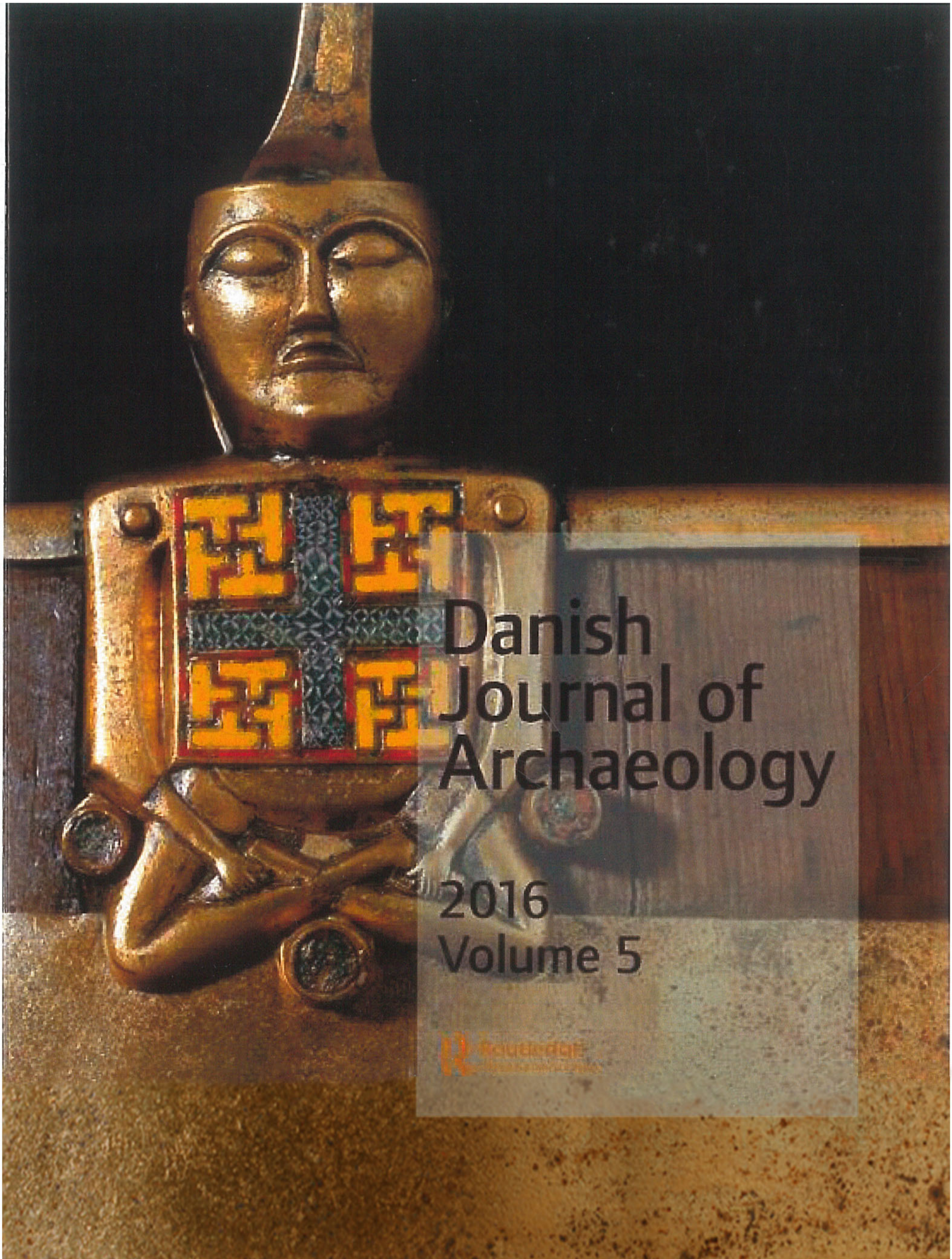

Danish Journal of Archaeology

2016
Volume 5

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2019

Danish Journal of Archaeology
Volume 5 Numbers 1–2 May–November 2016

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DANISH JOURNAL OF ARCHAEOLOGY, 2016
VOL. 5, NOS. 1–2, 1–2
http://dx.doi.org/10.1080/21662282.2017.1282190

Editorial

Five years have passed and five volumes have been produced since we started the revitalisation of the *Danish Journal of Archaeology*. Establishing new journals and perhaps even more so revitalising old ones is no mean feat. Yet, with the present volume, we have again witnessed a noticeable rise in the number of downloads. Especially the second quarter of 2016, which peaked at almost 4500 individual downloads, made a significant impact in the statistics. For this reason, already by the end of July, we had had our best year so far. We surely hope to continue on these very promising numbers and perhaps again improve the scope of our outreach for the coming volumes.

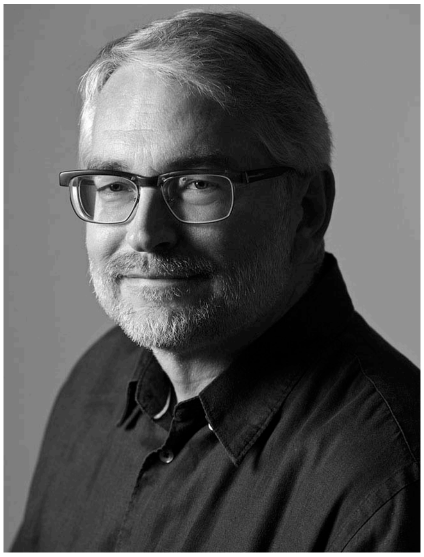
Besides retaining a solid flow of incoming articles with a very high scientific standard, we also plan to expand on the portfolio of the journal by introducing Special Issues in the coming volumes. As of yet, we cannot reveal too much of the exact content of these volumes, but we expect to be able to present a Special Issue, which relies heavily on cross-disciplinary studies of a subject area which readers of archaeological research only rarely see published in combination, but very often see cited within their own separate domains. Furthermore, the issue will fall into a (pre)historical period which we have only touched upon briefly in earlier volumes, so we surely hope to expand the range of submitted manuscripts, as well as attract a group of readers, which find attractive the Special Issues initiative and the opening up of a relatively quiescent subject area.

The year 2016 was also the last year where the *Danish Journal of Archaeology* operated under the auspices of the Agency of Culture and Palaces. During the last 6 years, we have been able to bring the journal into the highest level in the bibliometric classification (level 2) in Denmark and with a high quantity of international writers, reviewers as well as readers. Still, we find ourselves in the midst of a series of fundamental changes within the publishing world; in several countries, publishing under the Open Access flag has been introduced as a prerequisite when being funded by the government, and this situation will inevitably make an impact on the journal. However, with *Danish Journal of Archaeology*, we believe to have made a strong case for the continuation of 'traditional' methods of publishing and are quite confident that the journal will find its place in a changed publication landscape.

Another fundamental change will also characterise the coming volumes, and we here refer to change in the editorial group. Already, in early 2017, the representative from both of the involved Universities will see a change. From the School of Culture and Society at Aarhus University, Felix Riede will be replaced by Mette Svart Kristiansen. Besides her position as associate professor and teaching in medieval archaeology, she is well versed in the methodological development of archaeological fieldwork and has extensive experience as the head of excavation at several key sites in Denmark. She has specialized in the rural world of Medieval Scandinavia, in particular, the housing culture of the period – a subject matter on which she has published extensively. Furthermore, she is no novice to the quirks of editorial work and has been involved in the editing of several books and journal special issues.

At the SAXO-Institute at the Copenhagen University, Eva Andersson Strand will be replaced by Rune Iversen. He is currently employed as assistant professor at the institute where he focusses on Neolithic studies and in particular the Pitted Ware culture and the sociocultural development of the period. Also Rune is an experienced excavator and has been involved in field projects as diverse as princely burials from the Late Roman Iron Age to the Late Epipalaeolithic of Jordan. More recently, he has entered into cross-disciplinary research and especially the field of archaeolinguistics and the spreading of Indo-European languages during the Neolithic.

Replacing the members of the editorial group has been a stated objective from the beginning of our collaboration. The reason behind being that by presenting new members, we also change the personal network of the editorial group and thus hope to encourage a dynamic atmosphere between the involved persons and the institutions. This is also the reason why Mette and Rune specifically have been introduced to the group, as they have extensive networks in the areas of Medieval and Neolithic research, respectively – both areas in which the current editorial team members are only partly knowledgeable. In combination, we hope to boost these two research areas in the journal and that the coming articles to a larger extent will benefit from Mette and Runes competences and network. Both we and the new editors are very enthusiastic about the replacement in the editorial team and look forward to a further expansion of the article contents and consolidation of the journal's scientific position.



Professor Lars Jørgensen
(Foto: Royal Danish Academy of Sciences and Letters)

One of the former editors of the journal, Lars Jørgensen, and part of the current reference group initiating the revitalisation of the journal sadly passed away in early September. His tireless endeavour to promote and present Danish archaeology and research on the international scene is one of the underlying reasons why we could relaunch the journal back in 2011. He was a knowledgeable and trusted colleague and will be greatly missed. We sincerely hope that he would approve of the new journal and dedicate this volume to his memory.

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DANISH JOURNAL OF ARCHAEOLOGY, 2016
VOL. 5, NOS. 1–2, 3–18
http://dx.doi.org/10.1080/21662282.2016.1199235

Routledge
Taylor & Francis Group

RESEARCH ARTICLE

The Gotlandic box brooch from Fyrkat grave IV. A research into the casting technique and work methods associated with multi-piece brooches

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ABSTRACT
This study of the box-shaped brooch uses experimental archaeology in an attempt to gain more information about how these combination brooches were made. Some misunderstandings are addressed concerning the Fyrkat box brooch and Viking Age bronze casting in general. When trying to recreate the brooch, the four knot-shaped animals cast as one with the brooch throughout the work turned out to be the common denominator. They forced the original artisan to sacrifice an elaborate wax model when making the clay mould. Hollow models made of metal or solid bone could be used to produce this brooch only with difficulty. Again, due to the figural ornaments, a very complicated and time-consuming silver-plating technique was called for. Simple pure silver encasing was rendered nearly impossible. The very complex techniques used appear to have been the trademark of the artisan, designed to demonstrate his skill.

ARTICLE HISTORY
Received 14 December 2015
Accepted 6 June 2016

KEYWORDS
Fyrkat; Gotland; box-shaped; mould; silver-plating; copper-alloy; bronze casting

Introduction

The exhibition *The Vikings* in 2013 in Copenhagen brought renewed attention to the Fyrkat ring fortress near Hobro in Jutland. The predominant focus was on one of the graves at the Fyrkat graveyard – the inhumation grave IV, often referred to as 'the grave of the seeress' (Pentz and Prince 2013, pp. 196–197). Another designation for a seeress known from the Nordic sagas is *völva* (Pentz *et al.* 2009). Over time a particular item among the many exotic goods from grave IV has come to represent the Fyrkat seeress – a box-shaped brooch from the island of Gotland (Figure 1).

Grave IV dates to the period when the Fyrkat ring fortress had a purely military function, namely from the end of the 70s and into the 90s of the 10th century AD (Roesdahl *et al.* 2014, pp. 254–55).

This paper concentrates on the study of the box brooch and uses experimental archaeology to try to identify at least some of the techniques used to create the original brooch. The box brooch from Fyrkat would appear to represent one of the more advanced bronze brooches from this period. Indeed, these gold and silver-adorned brooches are categorized by the leading expert in the field, Lena Thunmark-Nylén, as 'praktspänner/brooches of splendour' (Thunmark-Nylén 1983b, p. 125.). The question is, were all the techniques associated with the manufacture of box-shaped brooches really that complicated, or just more time consuming? In order to find factual and objective answers, it is necessary to try to recreate the Fyrkat brooch.

Experiments based on the study of prehistoric metal brooches tend to involve five stages. The first stage, after a thorough study of the original material, consists of making a new model for the brooch in question. Using a rubber mould copy or a 3D scan copy is out of the question, in order to be able to address the question of what material/materials could have been used for the model. The second stage is making the mould for the casting. What materials for moulds were at the artisan's disposal in a prehistoric context? What do the archaeological finds tell us? Stage three is the casting itself: metallurgy, technology, heat resources, etc. Stage four encompasses the cold work of the raw casting: in short, any work – including repairs – done to the raw casting. Stage five normally involves the collaboration of other experimental archaeologists and colleagues. For example, in collaboration with textile experts, replica brooches with the proper needles can be tried on reconstructed costumes. In this paper,

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The following article is dedicated to the memory of Bjarne Lønborg (1949–2016).

Figure 1. D 169–1966. Fyrkat grave IV. Box-shaped brooch fason Gbl. 4/type 7b.

the author will mainly concentrate on stage two and part of stage four.

Experimental archaeology is still a relatively recent research method within professional archaeology. In Britain, John Coles with his eightfold principles defined experimental archaeology in 1973: '(1) All materials used should be those locally available to the society under study. (2) All the methods used in experimentation should remain within the bounds of the possible. (3) Modern technology should not interfere with the experiment, but should only be used in the analysis of results. (4) Both the scope and appropriate scale of work should be properly assessed in advance, but also in the light of the experiment itself (i.e. one should always factor in the sourcing, collection and transport of the materials used, as well as the time and manpower entailed). (5) Archaeological experiments should be repeatable. (6) A desired end result should be considered at the outset of each experiment. (7) The results should consist of observations that lead to suggested conclusions (in other words, the fact that something was possible does not necessarily mean that it was done that way). (8) Every experiment should be honestly assessed and the errors openly stated' (Coles 1973, p. 15ff.).

There is of course also a never-ending, self-teaching curve in conducting bronze-casting experiments with Viking Age techniques. Many prehistoric items were produced using techniques that are now at least partly forgotten. The author of this paper has conducted some 1500 copper-alloy castings using prehistoric methods since graduating in 1992 as an archaeologist at the University of Copenhagen. Most of the work has focused on Scandinavian brooches from the late Iron Age and the Viking Age (Hedegaard 1994, 2005, 2010b).

Typology and chronology

The brooch from grave IV is a Type 7b after Lena Thunmark-Nyléns' 2006 typological revision of Gotlandic box brooches (Thunmark-Nylén 2006, pp. 76–7). In Thunmark-Nyléns' earlier and meticulous work from 1983, the Fyrkat brooch was classified as a fason Gbl 4. Gbl stands for Guldbleck/Goldfoilmetal (Thunmark-Nylén 1983b, p. 25). In the present paper, it has been considered more practical to use mainly the 1983 typology as in this earlier work Thunmark-Nylén tried to identify the different prehistoric workshops for box-shaped brooches (Thunmark-Nylén 1983b, p. 8). The 2006 Type 7b also encompasses types of box brooches that in the 1983 work were defined as fason Gbl 5 and 6. At least from a metalworker's point of view, fason Gbl 5 and 6 stand well apart from the fason Gbl 4 (Thunmark-Nylén 1983b, pp. 76–9).

