of seamen's food rations (Latałowa et al. 2007, 51). Buckwheat could grow in poor acidic soil and was a suitable plant product to be stored in households to provide food in times of famine. Nonetheless, sometimes it is found in the contexts of rich households (Alsleben 2007, 30). The abundance of stored buckwheat found in the context of the 1748 Vilnius fire ties it to the Palace period, when the Pociej family lived here. This data contrast with previous interpretations of buckwheat being a buffer crop or food for the poor, rather than being a food source for all social classes. The former statement could be strengthened by the fact that the remains of buckwheat were ubiquitously found across Vilnius city from the 14th century onwards from contexts associated with both upper and middle-class residences (e.g., at the Lower Castle, in the Civitas Rutenica district, Upės St.) (Butkevičiūtė 2017; Motuzaitė Matuzevičiūtė et al. 2017; Stančikaitė et al. 2008). This observation emphasizes the importance of a multiproxy approach that considers more sources of evidence.

Vegetables and spices

Only a single macrofossil of black mustard (*Brassica nigra*) and of onion (*Allium cepa*), respectively, have been identified in the latest contexts (late 16th-17th and 18th centuries). Although, since the Early Modern Age, foreign guests have repeatedly noted that local nobility ate only few vegetables but plenty of meaty dishes with spices (Laužikas 2014, 59).

Earlier in the 16th century, most of the well-known vegetables, for example, cabbage, cucumbers, carrots, turnips, beets and garlic were grown locally (Dambrauskaitė 2020, 34). According to a 1623 listing it is known that the noble family of Radvila had a garden (and kitchen-garden) in Vilnius where they grew artichokes, asparagus, corn salad, arugula, spinach, beetroot, lettuce, anise, peppermint, tarragon, dill etc. (Laužikas 2014, 81-82). In addition, several account books from the 16th century of king Sigismund II Augustus (Antanavičius 2012) mention expensive imported spices such as saffron, pepper, cinnamon, ginger, caraway, anise, and caper (Dambrauskaitė 2021, 109-110). In the 16th-18th centuries, at least part of these known and cultivated vegetables and spices may have been consumed by the residents of Dominikonų St. 11. Unfortunately, no macrofossil evidence of these has been found. This is most likely due to preservation issues for uncarbonized macrofossils.

Nuts and berries

The commoners of Vilnius did not have private gardens, so they collected forest goods, such as berries, nuts, and mushrooms (Dambrauskaitė 2020, 34). Meanwhile higher status people owned private gardens or orangeries where they grew fruit-trees. Here they could grow not only local apple and pear trees, but also imported and expensive Hungarian plums, grapes, figs, lemons, oranges, almonds, and walnuts (Laužikas 2014, 81-83).

It is necessary to mention a small fragment of walnut shell found at Dominikonų St. 11. At least one more fragment of walnut is known from archaeobotanical researches in Vilnius (Rusų St. 5, forthcoming). The walnut tree is native to the Mediterranean region and even though it is debated when they were domesticated, it is mostly associated with the rise of the Greek and Roman cultures (Pollegioni et al. 2020). Through archaeological research, they have been found in many Central European cities dating from the 13th to the 18th centuries (Karg 2010, 119). Walnut shells are also found in 13th-15th century contexts in Tartu, Estonia, where they might have been imported by merchants of the Hanseatic League (Sillasoo and Hiie 2007, 83). Walnuts are relatively simple to store and transport and it is likely that a fragment of a walnut shell found at Dominikonų St. 11 reflects a similar way of trade. Despite the unfavourable climate, the possibility of local cultivation cannot be ruled out, as it is known that walnuts were also grown in Gdańsk and Vilnius in the 17th century (Latałowa et al. 2007, 59; Laužikas 2014, 81). In our current climate, walnut trees can be successfully cultivated in Lithuania as well.

Hazelnuts (Corylus avellana) are local trees in Lithuania and during archaeological excavation at Dominikonų St. 11 shells of hazelnut were discovered (n=3). Hazelnuts, same as walnuts, are easily stored and highly nutritious (Grigas 1986, 47) and could replace the expensive meat. They were harvested in local forests and were popular and, therefore frequently found in medieval city contexts across Europe (Karg 2010, 119). An example of their importance can be found in the written records from Finland where many native wild plants have been gathered, but only hazelnuts are listed in customs registers (Lempiäinen 2007, 111).

Raspberry fruits are found in almost every sediment sample taken during archaeological excavations in Vilnius. Here, at Dominikonų St. 11, most of the fruits date to the 15th-17th centuries (Table 3). Raspberries has been systematically cultivated in Europe since 15th-16th centuries (Latałowa et al. 2007, 60), but it is unlikely that the high number of raspberry fruits found in this area can be explained by their cultivation in gardens. Raspberries are frequently identified in archaeological contexts across a wide chronological range in Northern Europe, but harvesting or consumption of them are rarely mentioned in the historical records, which may indicate gathering of wild raspberries rather than cultivation (Karg 2007, 59, 123, 170). The preservation of raspberry fruits at Dominikonų St. 11 is expected to be comparable for all investigated periods, but abundant numbers have only been identified from the 15th-17th centuries when the land plot was inhabited by commoners. It is known that raspberries have been used not only for food (juice, jam or eaten fresh), but also for medical purposes, such as treatment for flu (Alanko and Uotila 2020, 52; Grigas 1986, 174). It is also possible that wild berries were gathered as an additional source of food and vitamins for lower status people.

Other plants

Following the topic of medicinal plants, it is worth mentioning three wild plants, whose fruits were identified: lemon balm, common self-heal, and thyme. Although only one macrofossil of each of them was found, they were discovered in the same context dated to the 18th century, which may suggest purposeful collection and preparation. All of these are considered medical plants, although some of them might also have been used as a spice (Latałowa et al. 2007, 55). Some other plants, such as cleavers, may be considered as medical herbs too, but because they also grow at the roadside, it mostly likely indicates accidental appearance in a waste pit with yard wastes at once rather than intentional collecting. Since medicinal plants are usually harvested before their fruits or seeds are ripe, it is unlikely that they will appear in the archaeobotanical record in larger numbers.

Conclusion

This article is the first attempt to introduce a complex dietary study of a particular household in Vilnius based on both bioarchaeological material and historical accounts. Multi-proxy research provided an insight into past human diet, which consisted of animal and plant foods. It is important to note that zooarchaeological material consist of hand-collected assemblage with the exception of the archaeo-ichthyological material that was collected during wet sieving together with archaeobotanical remains.

The examination of zooarchaeological and archaeobotanical remains at Dominikonų St. 11 has shown some interesting peculiarities related to the past consumption of crops, the biodiversity of animals, as well as evidence of animal butchering practices. Our bioarchaeological results derived from animal remains and carbonized plants corresponds with the anticipated social status of the residents from a particular time period throughout the 15th-18th centuries.

Based on historical and archaeological research the investigated land plot has been settled since the 15th century. According to the zooarchaeological material from the 15th-18th centuries, beef was the most frequently consumed type of meat. This coincides with a general tendency for Middle Age and Early Modern Age and can be linked to a rise in cattle production. Unfortunately, during archaeobotanical analysis only few remains of different crops were found. Therefore, it is not possible to identify a dominant cereal of any period. A bag of charred buckwheat is linked to Vilnius city fire in 1748. Buckwheat is often described as an important part of poor people's diet and best possible food in times of famine. Nevertheless, buckwheat was found during Palace period, thus challenging interpretations of buckwheat being served only as a food for the lower class. We argue that buckwheat was a reliable food source for all social classes. This practice of course not necessarily broadly applicable in other regions and consequently require more than one sources of evidence. Thus, it is important to emphasize an increasing necessity of a multi-proxy approach studies in order to reconstruct a specific aspect of human's lives in the past.

Although the data samples are not large enough to draw definitive conclusions, it is possible to observe a significant dietary transition from pre-Palace to the Palace Period. The Palace period (18th century) stands out by a slightly increase in consumption of veal and poultry (possible wild birds). In addition, were found a few bones of wild animals suggesting hunting privileges, oyster shells demonstrating international trade and shards of wine bottles testifying to the exceptional position of the noble Pociej family. Meanwhile the earlier periods (15th-17th centuries) are characterized by the abundance of small fish bones and scales, use of wild plants such as hazelnuts and raspberries, which can be associated with commoners and craftsmen.

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