The production of Gbl 4 brooches seems to have begun in the first half of the 10th century AD. Worn-out fason Gbl 4/Type 7b brooches are known from graves on Gotland dating to the early 11th century AD (Thunmark-Nylén 2006, pp. 86–7). Therefore nearly identical brooches would have been in use on Gotland contemporary with the seeress at Fyrkat being in possession of her box brooch.

There is no doubt about the provenance of the Fyrkat box brooch. Gotlandic Viking Age brooches worn by women are very distinctive. Whereas in Scandinavia tortoise brooches worn in pairs were the dominant type, 'animal head-shaped brooches', also worn in pairs, were the fashion in Gotland (Carlsson 1983) (Figure 7). As a third brooch – often to hold a cape or a shawl, trefoil or equal-armed brooches were in favour in Denmark, Norway and Sweden. These were sometimes substituted by a trophy brooch (Hedegaard 2010a, pp. 71–4). The third main brooch on Gotland was the box-shaped brooch. Another possibility is the large, elegant, up to 16 cm long, disc-on-bow brooch (Thunmark-Nylén 2006, p. 51ff) or the more humble extra animal head-shaped brooch.

Box-shaped brooch fason Gbl 4 Fyrkat, grave IV D 169–1966

The Fyrkat box-shaped brooch is indeed a combination brooch. Originally, it consisted of 43 parts in total: eight parts cast separately in copper-alloy, two pieces of copper-alloy wire, a twisted silver wire, four gold foil pieces probably with gold granulation work, some 23 pieces of thin silver foil with niello inlay and five iron wedges. Most Viking Age 'standard' brooches made do with three parts: shell/bow, needle and pin for needle.

Today, the heavily corroded Fyrkat Gbl 4 brooch retains only two of its original cast copper-alloy parts, one iron wedge, a tiny fragment of one of the copper alloy wires and less than half of the thin silver foils. Luckily, one of the preserved cast parts is the main part; often referred to as the shell, the hull or the *drum*. One of the four original corner posts is still in place on the drum, secured by its iron wedge. The missing parts are presumed lost or removed, before the brooch came to rest in grave IV close to the head of the deceased.

The drum is, without the four-legged animal figurines on the top, 3.1 cm high, has a lower diameter of 6.0 cm and is 5.8 cm in diameter just below the top. The knot-shaped animals with their defiant stance add another 1.2 cm to the height of the drum. The four animals and the drum are cast as one and should therefore be seen as *one* single copper-alloy part. Other box brooches, like fason 5 and 6, have four separately cast animals on the top of the drum, which were riveted on (Figure 2).

The brooch found in the 'seeress' grave seems to have been transformed into a small cup. Bereft of its bottom plate and central boss attachment, the brooch in an upside-down position resembles a small, four-legged cup. However, some 20 perforations would have made the improvised cup somewhat leaky. To solve this problem the holes were filled by partly melting in some lead and partly by hammering in small lead plugs (Figure 3). The creator of the 'cup' could also have made use of beeswax or pitch for this purpose, but then the cup would not then have been able to hold a hot liquid. The lead is today partly corroded into lead carbonate. This last ingredient has given rise to speculation as to whether the seeress incorporated the lead in the form of a lead-white cream to give her face a somewhat paler complexion (Pentz *et al.* 2009, p. 220). This misinterpretation might have arisen from the typological term, box-shaped brooch. The designation *box* quite naturally makes many people think of a container, and the purpose of a container is to hold something. Indeed, a few box brooches and animal head-shaped brooches were used as makeshift piggy banks, holding a piece of amber, a few coins or maybe a small silver rod

Figure 2. Gbl. 4 box brooch with cast-in-one figurines and G 6 box brooch with riveted flat figurines. Replicas.

Figure 3. D 169–1966. Inside of drum. Notice lead plugs.

(Thunmark-Nylén 2006, p. 22). However, for the duration of the (approx.) three centuries that box-shaped brooches were produced, the bronze casters never seem to have felt inclined to change the brooch design towards genuine practical portable containers.

The Fyrkat box brooch has four ribbon-ornamented squares on its rounded octagonal sides, sitting between the open spacing for the attaching of the four corner posts (Figure 4). The ornaments are cast as one with the drum and have been fire-gilded with an amalgam of gold. Some of the ribbons in the ornaments have been cold-worked with a bead punch. In order to fasten the bottom plate, a protruding rivet was placed behind each ornamented square. One of the ornamented sides shows damage and a small part of it is missing, together with the rivet. If this damage did not occur during the excavation in 1954, then one gets the impression of a person either not caring or unskilled with metal-work. This person has tried to remove the bottom plate rather forcefully with hammer and chisel, thereby with a bold stroke removing not only the bottom plate, but also the entire rivet and part of the ornamented square.

Figure 4. D 169–1966. Corner post and ornamented square.

Some previous studies of Gotlandic brooches

Finds of typical Gotlandic brooches outside the island are relatively rare. The Fyrkat box brooch long remained Gotland's only representative in Denmark. The last four decades of metal detector finds have somewhat changed this. It started with a fragment of a 9th century AD disc-on-bow brooch at Humlebakken near Aalborg, and more has followed (Petersen 1991, pp. 57–60, Figure 9a).

In Hedeby in Southern Schleswig (Germany) two box-shaped brooches have surfaced (Hedegaard 1994, p. 312). One of these is the top shell for a double-shelled fason G2 (Hb. G8/2) and the other the small and uncomplicated fason BS4 (Kat.nr. 95). The later had been transformed into a weight by sawing off the needle attachment and filling the drum with lead.

Odense Bys Museer on Funen possesses in their comparative collection two box brooches, fason G 6 and P 4 (Figures 5–6) and two animal head-shaped brooches, types 4:5 and 5:2 (Hedegaard 1994, p. 312). How these unprovenanced brooches some hundred years ago ended up in Odense is today a conundrum.

The Hedeby and Odense brooches formed the initial Gotlandic research material for the author and the basis for the first experiments (Hedegaard 1994). The early research was facilitated by Anders Carlssons' 1983 work, 'Djurhuvudformiga Spännen', and Lena Thunmark-Nyléns' publication from the same year, 'Vikingatida Dosspännen'. For these two scholars, the manufacturing process of the brooches and the organization of the production is a natural and important element in their studies.

In 2000 the author, together with Dipl. Engineer Jens Fich at the C.C. Jensen Ship Window and Metals Castings Company in Svendborg, conducted a computer-simulated casting of a 11th century AD fason P 4 box brooch (Hedegaard 2000). The results indicated some 'problem zones'. Where a relative massive inlet for the metal meets the (approx.)

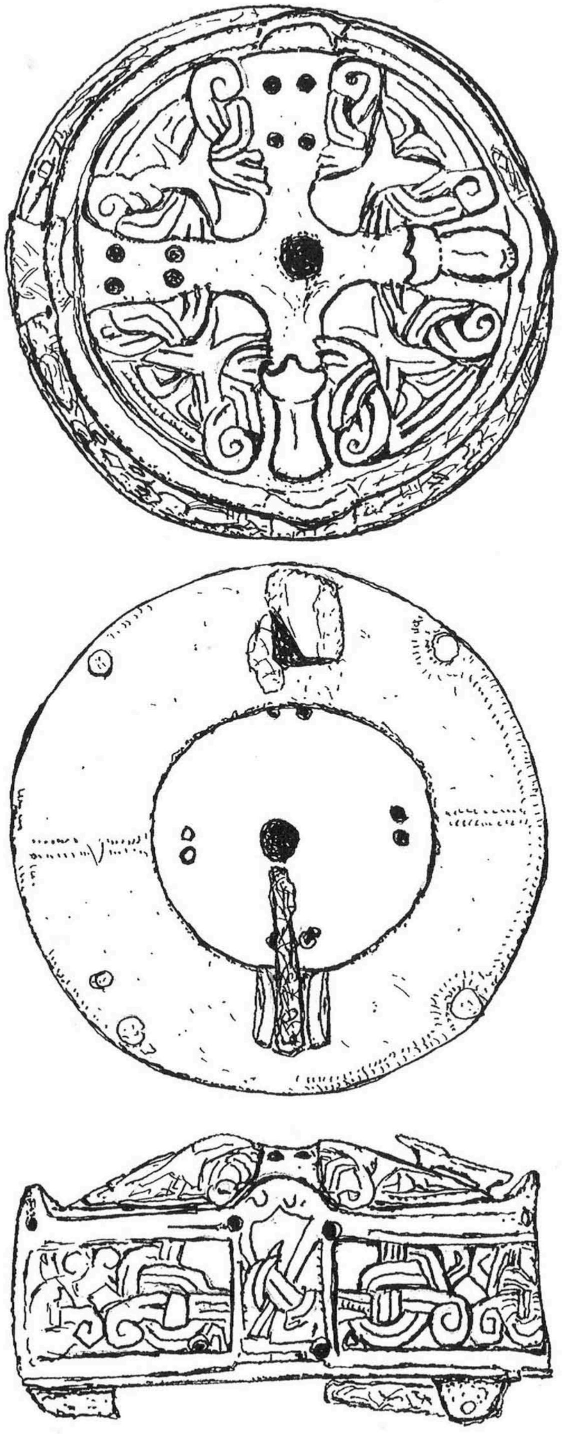

Figure 5. OBM 3200x29. Fason G6. Separately cast animal figurines and central boss. Lower diameter 6 cm.

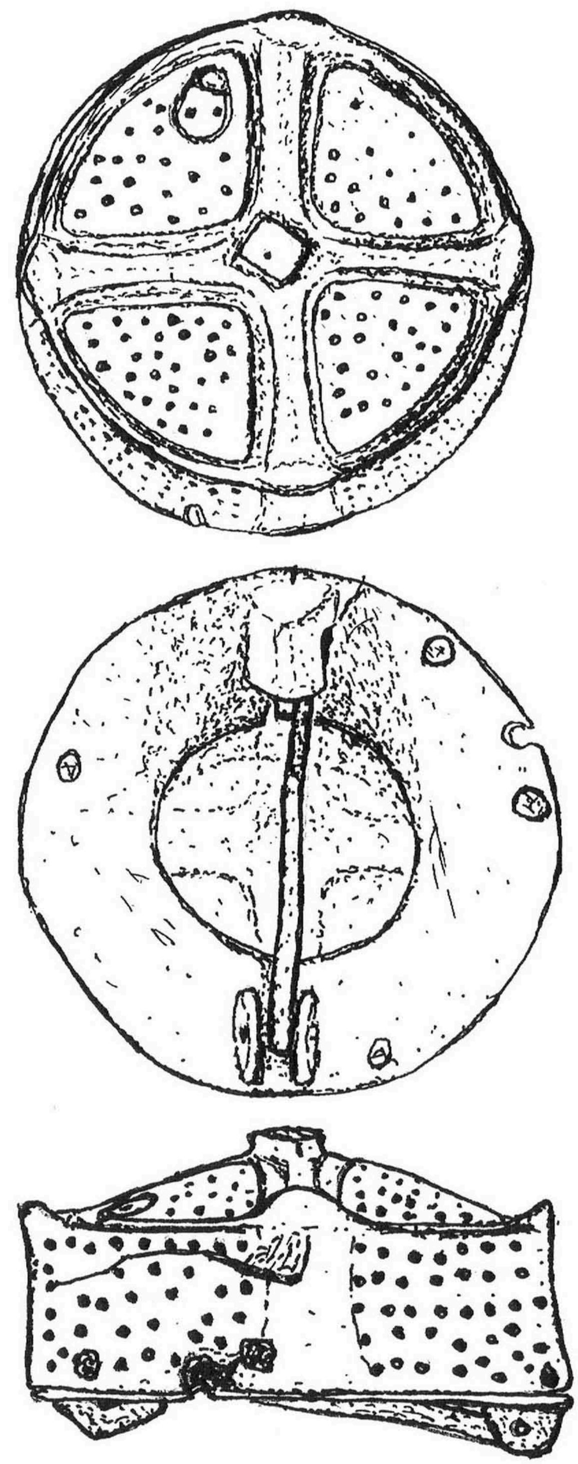

Figure 6. OBM 3200x27. Fason P4. Lower diameter 4.8 cm.

2 mm-thick wall of the brooch, there is a zone with a high risk for metal suction. This can result in a hole in the brooch after removal of the inlet. The animal head-shaped brooch from Funen (inventory number: OBM 3200x32) type 4:5 has such a casting error on its 'nose', thus proving where at least some of the Gotlandic metal-casters placed the inlet for animal head-shaped brooches (Hedegaard 2000, p. 83). Even more interesting, the simulation indicated a risk for the metal running cold at the

central boss on the top of the drum (Hedegaard 2000, p. 84). In the simulation, the sprue was placed at the lower rim of the drum. This position is borrowed, from what we know about the position of metal inlets in clay moulds for tortoise brooches (Brinch Madsen 1984: 33ff.). The fason P 4 brooch belongs to the group of relatively small box brooches – a fason P 4 is typically some 20–25% smaller than most fason G 6 box brooches. Comparing the amount of metal needed for casting a P 4 brooch to a G 6 box brooch, the latter will in general call for some 40% more metal than the former. The casting simulation programme predicted that the bigger the brooch, the greater the risk for a casting error involving the central boss. Fason G 3–6 all belong to a group of relatively wide and tall box brooches. When the casters on Gotland engaged in efforts to enlarge the size of the box brooches and wanted to secure an intact *and* enlarged central boss, they would have been well advised to go for separately cast central bosses. A fason P 4 brooch has in general a central boss cast as one with the drum (Figure 6), whereas a typical G 6 has a separately cast central boss (Figures 2 and 5). So changing a brooch design from nearly all details cast as one to a multi-piece brooch is not necessarily simply a question of fashion – it can be due to sound technologically thinking.

In 2009 the find of an animal head-shaped brooch type 4:5 in a grave with two tortoise brooches, type JP 37, generated renewed interest in Denmark for Gotlandic material (Figure 7). The grave in question is Snubbekorsgård grav 88 on Zealand (Sparrevohn 2009). Consequently, the author of this paper carried out new experiments with animal head-shaped brooches, this time focusing on metal models and three-piece clay moulds (Figure 8). This was inspired by A. Carlsson's identification of a hollow metal model for an animal head-shaped brooch (Carlsson 1983, pp. 79–80). A hybrid model combining a metal model and a bottom-plate in wax for a type 3:3 animal head-shaped brooch turned out to be very convincing. Not all box or animal head-shaped brooches with a fixed cast-as-one bottom plate call for a complete wax model that later will have to be sacrificed. However, the work method calls for clay moulds with a divided upper mould in order to liberate the hollow metal model.

Figure 7. Snubbekorsgård grave 88x20. Zealand. Animal head-shaped brooch type 4:5. Foto L. Sparrevohn.

Figure 8. Three-piece mould for type 3:3 brooch after casting. Bottom plate cast-as-one with brooch. Replicas.

The 2015 experiments

The above-mentioned renewed attention given to the seeress grave led to a demand at Vikingecenter Fyrkat for a fason Gbl 4 dissemination replica. The author of this paper was commissioned to undertake this project.

A replica of the drum was moulded in coloured wax. Wood – but especially bone – is suitable as material for a solid model for a box-shaped brooch, but wax is quicker to work with and errors can easily be fixed. Leather worked well in an attempt to recreate one of the four ornamented squares on the drum (Hedegaard 2005, p. 8; 2010b p. 95, Figure 15). To reconstruct a corner post for the Fyrkat brooch, wax seemed like if not the only, then the right, choice. Two wax plates were ornamented: one perforated plate with the posts' protruding ornaments and another plate with the deep-set ornaments. The first plate was placed on top of the second. The work was surprisingly easy. Once new mother models had been made by hand, these were copied using modern rubbermoulds.

At one point due to lack of time and skills, the work differed from the original brooch. The mainly 'steep rope cord'-ornamented silver-plated bands for the drum were substituted with a simple entwined wavy kordel ornamentation borrowed from a fason Gbl 5 box brooch (Thunmark-Nylén 2006 p. 78, Figure 53; SHM 12151). The kordel ornamentation was cast as one with the drum, as is also the case with many original brooches, but *not* with the Fyrkat brooch. Nevertheless, one wax drum copy was given bare, smooth bands. This version resembles the unfinished fason Gbl 3 box brooch from the Smiss find (Zachrisson 1962 p. 209, Figure 5). Gbl 3 and 4 brooches differ only in the ornaments on the squares.

The four knot-shaped animals for the top of the drum were also made in wax. They turned out to be somewhat difficult, and the animals ended up being too big. This mistake made the top of the drum a bit crowded.

The first three replica drums plus corner posts were cast in silicium-bronze, here referred to as 'CuSi bronze' (Cu 94%, Si 4%, Mn 1%, Fe 1%), a very hard alloy. The mould material was modern shell-casting (1).

The initial castings gave two extra box brooch drums: one with cast korde ornaments was intended for experiments with 'pure silver encasing' work and a second brooch with smooth bands for silver foil soldering work. New wax models for drums with more refined knot-shaped animals were now made. The intension was to form genuine clay moulds over these wax drums. The very plastic shape of the drums calls for moulds made in clay and excludes rigid moulds made out of, for example, limestone or solid bronze. The experiments took place mainly in the smithy at Vikingecenter Fyrkat. The work process was open to colleagues, students and the audience in general. An exhibition focusing on Viking Age Scandinavian and Gotlandic bronze casting supplemented the work. For the exhibition, the missing parts for the Fyrkat box brooch had been produced in CuSi bronze: bottom plate, cast needle, the three lost corner posts and the central boss. These parts were sourced from more intact fason Gbl 4 box brooches, like the one from Hellvi, grave 222c, C9322 (Thunmark-Nylén 1983b, p. 76, Figure 52a). This was to give the audience an idea about how many metal parts constitute a complete fason Gbl 4 box brooch (Figure 9). A positive bronze die had also been moulded in wax and cast in CuSi bronze. This was done in order to manufacture the four missing gold foils for the top of the drum. However, the foil that was actually put to use was cheap 0.4 mm copper.

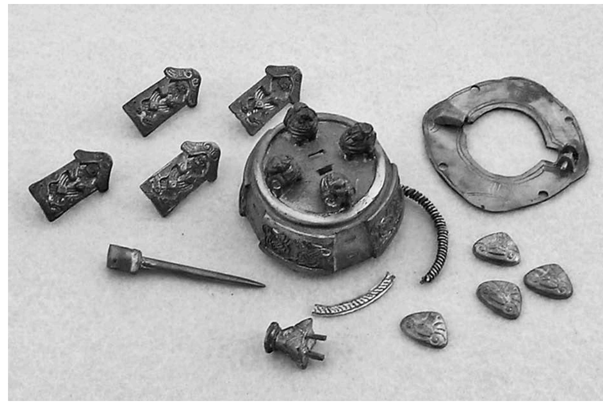

Figure 9. Fason Gbl. 4. Eight copper-alloy parts and more. Replicas.

Metal

It is brass alloys that dominate the more advanced box brooches, and it is important that the alloy contains as little lead as possible. This is due to the gold amalgam work, which is especially observed on Gbl box brooches. The mixture of mercury and gold used for amalgamating copper-alloy items does not adhere well if the content of lead exceeds some 2–3%. The casters on Gotland were very much aware of this fact, as we can see from well-preserved box brooches that have been metal analysed (2). The alloy selected in the experiments was 76.5% copper, 18.5% zinc and 5% tin. The fuel for melting the metal in a stone-lined pit was high-quality hardwood charcoal. The necessary 1200°C were reached with the help of manually operated double bellows. The chosen brass-alloy will be liquid at some 160 degrees below 1200°C, but excess heat is needed for the casting moment.

Crucibles

The crucibles we know from the Viking Age site Fröjel on Gotland seem to be dominated by a cylindrical design with a rounded bottom (Gustafsson and Söderberg 2007, p. 100, Figure 2). The shape of the Fröjel crucibles can be compared to the Ribe type 1 crucibles (Brinch Madsen 1984, p. 26ff.). In the Fyrkat smithy, crucibles of the semi-closed Ribe type 2 were favoured, in order to reduce loss of zinc during meltdown (Jouttijärvi 1999, pp. 44–5). These crucibles differ from Fröjel/type 1 by having a smaller top diameter. Ribe type 2 crucibles are thus in general more egg shaped than cylindrical. In addition, Ribe type 2 crucibles have a tap on the side. This tap has more than one function (Hedegaard 2005, p. 11). The 'hotspot' in a typical melting pit is between the blowhole and crucible. Placing the crucible with the tap pointing towards the blowhole in the melting pit, the tap helps to disperse the heat around the crucible. The tap, to a surprisingly large extent, also prevents the crucible from tumbling in towards the blowhole. A Ribe type 1 or type 2 clay crucible needs handling with iron tongs that have long, delicate, almost pincer-like thin arms. Unless the crucible is tiny and it and its content thus very light, you *never* grab a type 2 crucible at the very tap, but round the belly below or above the tap. Clay crucibles can at 1200°C be malleable, like marzipan. Many museum exhibitions and drawings in publications depict clumsy, unsuitable, heavy-duty blacksmith tongs for handling Viking Age clay crucibles.

A typical Viking Age type 1 crucible has a volume of some 20 cm^3 (Pedersen 2010, p. 173) and will thus in the author's experience hold on an average 120–180 g of copper-alloy in ingot and scrap form. Such a small amount of molten metal gives the bronze-caster only five to eight seconds to perform the casting, counting from the second the crucible is lifted free of the melting pit.

The CuSi-bronze replica drums, which already were at available, have a metal wall thickness of some 1.5–2.0 mm and their weight ranges from 126 to 156 g. Adding some 20 g for sprue and gate plus another 20 g for waste, it became clear that for the experiments we needed clay crucibles with a capacity of some 180–200 g of brass in ingot form. The crucibles were based on Miocene micaceous clay taken from the Gram clay pit in Southern Jutland (3). This very homogeneous clay was mixed with 30% ground, discarded crucibles, 20–25% fresh horse manure and a small amount of cut horsehair. The proportions for the mixture are in volume, not in weight. Crucibles made from this particular mixture normally stay servable for two and up to six 1200°C meltdowns. If the quality of the charcoal is compromised, a crucible might only manage one single casting.

It only takes some five minutes to form a type 1 or 2 crucible with your hands (Hedegaard 2005, pp. 10–11). After some three to four days of drying, the crucibles are pre-fired by placing them close to a fireplace. About an hour later, they are moved into the very centre of the hearth and are fired for a further three to four hours at c. 700°C.

Moulds

The clay used for moulds also came from the Gram clay pit. Clay from clay pits on Gotland ought to have been tested for both the moulds and the crucibles. However, the author did not succeed in obtaining such clay. The clay was dried and pulverized, whereby one can easily remove any impurities. The proportions of the mixture in volume are 50% fresh horse manure from grazing animals, 40% pulverized clay and 10% pulverized discarded moulds as temper. At this stage is also added cut horse or human hair. This last ingredient is difficult to measure; one should always go for a 'very hairy mixture'. If the horse manure is particularly fresh, only a small amount of water needs to be added in order to knead the mixture. This batch is referred to as '*regular mould-loam*'. A batch about the size of a loaf of bread is more than enough to make moulds for one fason 4 box-formed brooch.

A fistful of regular mould loam is now mixed with a fistful of pure pulverized clay that has been moisturized. The proportions for this new mixture will be some 70% clay, 25% manure and 5% temper. If deemed necessary, a little more temper is added. This mixture is referred to as '*impression loam*'.

A final mix consists of 95% pulverized clay and 5% pulverized discarded moulds, plus water. This mix is called '*the finer impression loam*' or simply the slurry. Only a small cupful is required.

For the past 25 years the author has based nearly all his Viking Age experimental castings on the above recipe for mould loam. However, the clay did not always come from Gram. Cow manure has also been tested and the resulting moulds were found to be very much in congruity with original Viking Age moulds (4).

It stands to reason that every Viking Age bronze caster would have had his own recipe for both crucibles and clay moulds. Natural clay has, depending on its chemical composition and levels of natural admixtures, very different physical properties. This will have an influence on, for example, the amount of shrinkage and the firing temperature. The artisan would have been strongly influenced by special local resources, like maybe a pit of prime quartz sand for temper in crucibles or butter clay from a nearby marsh for impression loam. Nevertheless, his mixtures for mould loam would have needed a content of at least 25% organic material. A common observation for Viking Age clay moulds is that they are light and porous. The Scandinavian late Iron Age clay mould technology is based on this porosity. Regular inserted air vents are not needed to help air and gas, mainly in the form of hydrogen and carbon monoxide, to escape from the mould cavity. It is important to understand that the gases rarely pass all the way through the mould – they are *absorbed* by the porous walls of the hot mould. Some gas and air will naturally also be able to escape along the junctions of a multi-piece mould. This casting technique must never be mistaken for the more modern flask-supported sand-casting.

The making of the moulds could now begin. As mentioned above, the four knot-shaped animals were cast as one with the drum on the Fyrkat grave IV specimen. This fact makes it very difficult, if not downright impossible, to use a solid model in a clay mould. Of course, it also makes it somewhat difficult for another less skilled or lazier bronze caster to copy 'our' casters brooch. A simple brooch design can be copied by pressing the brooch into moist clay. In this offprint, you then pour melted beeswax (Hedegaard 1989, pp. 74–5). Had the knot-shaped beasts been cast separately with the intension to rivet them on, a metal, wood or bone model for the drum would have been feasible. This would have called for a more time-consuming mould built up in three to five different pieces, but such work should have been fully within the ability of most Viking Age metal casters.

One possible compromise could be a hybrid model. This could be a hollow model in metal for the drum and four animals on top in wax, which would call for a separate mould piece for the very top of the drum. In this piece, the four wax animals are embedded. Just before the loam is so-called leather hard, the multi-piece mould is opened and the metal model taken out. The mould piece for the top would retain the four wax figures. However, such a procedure is likely to leave behind some small telltale clues on the surface of the finished brooch – these have not been observed on the original material with any degree of certainty. Thus it was decided to base the experiments on hollow wax drums complete with wax animals and wax rivets.

Mould A was built up over a wax model with kordel ornamentation using the same method as for a fason G 6 box brooch from the 1994 experiments, in other words a 'standard' two-piece mould (Figure 10). The only tangible and original Gotlandic material to take guidance from is one clay mould fragment for the top of a fason D 5/type 2a box-shaped brooch (Thunmark-Nylén 1983b, pp. 24–5) and some tiny metal flanges round the lower edge of the unfinished fason Gbl 3 brooch from Smiss (Zachrisson 1962, p. 209, Figure 5). The wax model for mould A, including a fixed wax-sprue, was placed on an oak plank. Here four small holes had been drilled to accommodate the four wax rivets; into the plank was cut a groove to take and support the

Figure 10. Mould A. Upper mould. Next to it, CuSi brooch, wax model with sprue for corner post and corner post cast in brass. Replicas.

Figure 11. A selection of Gotlandic and Scandinavian Viking Age brooches. All with the ability to sit flat. Replicas.

sprue. Following B. Lønborgs' definitions, the part of the mould that creates the ornamented impressions for the surface of the brooch is referred to as the *upper mould*; the part of the mould that creates the inside or the belly of the brooch is referred to as the *lower mould* (Lønborg 1998, p. 100). The majority of Viking Age brooches have the appealing ability to be able to 'sit flat' on a wooden plank (Figure 11). That would of course be after cutting holes to take protruding taps for the needle attachment, or in our case rivets. This feature was introduced during the 7th century AD and probably started with rectangular and round disc brooches. This fixation on the models greatly facilitated work on the upper mould pieces, especially for large brooches created from hollow wax models. Because once work is started with addition of a thin film of slurry, then impression loam in a layer some 0.2–0.3 cm thick, and later the more coarse regular mould loam in a layer up to 1.5–2.0 cm, the moist loam will start to lower the temperature of the wax. Pure beeswax becomes rather brittle below about 12°C. Sometimes the wax model cracks or a small wax knot-shaped animal breaks free of the drum. Round the edge of the upper mould that is in contact with the wood, you cut or press negative key holes.

The upper mould is allowed a night to dry. It is then turned over and work on the lower mould is started (Figure 12). As the inside of the brooch has no ornaments, the use of finer impression loam is not mandatory. However, original brooches cast using the textile cavity method (Hedegaard 2010b, pp. 90–1), as well as the few intact lower mould fragments that have been found in Scandinavia, indicate that it was done anyway. A depression in the lower mould ensures that during the early stages of the drying the loam can be pressed continuously and firmly against the inside of the wax model. Positive keys on the side of the lower mould are formed to fit into the upper mould's negative key holes. In order to be able to subsequently separate the two mould pieces, a little dust from finely crushed used moulds is smeared onto the contacting surfaces.

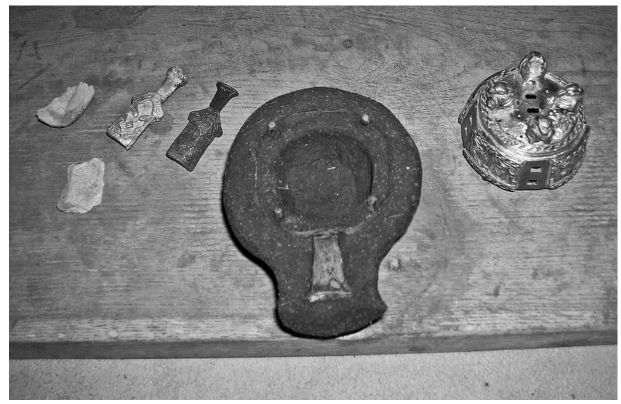

Figure 12. Mould A. Lower mould in progress. Notice depression in loam.

Now the caster will have to decide whether to seal the two mould pieces or not. Sealing is simply an extra layer of regular mould loam. With no sealing, the mould pieces can be separated after the burnout of the wax, thus providing an opportunity to control the cavity for damage. The downside is that the caster then will have to seal the mould pieces with fresh loam, dry the mould again for about two days and burn it again for at least another hour. Short of time, the author chose the 'instant sealing' option. Under any circumstances, a clay mould of this size needs five days of drying. After this, the mould needs to be fired for some four hours. The firing takes place in an ordinary fireplace at about 700°C.

The drying period is *critical*. The moulds must be left to dry in the shade in a well-ventilated room. In this room, there should not be any strong, artificial heating. On very rainy days with high humidity, there is a risk that the drying process slows down or might even come to a full stop. If the moulds are not fired within ten to fourteen days, the manure and hair inside them might start to decompose, thereby reducing their porosity. Once the moulds are fired, they can be stored for a prolonged period. Later they are re-heated until they glow inside, as seen down through the inlet. Then, they are ready for casting. However, as fired porous clay moulds can be very fragile, one should store them accordingly and always limit transport and handling to a minimum.

Mould B was built in a different manner. Here the 'Smiss' CuSi-bronze replica drum with bare bands was tested in the role of a supporting metal model (Figures 13–14). It was placed on the oak plank and the upper mould was formed against it in three separate pieces, plus a separate piece for the top of the sprue. Later the pieces were removed and the metal model was replaced with a wax drum with kordel ornamentation. The still flexible upper mould parts were now applied to the wax drum. This was done to see if it was possible to improve the build-up of the upper mould and to spare the hollow wax model from abuse during the process.

The construction of mould B confirmed earlier observations. The porous mould-loam does not really necessitate a multi-piece mould. If it is decided to sacrifice a wax model, you then can wrap the model completely in mould loam, dry it, fire it and cast. If the inner layer of impression loam has been in close contact with the wax model, the cast result should be fine. It is interesting that it makes good sense to build up your mould like a multi-piece mould, whether your model is solid or wax. With a multi-piece mould, you have a much better contact between loam and model. As an added bonus, you can check a multi-piece mould for inside flaws before casting. These facts might explain why the majority of the mould fragments that we know from the Scandinavian Viking Age derive from multi-piece moulds.

Figure 13. Mould B. 'Smiss' replica-brooch tried as aid for separate top for upper-mould. Result partly negative.

Figure 14. Mould B. Adding slurry and impression loam with spatula and brush to knotty animals on wax model.

Other moulds

Also produced were two-piece clay moulds for four corner posts and one bottom-plate. One-piece moulds were made for a needle and a centre boss. For these seven moulds, wax models were used. In particular, the flat bottom plate is a classic example of a metal object cast in a two-piece mould formed over a solid model.

The castings

All castings in the above-mentioned moulds gave complete and acceptable items (Figures 15–16). However, drum B has some minor flaws (Figure 17). When casting in mould B the caster (the author) overlooked a 20 g ingot of metal and did not get it into the crucible. As a result, there was barely enough metal in the crucible to fill the cavity of mould B. The very last metal in a crucible is always relatively cold and contains nearly all the impurities of the melt.

Figure 15. Mould A after casting. Ribe type 2 crucible and tong with pincer-like arms.

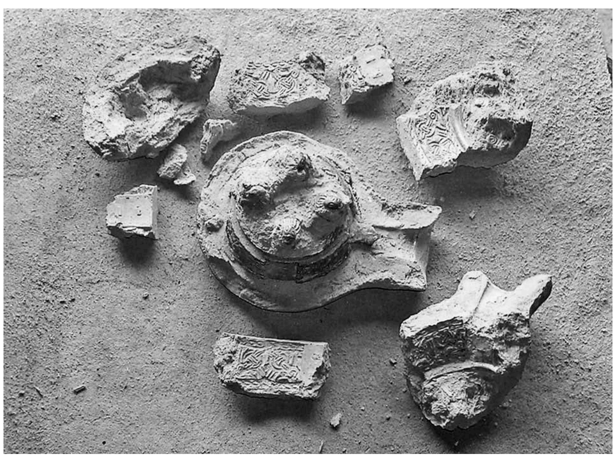

Figure 16. Mould B opened after casting.

Mainly due to shrinkage of the solidifying metal, all moulds partly cracked or even all together disintegrated after casting, especially if quenching in water was involved. A porous late Iron Age clay mould can only be used once in high-temperature castings of hollow copper-alloy brooches (Hedegaard 2010b, p. 92). Had it not been for the four animals, the making and the casting of the moulds for the drums would have involved the same level of difficulty as a standard, single-shelled oval tortoise brooch or an animal head-shaped brooch.

Drum A in the state of an unworked raw casting, but with the sprue removed, had an average thickness of 2.47 mm; its weight was 177 g. Corresponding values for Drum B' were 2.46 mm and 175 g. The average weight for a replica corner post with the sprue removed is 10 g. Today the original Fyrkat box-shaped brooch has a weight of 94 g, including corner post, lead, silver plating and conservation lacquer. Its drum has an average thickness of 2 mm. The outer measurements for drums A and B are within the parameters of the original brooch.

In theory, when taking some 20% of the weight of drums A and B due to the excess 0.5 mm in thickness, will provide some 140 g for each drum. This would have roughly been the original weight of the Fyrkat grave IV drum when it was a fresh, raw casting. The total weight of the 'complete' CuSi bronze fason Gbl 4 replica in Figure 9 is some 240 g. For comparison, a large trefoil brooch like the

Figure 17. Drum A and B. Flaws round inlet/gate on drum B due to impurities in melt.

Figure 18. Gotlandic brooches and needles on cape and dress. Box brooch fason P6/type 6b, animal head-type brooches type 7:4. Box brooch supported by two type 4b (Thunmark-Nylén 2006, p. 122) bronze needles. Replicas of bronzes from grave 127 at Havor, Hablingbo Parish. SHM 8064. NB: double-cape and dress does *not* derive from any original find.

Figure 19. A 1524. Stanga Parish. Pure silver encasing. Foto Franceschi 2005. Fig. 175.

type JP 115 'Tingelstad' would weight some 110 g (Petersen 1928, p.113, Figure 115).

It does not appear, however, that the casters on Gotland cared much for creating light advanced box brooches. The well-preserved Mårtens brooch (fason Gbl 5/type 7b) today weighs 327 g (Thunmark-Nylén 1983b, p. 381. 12151 Gröllingbo). Nor did the less advanced, but still large, box-shaped brooches with no gold foil and only a simple silver wire become light-weights, due to their having often been cast from an alloy with an average content of c. 19% lead (Thunmark-Nylén 2006, p. 381). In order to prevent these top-heavy brooches from sagging, it is reasonable to think that it was necessary for the women on Gotland to support their box brooches with two sturdy bronze needles passing through the cape and into the inner garments (Figure 18).

Encasing

Parallel to the work with the moulds, silver-encasing work was tried out on a drum with cast kordel ornamentation, a corner post and a centre boss, all cast in CuSi bronze. Sterling silver plates were annealed and hammered down to foil metal with a thickness of some 0.1–0.2 mm. Studying original box-shaped brooches in close-up, it is clear that the silver foils are not just lying flat on the positive-standing ornaments: the silver is also bent down around the ornaments, as can be observed on a fason G 6 from Stanga Parish (Figure 19). Using the brooch as a positive die and inserting a lead plate between silver foil and hammer, the silver is hammered down into the ornaments. It is important that the underlying ornaments begin to show on the surface of the silver. The silver foil is removed and cut into shape. After more annealing, the silver is replaced on the bronze ornaments. With specially forged pointed iron punches, so-called drifters, the silver is driven down into the groves and open spaces in the ornaments. Later the silver is tapped into the sides of the ornaments, this time with a more blunt punch using a spot-hitting technique. This method is what the author has chosen to label as '*pure encasing*'. A less refined and almost brutal process is driving the silver down onto a flat surface of a relatively soft copper-alloy. With a sharp punch, the metalworker forms the underlying ornaments through the thin silver foil as he goes along with

Figure 20. A 1524. Corner post. Here direct pure encasing. Foto Franceschi *et al.* 2005. Fig. 164.

his tool. The result can appear rather random (Figure 20).

During the trials with pure encasing, it became clear that the four animals on top of the drum posed as serious obstacles (Figure 21). It was necessary to construct a special wooden vice to hold the drum during encasing and cold work. This might explain

Figure 21. Attempted pure silver encasing on cast kordel ornamentation. Brooch seen upside down. CuSi replica.

Figure 22. Positive die with steep rope-cord ornamentation for producing silver plating. Replica.

why the original box-shaped brooch from Fyrkat was not given silver-plating work using the simple pure encasing technique. Under the partly torn off silver foil, no positive cast copper-alloy ornaments can be made out. The silver plating work had to be formed over specially made metal dies (Figure 22). The Fyrkat Gbl. 4 brooch's silver foil work called for no less than six or seven different dies. Thunmark-Nylén suggests a freehand ornamenting technique for the very thin silver bands (Thunmark-Nylén 1983a, p. 184). This technique was tested by the author, but with limited success.

The silver foils do not bend much around the bare positive bands on the original drum. This feature makes sense when it comes to soldering on the foil, due to vapour from the solder. The soldering of the almost flat silver plating was supported by fixing it with at least three identified silver rivets to the top of the original drum. The niello work must have complicated the soldering process. The mixture of sulfur, lead, copper and silver that constitutes the black metallic alloy, known as niello, fuses round 380°C (5). This means that high-temperature silver soldering was needed to hold the silver plating in place on the drum, the corner posts and the centre boss during the melt-in of the niello. The balance between the temperatures also had to take into account the gold amalgamation work on the drum, as the highly poisonous mixture of mercury and gold calls for temperatures between 357–375°C (Lønborg 1998, pp. 63–4). Work with niello and gilding was not undertaken during the 2015 experiments.

Conclusion

The research revealed that the maker of the original fason Gbl. 4 box-shaped brooch deliberately chose not to take any short-cuts. The four knot-shaped animals cast in one with the drum must be regarded as the common denominator because of them, an elaborate wax model, had to be sacrificed. This wax model was very time consuming in its making. The build-up of the mould and the casting became more complicated as more could go wrong. To encounter these problems the caster probably chose to work with a multi-piece clay mould, even if the lost wax method and the porosity of late-Iron Age clay moulds do not call for this. When cleaning the raw casting and cold working it with mini-chisels, engravers and punches, the animals made access difficult and slowed work down. The heads of the animals hovering over the drum's upper bands made it very difficult using the simple pure encasing method without damaging the animal figurines. So the silver encasing work on the original Fyrkat box-formed brooch had to be done separately, calling for several specially manufactured dies. The artisan behind this brooch did apparently not lack resources and time.

Apart from making it difficult for another caster to directly copy 'our' bronze-caster's work, from a combined archaeologist's and metalworker's point of view there seems to be only one logical explanation to the mentioned exertions. The artisan behind the box-shaped brooch from Fyrkat wanted to send a rather self-assertive message: 'Look what I can do; see how I master the wax, the mould loam, the brass, the silver and the gold!' Who had the metallurgical knowledge in order to fully appreciate the caster's talents? One group of people certainly did. This group was the other contemporary metalworkers on Gotland, as well as any metalworker outside of the island.

The casters of non-ferrous metals in the Viking Age gathered knowledge by studying each other's products. The finds from Viking Age centres of trade like Hedeby, Ribe, Birka, etc. indicate some regular export and import of cast brooches (Ambrosiani 1992, p. 37). A metal caster could also have procured exotic brooches through merchants dealing in scrap metal. A more 'direct trade', with almost brand new top-of-the-range box-shaped brooches, was certainly derived from plundering (Ulriksen 1997, pp. 210–11) (6). As there was a very limited market for an advanced box-shaped brooch outside Gotland in the 10th century AD, plunder is the most convincing explanation as to how the fason Gbl 4 brooch found its way from Gotland to Fyrkat. Every metal caster in Denmark would have loved to study it, but once the caster's curiosity was satisfied the now partly disassembled brooch was regarded as scrap metal. However, before the entire brooch ended up in a crucible, the Fyrkat seeress somehow intervened. She acquired the drum and had it made into a cup.

(1) The author would like to thank Jørn Svendsen and his crew at Skulpturstøberiet in Svendborg for access and help with the CuSi copper alloy box-shaped brooch castings. I would also like to thank Dipl. Praehist. Klaus Hirsch from Museum Sønderjylland–Arkæologi Haderslev for proofreading.

(2) Examples of metal analysed brooches: Fason G 2 box brooch. SHM 2286. 79.6% Cu, 16.1% Zn, 0.9% Sn + div. Oldeberg 1942–43 I, pp. 218–19. Fason D15/Type 2D box brooch. SHM 27739: 81.3% Cu, 17% Zn, 0.9% Pb + div. Thunmark-Nylén 2006, p. 381.

(3) Natural History and Paleontology Museum. Lergravsvej 2, DK6510 Gram.

(4) After a nasty parasitic infection acquired from bovine manure, the author has decided to stick to horse manure.

(5) It is, however, possible to make niello malleable at 200°C. See Lønborg 1998, p. 65.

(6) According to the 12th century AD Gutasagaen chapter 2, Gotland was 'in the heathen period raided by foreign kings'. Gotland officially became Christian in the year 1030 AD (Lindkvist 1983, p. 282 and Thunmark-Nylén 2004, p.165).

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DANISH JOURNAL OF ARCHAEOLOGY, 2016
VOL. 5, NOS. 1–2, 19–33
http://dx.doi.org/10.1080/21662282.2016.1245885

RESEARCH ARTICLE

Between Sutton Hoo and Oseberg – dendrochronology and the origins of the ship burial tradition

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ABSTRACT

New dendrochronological dates from Western Norway prompt an old question to be posed in a new way. They show that two ship burials on the island of Karmøy date from AD 780 and 790, that is, the very beginning of the Viking Age, and are therefore the very earliest known ship graves – with one exception: Sutton Hoo. So where did the ship burial tradition originate?

Sutton Hoo's early seventh century ship burials, in large, ocean-going vessels, are often compared with the boat graves of Vendel, Valsgärde and other sites in the Lake Mälar region of Sweden, while Oseberg and the other ship burials in the Oslofjord area have traditionally been interpreted as the precursors of, and models for, the Karmøy ship graves. In this paper, we aim to demonstrate that the use of ships and boats in burials was common practise around the North Sea and in the Western Baltic during the Late Migration period and was introduced to Eastern England with the same 'wave' of cultural influences that took new forms of brooches and a new dress code from Western Norway to Anglia in the late fifth century AD. And, furthermore, that the East Anglian ship graves of the early seventh century (Sutton Hoo 1 and 2) represent an elaboration of this common practice, related to political centralisation and Christianisation in the Anglo-Saxon kingdoms. We also suggest that this high-status, indeed royal, form of burial, that is, actual ship graves as opposed to the much more widespread practice of burial in relative small boats, was introduced to Scandinavia from Eastern England via Western Norway in the eighth century, culminating in the well-known Viking Age ship graves at Oseberg, Gokstad, Tune and Ladby.

ARTICLE HISTORY
Received 19 July 2016
Accepted 5 October 2016

KEYWORDS
Dendrochronology; Viking Age; ships; Norway; Oseberg; Karmøy; Sutton Hoo; ship graves

The beloved leader laid they down there,
Giver of rings, on the breast of the vessel,
The famed by the mainmast. A many of jewels,
Of fretted embossings, from far-lands brought over,
Was placed near at hand then; and heard I not ever
That a folk ever furnished a float more superbly
With weapons of warfare, weeds for the battle,
Bills and burnies; on his bosom sparkled
Many a jewel that with him must travel
(Beowulf 1892, I, 35-43).

In 1905, when archaeologist Haakon Schetelig – later known as Shetelig – told members of the Viking Club in London, and readers of the club's annual Saga-Book, of the archaeological discoveries made in Norway in the preceding year, he naturally concentrated on the excavation of the Oseberg ship. Only one other discovery is mentioned in his report: the stern of a ship found at Sunnanå in Rogaland, Western Norway. Schetelig considered the latter to be 'a useful supplement to our knowledge about the ships of the Viking Age' (Schetelig 1906a, p. 66, 1906b). In the following, we argue that these two finds might actually be more closely related than Schetelig imagined.

Dating the Viking ships of the Oslofjord area

In terms of the later part of the Iron Age in Scandinavia – the Viking period – dendrochronology has made it possible to make direct comparisons between written and archaeological sources, something which is impossible with 'traditional' dating methods, including other scientific techniques such as radiocarbon dating (Roesdahl 1994).

Dendrochronological research has proved crucial to Danish archaeological research into the later Iron Age – the Viking period – enabling important Viking Age sites to be placed in an historical context. For example, the dating of Trelleborg on Zealand to

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AD 981 ended many years of sometimes very lively discussions (Bonde & Christensen 1984). Trelleborg belongs to the well-known group of Danish ring fortresses, which also includes Fyrkat and Aggersborg. Together with the dating of the earthwork complex Haithabu/Hedeby (Eckstein and Schietzel 1977), Dannevirke (Andersen 1995), the Kanhave 'canal' (Nørgård Jørgensen 1995), the royal site of Jelling (K. Christensen and Krogh 1987, Dengsø Jessen *et al.* 2014), the bridge at Ravning Enge (K. Christensen 2003) and the Mammen grave (Andersen 1991), this has given a much better understanding of the Viking period, because systematic tree-ring dating offers an increasing number of fixed reference points for the history of the Viking Age (Axboe 1995).

Towards the end of the 1980s, the National Museum of Denmark began work on a Norwegian master chronology for oak (*Quercus* sp.) by sampling living oak trees along the coastal regions of Southern Norway. Tree-ring measurements from more than 300 trees showed that tree-ring curves for oak trees in Southern Scandinavia have similarities, making it possible to cross-date a curve based on data from trees growing in Southern Norway with the long-established oak master chronologies for Denmark and Southern Sweden (K. Christensen 1993). The results indicated, furthermore, that the produced data, comprising more or less the entire natural habitat for oak in Norway, falls into two large groups located, respectively, to the east, and to the north and west of Cape Lindesnes (Christensen and Havemann 1994). With a few gaps, the oak chronology for Denmark covers the entire period from the present back to the Neolithic (K. Christensen 2004, 2007), while two oak chronologies from Sweden extend back to the sixth century AD (Bråthen 1982, Thomas S. Bartholin *pers. comm.*).

When attempting to date the East Norwegian ship graves of Oseberg, Gokstad and Tune (Bonde and Christensen 1993, Bonde 1997a), the above situation meant that a well-replicated curve based on timbers from these three sites could be dated with the aid of the master chronologies from Denmark and Sweden (Figure 1). Samples were taken from the three timbered burial chambers, partly because it was assumed that the ships themselves might have already been old at the time of burial, and partly because the timbers used in the chambers – unlike those of the ships – were probably of local origin. Based on the chamber timbers alone (18 samples), a regional chronology covering the period AD 537–891 was established. This chronology cross-dated with the oak master chronologies for Denmark and Sweden and could therefore be dated absolutely. The chronology was then used in dating the three ships. The curves from the Tune and Gokstad ships cross-dated with the regional chronology, thereby proving that these two ships were built using timbers from the same general area as those used for the burial chambers (Bonde *et al.* 1997, Bonde 2005).

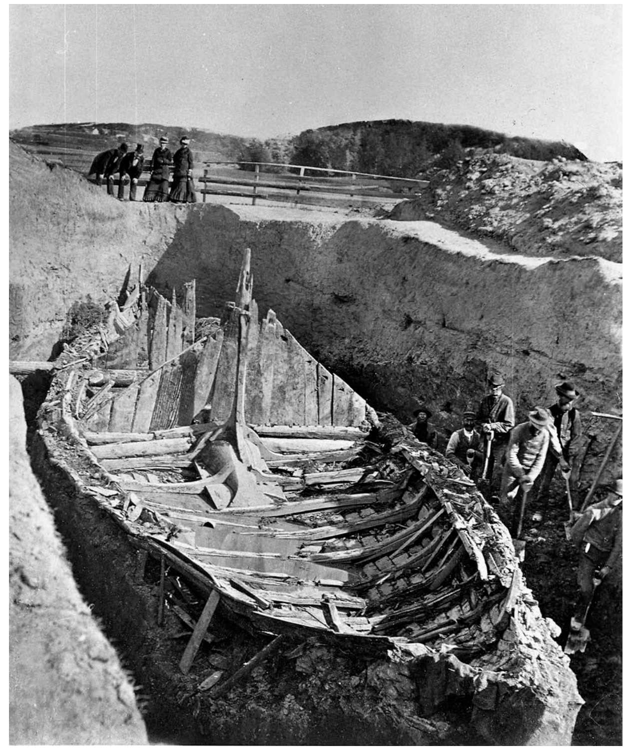

Figure 1. The Oseberg ship under excavation in 1904. Photo: Museum of Cultural History, Oslo.

The curves from the Oseberg ship were, however, different. Although the chronology based on samples from the ship itself cross-dated with the Southern Scandinavian master chronologies and with the regional curve, the provenance (dendroprovenance) of the timbers could not be determined on this basis. This prompts the conclusion that the Oseberg ship was, in all probability, not built from timbers felled in the Oslofjord area – and probably not even in Eastern Norway.

Ship graves in Western Norway

Apart from the three famous Viking Age ship graves in Eastern Norway, there are two similar, but much less known, ship graves on the country's west coast, Storhaug and Grønhoug. These were found 1.5 km apart on the island of Karmøy in Rogaland and both were excavated more than a century ago. Even though the finds attracted some initial attention (Lorange 1887, Schetelig 1902), they were soon to be eclipsed by the magnificent Oseberg ship burial, the find which surpasses all else in Scandinavian archaeology.

The northern part of Karmøy, centred on Avaldsnes, is one of Norway's richest archaeological areas, containing monuments, sites and finds of international importance that relate to most periods from the Early Bronze Age to the Middle Ages. These include the large Bronze Age barrows in Reheia and the Late Roman period chieftain's grave at Flagghaug, as well as the ship graves at Storhaug and Grønhaug (Reiersen 2009, Opedal 1998, 2005, Nordenborg Myhre 2004, Stylegar *et al.* 2011). The sheer size of some of the monuments in this area is impressive. The barrow covering the Storhaug burial was originally at least 40 m in diameter and 5–6-m high, and both the nearby Salhushaugen and Flagghaug were of similar size. The monuments and finds in and around Avaldsnes most probably relate to an early, regional centre of power, perhaps even a monarchy (Bjørkvik 1999, Opedal 2005); a royal manor was situated there in the Early Medieval period.

The excavation of Storhaug in 1887 revealed that the barrow contained the remains of a large oak-built ship with a keel length of c. 22 m (Figure 2). The ship had been placed in a shallow natural depression and it was supported by large boulders. The remains of a small boat, also of oak, and other parts of the ship's equipment were found nearby. The deceased, a man, judging from the furnishings, had been placed in a wooden chamber. Several objects were found with him, including two swords, two spears, a round quiver containing two dozen arrows, an entire set of blacksmith's tools, a hand-quern of coarse-grained granite, a small box containing a bronze ring and a large bird's feather, fire flint and steel, a large iron pot, two splendid sets of gaming pieces, one of glass, the other of amber, a wax disk, a gold arm ring and beads of glass and glass mosaic (Opedal 1998). As for the ship, it was classified as a rowing vessel as no traces of a mast were found. Storhaug is probably the only large Scandinavian ship grave not to have been plundered in antiquity.

Grønhaug was excavated in 1902. Inside the large barrow there was a kernel heap of stone and within this a depression holding a *c.* 15-m long burial ship made of oak (Schetelig 1902). Extensive remains of feather beds were found together with various textiles, including small pieces of silk fabric woven with figures, the colours of which were still fairly bright. Here too, the deceased – a man – was laid on a bed, clad in costly fabrics. With him were the remains of a glass beaker, various wooden vessels and again pieces of wax, indicating grave furniture of the same kind as that seen in the other great ship burials. There was also a burial chamber. As in the case of Storhaug, the Grønhaug ship was most probably only propelled by rowing.

It is difficult to date the Karmøy ship graves solely on the basis of the artefacts. Shetelig, referring to the much later kings' sagas from the twelfth and thirteenth

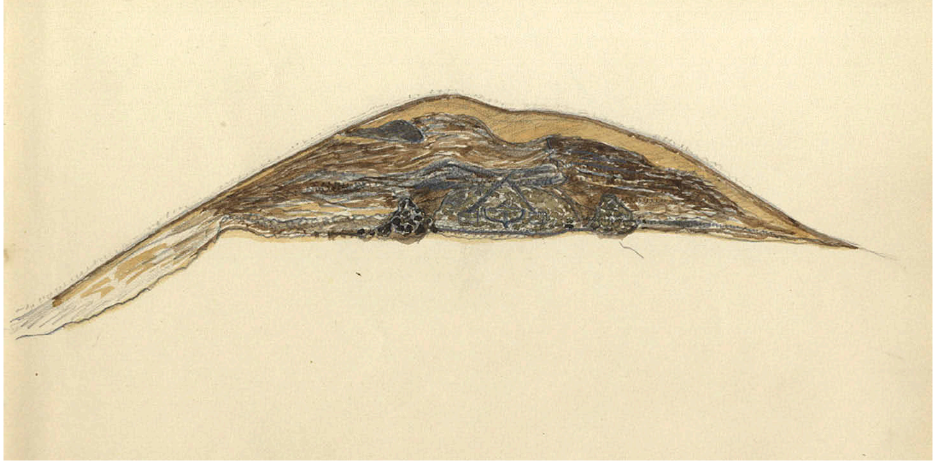

Figure 2. Storhaug, cross section. Water colour drawing by A. Lorange. Photo: University Museum, Bergen.

centuries, thought it obvious that they were later than Oseberg and the other ship graves in Eastern Norway (Shetelig 1917a, p. 226). In fact, the Karmøy ship graves could potentially date from any time between *c.* AD 700 and *c.* 900, and since their excavation they have variously been placed at either end of this time span (for more on their research history, see Bonde and Stylegar 2009). Consequently, the Storhaug and Grønhaug burials were obvious candidates for dendrochronological investigation in the 1990s, but initial attempts were unsuccessful due to a lack of comparative material, that is, an oak master chronology from Western Norway.

The Oseberg connection

The dendrochronological study was carried out, even though no oak master chronology exists for Western Norway. The aim was to test the possibility of dating the Karmøy finds using the curve for Oslofjord and/or the basic Danish and Swedish chronologies.

The finds from Karmøy are kept at Bergen Museum and samples for dendrochronology – all of oak – were taken from all suitable material from both sites. In all, 24 samples were taken from the Storhaug material: 12 from the ship (all board planks), 7 from the small boat (board planks), 1 from a presumed keel and 5 from stray finds. Seven samples were taken from the Grønhaug ship. All the samples were taken as cross sections.

All the tree-ring curves from Storhaug and Grønhaug were compared with the Oslofjord curve and a local chronology for the Kaupang site (Bonde 2007) as well as with all the oak reference curves for Southern Scandinavia, that is, all relevant master chronologies and site chronologies. There was no match, but this was not surprising. Dendrochronological studies of samples from the Oseberg ship had similarly shown that the tree-ring curves did not match with either the Oslofjord or the Kaupang curve.

The idea then arose of comparing the tree-ring curves from Storhaug and Grønhaug with that from the Oseberg ship. Perhaps the three ships used in the burials had been built of timber that had grown under the same conditions and the tree-ring curves would cross-date. This would indicate that all three had been built in the same area, that is, they would have the same dendroprovenance (Bonde *et al.* 1997, Bonde 1997b).

As it turned out, the curves from the Storhaug and Grønhaug ships gave an excellent cross-match with that from the Oseberg ship, meaning that 18 of the samples from Storhaug could be dated: 9 from the ship, 6 from the boat and 3 from stray finds. Four of the samples have sapwood preserved – two from the ship and two from the stray finds. Moreover, one of the latter even had an intact waney edge; that is, the last tree-ring formed by a tree (Kaennel and Schweingruber 1995: 380). The presence of sapwood made it possible to determine the felling date for the trees from which the samples came to within a narrow time frame. For the sample with the waney edge, it was even possible to determine the time of year (the season) the tree was felled.

The felling date can be estimated by adding the number of missing tree rings, due to rot or trimming of the timber, to the latest preserved tree ring in the sample. Surveys based on empirical studies of the number of sapwood rings in oak trees exist from several regions in Europe. The present study uses data from a Norwegian survey based on samples from living oak trees (Christensen and Havemann 1998). It shows that oak trees growing in Southern and Western Norway, on reaching the age of 100–200 years, can be expected to have between 8 and 37 sapwood rings, with an average of *c.* 18. After correction for the missing rings in the sample with intact sapwood from the Storhaug ship, it can be concluded that the tree was felled during the period AD 758–87, probably around AD 770; this also indicates the building date for the ship (Figure 3 + Tables 1 and 2).

None of the six dated samples from the small boat in Storhaug had sapwood preserved. It is therefore only possible to give a *terminus post quem* date for the felling of the trees used in building the boat, that is, after AD 733; this also indicates the construction date for the boat.

Five samples were taken from the stray finds in the Storhaug burial. With one exception, their function could not be determined but it seems likely they were connected with the construction of the burial mound. Three samples were dated, of which two had sapwood preserved and one of these had an intact waney edge. The felling date for the tree from which the latter came can therefore be determined as summer AD 779 (Bonde and Stylegar 2009, Figures 13 and 14).

In the case of the Grønhaug ship, very little of the vessel was preserved and the seven samples taken were of poor quality. Nevertheless, it was possible to

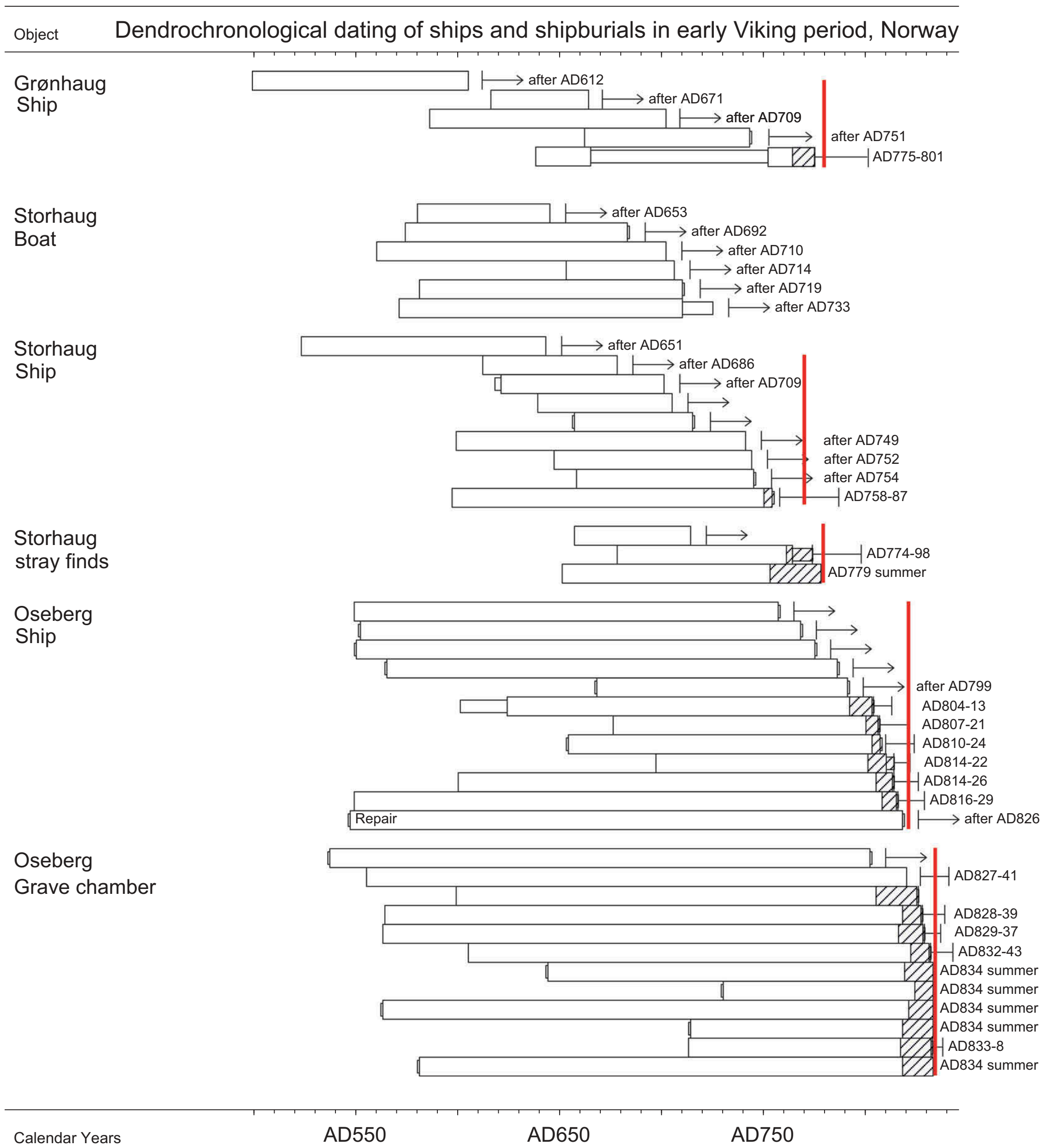

Figure 3. Bar diagram which shows the position of the dendro-dated samples from the three sites discussed in this article against the time scale. The length of the rectangles shows how many tree rings are preserved in each board. In total 46 samples dated of which 20 have sapwood preserved (hatched signature) and 6 with waney edge. The red lines indicate the interpretation for time of felling of the trees and building of the ships and the burials. Grønhaug ship: c. AD 780. Storhaug ship: c. AD 770. Storhaug burial: AD 779 summer. Oseberg ship: c. AD 820. Oseberg burial: AD 834 summer.

date five of them, primarily because the curves cross-date with those from Storhaug. One sample has a remnant of sapwood preserved with 11 tree rings, with the outermost tree-ring being formed in AD 775. Taking into account the missing tree-rings, it can be estimated that the tree from which the sample originated was felled in the period AD 775–801, probably around AD 780; this also indicates the construction date for the Grønhaug ship.

The dendrochronological study shows that burial mound at Storhaug was probably constructed in the summer of AD 779, whereas the ship within the mound was built in *c.* AD 770 and was barely 10 years old when used for the burial, together with a small boat of the same age. As for the Grønhaug mound, the ship used for the grave was built around AD 780. Taking in to account the date of the Storhaug ship and the dendrochronologically dated ships in the graves at Oseberg, Gokstad and Tune, we can estimate the date of the burial, it is clear that these were all 10–15 year old vessels when used, not old and redundant. They were probably

Table 1. Triangular cross-dating matrix for *t*-values. *t*-value is a measure of similarity between two tree-ring series which show how well the series cross-date.

Curves	–	–	Grønhaug ship	Storhaug ship	Storhaug boat	Storhaug stray finds
–	start	dates	AD 586	AD 523	AD 560	AD 657
–	dates	end	AD 702	AD 754	AD 702	AD 715
Grønhaug ship	AD 586	AD 702	*	5.10	4.98	0.71
Storhaug ship	AD 523	AD 754	*	*	5.85	5.55
Storhaug boat	AD 560	AD 702	*	*	*	2.02
Storhaug stray finds	AD 657	AD 715	*	*	*	*

Values equal to or greater than 3.5 are regarded as significant indicators of a likely match. The higher, the better. For *t*-values, see Baillie and Pilcher (1973) and Baillie (1982, p. 80–85).

Table 2. Rectangular cross-dating matrix for *t*-values. *t*-value is a measure of similarity between two tree-ring series which show how well the series cross-date.

Site/object chronos	–	–	Grønhaug ship	Storhaug ship	Storhaug boat	Storhaug stray finds	Grønhaug + Storhaug	Oseberg grave
–	start	dates	AD 586	AD 523	AD 560	AD 657	AD 499	AD 537
–	dates	end	AD 702	AD 754	AD 702	AD 715	AD 778	AD 833
Oseberg ship	AD 549	AD 813	4.16	8.41	5.65	6.17	8.75	3.10

Values equal to or greater than 3.5 are regarded as significant indicators of a likely match. The higher, the better. For *t*-values, see Baillie and Pilcher (1973) and Baillie (1982, p. 80–85).

fully operational up to the time they were used in the burials (Bonde 1997b). It is therefore reasonable to date the Grønhaug burial to AD 790–5.

Narrowing down the location of the shipbuilding site

On the Oseberg ship, which was otherwise built of oak, use was surprisingly also made of beech (*Fagus sylvatica*). Part of the beautifully carved gunwale, at both stem and stern, is made of this species. These pieces do not constitute repairs but form an integrated part of the ship's ornamentation. The technical term for this in traditional Nordic shipbuilding is *brandara* (Shetelig 1917b, p. 330–1).

An overview of the natural distribution of beech in Europe shows that the northernmost beech woodlands are found in Norway and that the distribution pattern there is quite exceptional: Old beech woods are found exclusively in two places: on the Skagerak coast with a main concentration in the southern part of Vestfold and on Vollom at Lurefjord in Lindås/Seim, Hordaland (Hultén 1971) Figure 4. The latter – the world's northernmost ancient beech wood – has attracted the attention of scholars for almost two centuries. The beech woodland on Vollom lies so distant from the other occurrences that it seems very likely to have had a cultural origin, that is, the beechnuts were taken there by people. Pollen studies at Lurefjord show that the beech wood must have been established in the Viking Age, at roughly the same time as those in Vestfold (Fægri 1954). New research has yielded further information on the Norwegian beech populations and indicates, on the basis of genetic studies, that beech very probably came to Norway from Denmark via trading links during the Iron Age (fifth–sixth centuries AD) (Myking *et al.* 2011).

As already mentioned above, the oak trees that produced the timbers for the Oseberg ship did not grow in the vicinity of where the vessel was found in Vestfold, but somewhere in Western Norway. Beech wood has also been used in shipbuilding in the Oslo area. The Klåstad ship found at Sandefjord has top frames made of beech (Christensen and Leiro 1976; A.E. Christensen *pers. comm.*), and the timber involved very probably originated from the beech woods in Vestfold. This cannot, however, be the case for the beech timber in the Oseberg ship, unless it was repaired between its construction in *c.* AD 820 and when it was placed in the burial mound in AD 834, and there is nothing to suggest this was the case. There is a very real possibility that the beech timber in the Oseberg ship originated from trees that grew in the only beech wood in Western Norway, that at Lindå/Seim, north of Bergen. This conclusion contributes to narrowing down the place of construction for the Oseberg ship.

Another category of archaeological find can assist us in localising the construction site even more closely, as shown by a detailed study of the distribution of a type of archaeological find primarily associated

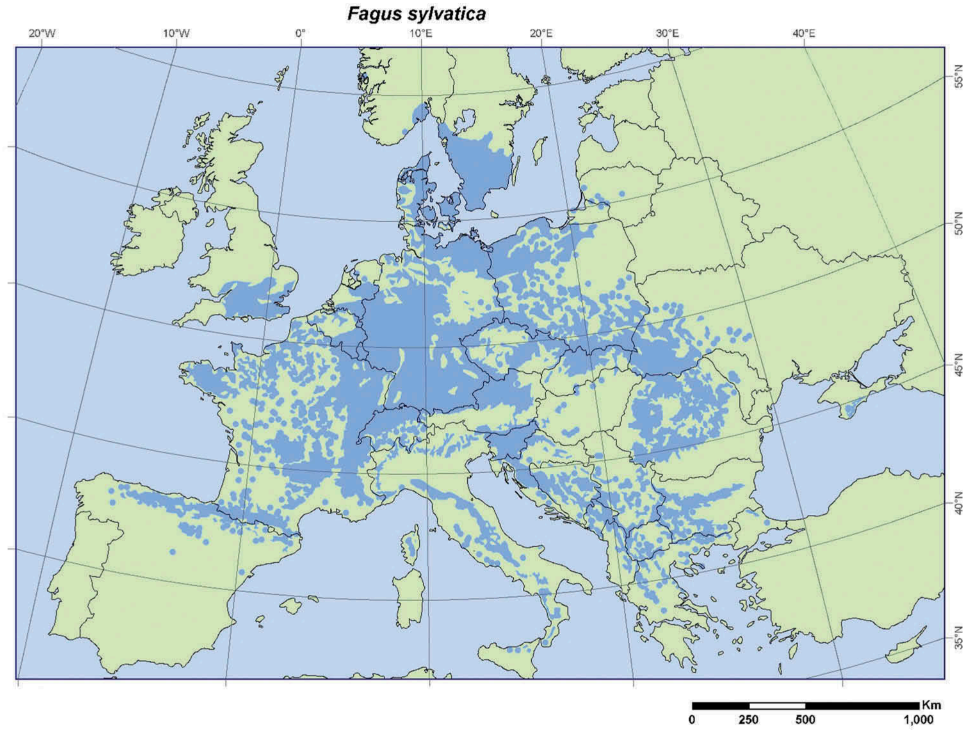

Figure 4. Map showing the natural distribution of Beech (*Fagus sylvatica*) EUFORGEN (2009).

with the west coast of Norway, that is, wooden blanks – or rough-outs – employed in ship and boatbuilding. The find sites for these are, without exception, associated with water or wetlands. The ship's stem from Sunnanå, mentioned by Schetelig in his 1906 report, belongs to this category of find (Figure 5). Oak blanks for keels, stems and frames were kept wet so they were easier to work when needed. This appears to have been standard practice in traditional wooden boatbuilding in Western Norway (Brøgger and Shetelig 1951, p. 66), but is also a phenomenon which is normally associated with the Iron Age's so-called wet wood technology (Vadstrup 1994). The dated finds belong to the Iron Age and the Viking period and most of the records come from the Norwegian west coast. There is a marked tendency towards concentrations of these finds in places that were important centres for the building of wooden boats in recent times. This is true, for example, for of two Viking Age ship's stems found at Sunnanå in Northern Rogaland which, both typologically and in terms of size, have been compared with the Gokstad ship. Similar finds are recorded from coastal districts in Central Norway, but here conifer wood was almost exclusively used. However, the finds here are also linked to the boatbuilding districts of later times

Figure 5. Oak stem from Sunnanå, Rogaland. Photo: Museum of Archaeology, Stavanger.

(Sylvester 2009). Finds of ship components of oak display clear concentrations around the fjords in the southern and central parts of Western Norway, that is, in Rogaland and Hordaland (Figure 6). It seems therefore reasonable to conclude that the construction site for the Oseberg ship is to be found in one of those places. To date, a shipbuilding site has only been discovered in association with blanks at one locality: at Mangersnes in Hordaland. This seems to have been active from around the birth of Christ and at least up until the eighth century (A.E. Christensen 1995). Larger boats/ships were also built there. With respect to the present article, it is obviously relevant that the locality lies only 5–6 km from the beech wood at Vollom.

This study suggests that the construction site for the Oseberg ship and the two vessels from Karmøy can be narrowed down to the district of Hordaland, and presumably to the area just north of Bergen.

Origins of the ship burial tradition

The dates for the burials at Karmøy also mean that Shetelig's old idea about the practice of ship burial being 'transplanted' from the Oslofjord area to

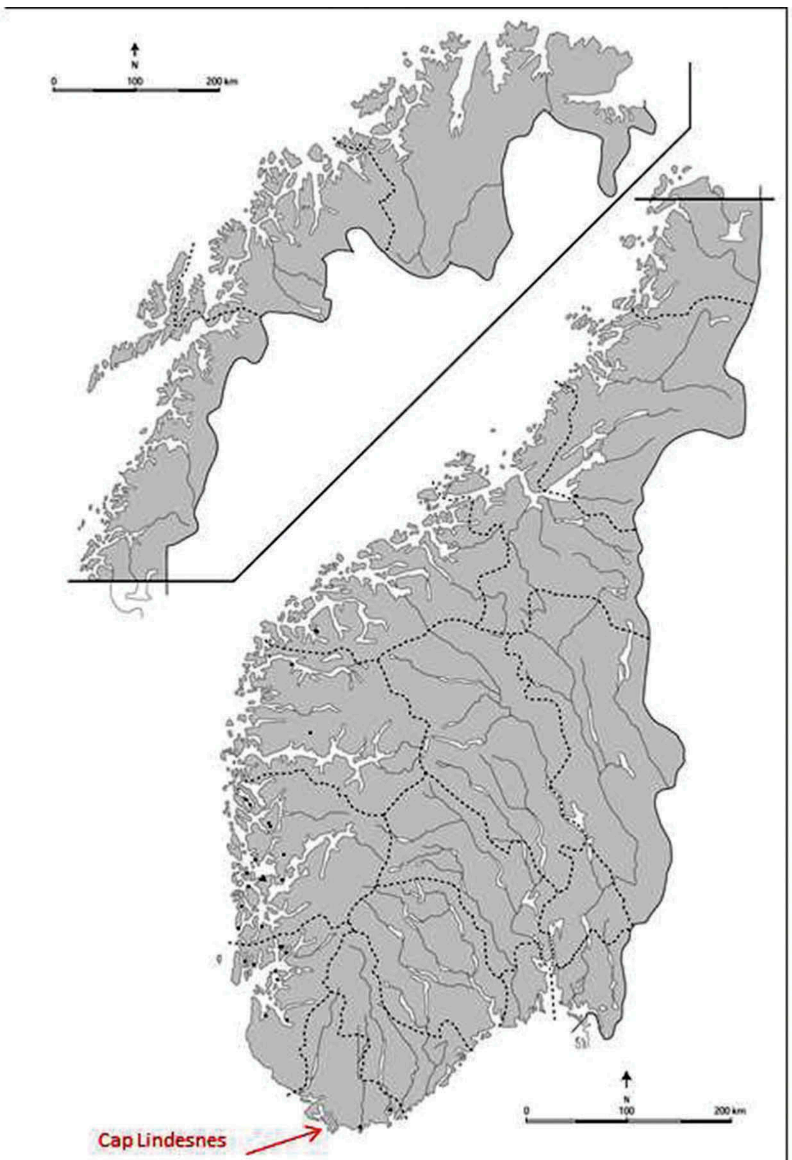

Figure 6. Finds of oak ship components in Norway. Map: Authors.

Karmøy (from the east to the west of Norway) is no longer tenable since Storhaug and Grønhaug are now the oldest known ship graves in Scandinavia. The Oseberg burial differs from the other ship burials in the sense that the ship was built in a completely different region from where the burial took place. Since the Viking Age ship graves represent burials at a very high social level, it is likely that the Oseberg burial was a direct result of inter-dynastic relations between Western Norway and the Oslofjord area in the early Viking Age. But the new, early dates for the ship burials in Western Norway also make it relevant to delve into the background for this particular practice. Where did the idea of burying a deceased in his or her ship originate and what was its significance?

On a general level, the boat graves of the Iron Age provide us with a background for the practice. In Scandinavian archaeology, however, it is usual to make a distinction between boat graves and ship graves. Following a time-honoured tradition, extending back to Norse times, vessels with up to six pairs of oars, the so-called *tolværing*, are considered boats, while 'a ship is a large seagoing vessel, superior in size, complexity and status to those comtemporary vessels which were referred to as boats' (Hutchinson 1994, p. 189. See also, Marsden 1996, p. 224).

Boat graves were a common feature of the areas bordering the North Sea and Baltic at least from the Late Roman period to Viking Age. The greatest numbers of boat graves have been discovered in Norway and Sweden, where the majority date from the Viking Age (Müller-Wille 1974, 1995). Apart from the basic use of a boat for burial, these graves are very diverse. Some are richly furnished, others are not; some are cremations, others inhumations; some are female, others male etc. (Müller-Wille 1974). The earliest known Iron Age boat graves are those at Slusegård on Bornholm (Crumlin-Pedersen 1995), with the Valderøy boat in Western Norway only slightly later (Myhre 1980). The Slusegård vessels were expanded log boats, of a type also seen in later boat graves in England (Snape), Sweden and Norway (Filmer-Sankey 1992, Filmer-Sankey and Pestell 1995, Gjerpe 2005, Larsson 2007). However, apart from the Slusegård and Valderøy graves, the oldest boat graves seem to be from the fifth and sixth centuries. They are few in number, but this Migration period boat graves have a relatively pronounced *western* distribution in Scandinavia. In addition, Carver (1990, 1995) mentions a number of possible early finds in England, all of them confined to the east coast. As pointed out by Næss (1969), the idea of a Swedish point of distribution for the boat-burial tradition does not fit with the archaeological evidence, since the earliest boat graves in Vendel, and other sites in Eastern Sweden, are later than the West Norwegian examples, and perhaps also than those in England (see also Ljungkvist 2005 for a more recent discussion of the chronology of the rich Eastern Swedish finds).

Given this distribution pattern for the early boat graves, it must be concluded that the use of boats in burials was a common practice across the North Sea and the Western Baltic during the Late Migration period (Figure 7). As Carver writes, from an English point of view, 'boat burial is a signal of ideology' that is coming from, or shared with, contemporary peoples to the north-east across the North Sea' (1990, p. 119). In the Late Migration period, England and Scandinavia share several common artefact types, for instance bracteates, relief- and equal-armed brooches, as well as stylistic details such as those seen on some cruciform brooches and ceramic vessels and the use of tablet-woven braids and ornaments in Style I and Style II. However, since no early boat graves have been recorded in Denmark and they have a relatively pronounced western distribution, it seems likely that the introduction of this practice followed a more northerly route. All things considered, we suggest that boat burial was introduced to Eastern England as part of the particular 'wave' of cultural influences which transferred wrist clasps and a new *tracht* from Western Norway to England in the late fifth century, and which might have involved settlers moving from Southwest Norway to East Anglia and Humberside (Hines 1984, 1992, 1993).

However, both Karmøy graves differ from all of these early boat graves, first and foremost because the Karmøy graves involved the use of proper, ocean-going ships. But also because of other characteristics, that is, the use of a timbered burial chamber placed inside the ship and burial beneath a large earthen barrow. Ship graves like those at Storhaug and Grønhaug were a rare and exclusive form of burial in the late Iron Age, but there are close parallels elsewhere in Scandinavia: the graves at Oseberg

Figure 7. Early boat graves in North Europe. Map: Authors.

(AD 834), Gokstad (AD 900–5) and Tune (AD 910–20) in the Oslofjord area, as well as Ladby on Funen (*c.* AD 900) (Sørensen 2001). There is also the 'Bootkammergrabe' (boat-chamber grave) at Haithabu (*c.* AD 850) (Wamers 1994), in addition to the three cremations at Myklebost in Western Norway, Borre in the Oslofjord area (*c.* AD 900) (Myhre 1992) and Ile de Groix in Brittany (*c.* AD 950) (Müller-Wille 1978), which all show affinities to the Karmøy graves. Similarly, the Swedish boat graves do not match up; while these were also inhumations, they do not have chambers, and they either lie under a flat surface or are only covered by a low mound. The recent finds from Salme on Saaremaa in Estonia are still awaiting publication; however, these burials from around AD 750, while extraordinary in many respects, do seem to line up more with the boat graves of Eastern Sweden (Allmäe *et al.* 2011, Peets 2013). Ship burial with a chamber and beneath a large barrow is clearly a western phenomenon; one which was, first and foremost, associated with the North Sea. This conclusion is supported by the fact that the two oldest proper ship graves in the archaeological record both lie in England – Snape and Sutton Hoo.

An Anglo-Saxon background?

Snape, as far as its record extends, and Sutton Hoo (mound 1) are definitely comparable with the later Scandinavian ship graves. In the case of Sutton Hoo, we recognise not only the ship (a rowing ship, like in the Karmøy graves), but also the burial chamber onboard and the large barrow built over it. The similarities seem obvious but attention is drawn instead to the more or less contemporary boat graves at Vendel and Valsgärde in Sweden, something which extends back to the very beginning of Sutton Hoo research. In Scandinavia, a Swedish connection was suggested by Shetelig as early as 1940, based on similarities between some of the objects in Sutton Hoo and finds from Vendel and Old Uppsala.

Nerman took the argument one step further when he argued that Sutton Hoo 1 was in fact the burial mound of a Swedish king (Shetelig 1940, Nerman 1948).

It is not our intention here to deny the close links between some of the artefacts from Sutton Hoo and finds from Eastern Sweden, far from it, even if some of the similarity may be due to these artefacts being produced in the same workshops in the Frankish empire, and not in either Sweden or Anglo-Saxon England (cf. Arrhenius 1985). Many of the similarities are genuine (Lamm and Nordström 1983), but these similarities do not extend to the burial practice itself, even though this is often assumed. These differences aside, the Vendel period boat graves in Eastern Sweden are rarely interpreted as belonging to the uppermost social strata ('kings'), but rather to a militarised aristocracy. Discussing the Vendel period (*c*. AD 550–750) high-status burials in Eastern Sweden, Ljungkvist (2005, p. 256) writes that 'the burials with the most status-laden artefacts … are in fact not the boat graves. The most exclusive finds in the Early Vendel period are from the Uppsala högar', that is, from cremations graves beneath large barrows. Sutton Hoo, on the other hand, was almost certainly associated with the royal dynasty of East Anglia (Carver 1998). This attribution to (petty) kings is also true for the later ship graves, including the ones on Karmøy (Bonde and Stylegar 2009).

Two questions then spring to mind: What did ship burial 'represent' in an early seventh century Anglo-Saxon context and what, if anything, links this practice with the later ship graves in (western) Scandinavia? Carver has argued that the Kingdom of East Anglia was an innovation of the late sixth century and that it was formed within an ideology that was not yet Christian, but pagan with strong Scandinavian affinities (1990, p. 119). As the situation now stands, it seems reasonable to suggest that elements of the boat-burial practice, as it existed on both sides of the North Sea, became transformed during this process, leading to the advent of ship burial as a particularly elaborate and exclusive practice fit for 'kings'. Furthermore, we suggest that, once in existence, ship burial was able to 'travel' to Scandinavia via the same kind of networks that, in the previous period, had distributed boat burial as a funerary practice.

From about AD 500, a number of chiefdoms existed along the coast of Norway, and through mutual rivalry and competition these polities gradually developed into more permanent, supraregional lordships (Myhre 1992, Sawyer 1993). In the eighth century, three central areas stand out – one of them being Karmøy, which most probably constituted the centre of an emerging kingdom encompassing most of the west coast (Myhre 1993). In this process, families claiming royal status could utilise an already existing 'template' derived from the Anglo-Saxon kingdoms, and this eventually also lead to Christianisation, via English missionaries. In the eighth century, if not before, ship burial was part of the same 'package'.

As for the second question, even if both the relative and absolute chronologies of the ship graves are now revised, the gap in time between the latest Anglo-Saxon grave (Sutton Hoo) and the oldest Scandinavian example (Grønhaug) is still considerable: about 150 years. This is more than twice the interval between the oldest ship grave in Eastern Norway (Oseberg) and the second oldest (Gokstad). But the exclusivity of ship burial in the late Iron Age means that just one further discovery of this kind could bridge this gap considerably. Of greater importance is the question of whether there actually *were* cultural contacts with the higher echelons of society across the North Sea during the seventh and eighth centuries? As Myhre points out, 'the Scandinavian upper social strata … were not isolated from the rest of Northern Europe during the Merovingian period, but shared cultural ideas and values with other Germanic kingdoms' (1998, p. 26). With regard to Anglo-Saxon – Scandinavian relations in general after the Sutton Hoo horizon and before the first attested Viking raids just before AD 800, the evidence is scarce and mostly indirect. Perhaps the most important indication of continued contacts is the English influence seen on Scandinavian Style II (Ørsnes 1966). On the other hand, there is little direct evidence; for example, there are no records of early English *sceattas* from Scandinavian contexts. Even if some insular ecclesiastical objects had reached Norway by the eighth century (Myhre 1998, p. 27), the bulk of insular imports to Scandinavia began in the Viking Age with, interestingly, Western Norway as the initial main recipient (Wamers 1985, 1998, Bruce-Mitford

2005). The Oseberg ship burial for instance contains its fair share of imports from England – Ireland, including the famous 'Buddha' bucket with its anthropomorphic escutcheons in squatting posture (Figure 8), and two decorative mounts, probably from a belt or a horse bridle (Figure 9), which are so similar to a mount found in Markyate, Hertfordshire, that they may actually originate from the same workshop (Grieg 1928, p. 72ff and 239; Bruce-Mitford 1964).

Figure 8. The 'Buddha bucket' from the Oseberg grave. Photo: Museum of Cultural History, Oslo/Eirik Irgens Johnsen.

Figure 9. Mounts from Oseberg. Photo: Museum of Cultural History, Oslo.

But there are also some important indications of continued elite contacts between Eastern England and Western Norway in particular during the previous period (Bakka 1971). Beginning with the Grønhaug ship grave, there is a distinct possibility that a sherd from a glass vessel found in the ship comes from an Anglo-Saxon pouch bottle, as suggested by Schetelig (1912, p. 223; cf., 2001). With this one possible exception, all the known specimens of this type are from Eastern England (Evison 2008, p. 7). We are on safer ground, however, with two definite and two less certain dark blue squat jars from burial contexts in Western Norway (Holand 2001, cf. Näsman 1986). These distinctive blue globular beakers, with thick zigzag trails, are exclusive to England, with the exception of those that found their way to Norway (Evison 2008, p. 7). This type is conventionally dated to the late sixth and the seventh century (Figure 10).

The occurrence of these Anglo-Saxon glass vessels in Western Norway suggests that contacts between Eastern England and Western Norway still existed on an elite level when the first ship burials took place in Western Norway in the late eighth century, and that the ship burial 'idea' could have arrived on Norway's west coast via these same elite networks.

Sutton Hoo's early seventh century ship burials, in large, ocean-going vessels, are often compared with the boat graves of Vendel, Valsgärde and other sites in the Lake Mälar region of Sweden, while Oseberg and the other ship burials in the Oslofjord area have

Figure 10. Globular beaker from Løland, Lindesnes, Vest-Agder. Photo: Museum of Cultural History, Oslo/Ove Holst.

traditionally been interpreted as the precursors of, and models for, the Karmøy ship graves. In light of more recent research it is more likely that the use of ships and boats in burials was common practice around the North Sea and in the Western Baltic during the Late Migration period and was introduced to Eastern England with the same 'wave' of cultural influences that took new forms of brooches and a new dress code from Western Norway to Anglia in the late fifth century AD, and, furthermore, that the Anglian ship graves of the early seventh century represent an elaboration of this common practice, related to political centralisation and Christianisation in the Anglo-Saxon kingdoms. In light of new dendrochronological dates from Avaldsnes in Western Norway, it seems probable that this high-status, indeed royal, form of burial, that is, actual ship graves as opposed to the much more widespread practice of burial in relative small boats, was introduced to Scandinavia from Eastern England via Western Norway in the eighth century, culminating in the well-known Viking Age ship graves at Oseberg, Gokstad, Tune and Ladby.

Acknowledgements

Our thanks go to Sigrid Kaland of Bergen Museum, for making the ship remains from Karmøy available to the authors for study and for granting permission to take samples, and to Svein Agdestein, also of Bergen Museum, for practical assistance. A.E. Christensen is thanked for initial discussions about dating the Viking ships. All the samples from Storhaug and Grønhaug have been returned to Bergen Museum as well as all samples from Oseberg to Kulturhistorisk Museum, Oslo.

For the dendrochronological study, we used the software packages 'Dendro' by Ian Tyers and 'TSAP' by Frank Rinn.

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DANISH JOURNAL OF ARCHAEOLOGY, 2016
VOL. 5, NOS. 1–2, 34–51
http://dx.doi.org/10.1080/21662282.2016.1245970

Routledge
Taylor & Francis Group

RESEARCH ARTICLE

When did weaving become a male profession?

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ABSTRACT
The article discusses the development and technological changes within weaving in the Middle Ages when it developed into a major craft and one of the most important industries of the Middle Ages in Northern Europe. While prehistoric weaving appears as a predominantly female work domain, weaving became a male profession in urban contexts, organised within guilds. Hence, it has almost become a dogma that the expanding medieval textile industry, and corresponding transition from a female to a male work domain, was caused by new technology – the horizontal treadle loom. By utilising various source categories, documentary, iconographic and archaeological evidence, the article substantiates that the conception of the medieval weaver as a male craftsman should be adjusted and the long-established dichotomy between male professional craftsmen and weavers, and women as homework producers of textiles should be modified, also when related to guilds. The change from a domestic household-based production to a more commercially based industry took place at different times and scales in various areas of Europe and did not only involve men.

ARTICLE HISTORY
Received 21 June 2016
Accepted 5 October 2016

KEYWORDS
Textile production; technology; weaving; gender roles; crafts; guilds; Middle Ages; Northwestern Europe

Introduction

This article focuses on the development and technological transformations within weaving in the Middle Ages – a period of expanding urbanisation, commercialisation and specialisation within crafts, often organised as guilds. The aim is to illuminate the interaction between textile production, technology and the actors. Here, gender and the social organisation of the production also play an important role. In prehistory, weaving appears as a predominantly female work domain, and it is first in the Middle Ages weaving becomes a male profession in urban contexts. Hence, it has almost become a dogma that the transition from a female to a male work domain was the result of new technology – the introduction of the horizontal loom. It has been regarded as unlikely that the expanding urban weaving centres in England and elsewhere of the twelfth century and onwards could have been using anything other than the new treadle loom. But were the new looms only used by men, and when did they replace the old vertical looms?

The issues addressed in this article thus concern how, when and where technology in weaving changed and who the agents were behind such change. The answers to these questions may also have consequences for other conceptions of the organisation of crafts, work, productivity, gender roles and relations, and medieval society in general. Next to food production, textile production constituted the most important industry of the Middle Ages (Munro 2000b). The early medieval sources to this technological change are scanty and uncertain. As for gender roles, sources are also more ambiguous than stated in previous research. Here, later conditions, not least related to the establishment of guilds in the High and Late Middle Ages, may have affected earlier interpretations of this technological transformation and shift in gender roles. To address these issues from a more holistic outlook, several source categories have to be considered: contemporary archaeological remains related to textile production in various contexts, iconographic and written evidence, as well as later ethnological sources.

Textile production and weaving clearly represent long achieved competency and expertise within a culturally defined female work sphere centuries before the introduction of the horizontal loom. According to the anthropologist Francesca Bray, one fundamental way in which gender is expressed

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in any society is through technology, where technical skills and domains are generally divided between and within the sexes, thus shaping masculinities and femininities. Such gender systems are generally regarded as more difficult to change than material technologies – and reveal how technology is indicated in gender inequalities. This has also tended to make women 'invisible'. New technologies may, however, also promote processes of boundary work and renegotiations of which is considered masculine and feminine (Bray 2007, pp. 38–42).

It is therefore not unlikely that innovations within textile production were adopted, adapted and developed by those who had the experience and expertise in this field of work. Additionally, transgressing established gender roles could threaten masculinity and cause loss of honour, as evidenced in the Norse sagas (Meulengracht Sørensen 1995). The present hypothesis is that the transition of weaving implements and gender roles may have been a gradual process and that male weavers were not necessarily the main agents in the earliest periods when traditionally men appear as the most visible actors as heads of households.

When was the horizontal loom introduced – and how did it work?

The origin and diffusion of the horizontal treadle loom in Northwestern Europe in the Middle Ages is not so clear. Traditionally it is regarded as a medieval invention, dated to the eleventh century, when it is also first mentioned, although indirectly. It is written in Hebrew, by Rabbi Solomon Izhaqi, better known as Rashi of Troyes (1040–1105) after his home town in France, in his commentary on the tractate Shabbat of the Babylonian Talmud in the context of a discussion about what kind of tasks that should be reckoned as work and thus prohibited on the Sabbath (Shabbath 105a). In a section about weaving, the Talmud seeks to define how many threads a weave may be joined before this is counted as work. It is in this context Rashi comments upon different ways of weaving and makes a reference to '… that part of the loom of weavers who weave by foot which is in place of the rod that goes up and down in the loom used by women ' (translation in Carus-Wilson 1969, p. 69). Others refer to this source less precisely (e.g. Hoffmann 1964, p. 260, Munro 2000a, p. 17), generally replacing 'weavers' who weave by foot by 'men' and without further contextualisation. The passage in Rashi may indicate that the horizontal loom was a rather new implement at that time, and therefore needed to be explained in relation to the better-known vertical loom. His interest in the tool relates to the implications it poses related to definitions of work, not to gendered labour as such.[1] Being a Talmuic reference, it may also be questioned how representative this early mention is for the European area as a whole.[2] This is not so obvious either for its novelty or as for gender. It has, however, often been taken as an indication to be used for wider generalisations (e.g. Hoffmann 1964, Kjellberg 1979, Walton Rogers 1997, Henry 2005). The loom's medieval origins have been doubted and may rather have Oriental beginnings and may have entered Europe from the Byzantine Empire at an early stage (e.g. Endrei 1961, Munro 2000a, p. 18). But on the other hand, the loom may not necessarily have a common origin (Wild 1987, p. 460).[3] According to recent finds of pit houses with possible traces of horizontal looms, it had reached the northern parts of Switzerland by the ninth and tenth centuries (Windler 2008, pp. 213–215). The spread of the loom further north, its relation to earlier types of looms and the actors involved are therefore examined in the following.

There is no doubt that the horizontal loom was worked by treadles in a sitting position in contrast to the vertical warp-weighted loom, being worked standing and upwards against the gravity force. Still, the archaeological evidence of the whole construction is meagre and the first illustrations appear several centuries later, and in some cases also in a simplified way. Although the archaeological remains of the different loom categories can only be traced as fragments, they still leave clues about dating and different constructive elements in time and space.

The medieval iconographical evidence of treadle looms from England and other parts of Northern Europe indicates that there were different types of looms in use and that the horizontal loom also changed over time. However, a common characteristic is that it has warp threads stretched out horizontally between two beams, the cloth beam in front of the seated weaver and a warp beam at the far end of the loom frame; to this treadles were connected, linked by pulleys as parts of the mechanism for making the shed. They were joined to the heddles, i.e. loops for the warp threads, and fastened to the shaft rods that could be lifted and lowered by the treadles, creating the shed, the space between the two layers of warp threads, where the weft threads could pass through (Grenander-Nyberg 1975, p. 36). The pulleys were basically formed as a block wheel with a groove for a string to run over and could be attached to heddle horses,[4] again connected to the heddle rods and the treadles (Figures 1 and 2).

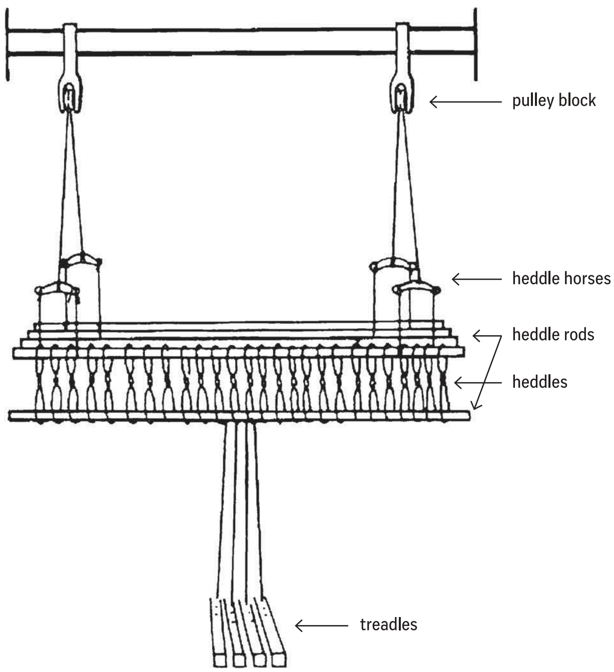

Figure 1. Schematic drawing of the horizontal loom operated by treadles. These were linked by pulleys, joined to heddles – loops for the horizontal warp threads– and fastened to heddle rods to be lifted and lowered by the treadles so that the weft could go through, creating the shed (cf. Figure 3).

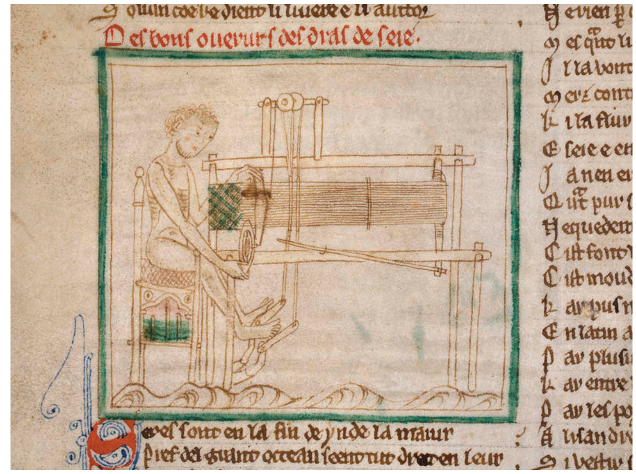

Figure 2. Weaver at the loom *c.* 1250: one of the earliest depictions of the horizontal loom, appearing to be a two-treadle type. A shuttle is used to insert the weft. Here, pulleys are threaded on the upper loom bar without being connected to heddle horses (MS 09.32v with permission from the Master and Fellows of Trinity College Cambridge).

Reeds, frames with vertical slits to separate the warp threads and hold them in positions as it was woven, were also parts of the loom (see Figures 3, 8 and 9).

Archaeological finds, such as pulley blocks and wheels, reeds, heddle rods, heddle horses and treadles, predate the illustrations and the oldest of such finds date back to the eleventh century, matching the oldest documentary indication. Altogether, the archaeological traces provide the best dating evidence but it can be problematic to identify single finds as parts of looms when they are found in unclear contexts. The traces are also *ante quem*

Figure 3. The Weaver's Ordinance Book (*Keurboek*) from Ypres, Flanders, 1366 – the earliest illustration of the broadloom operated by two weavers – a man and a woman. It is also one of the earliest depictions of the new spinning wheel. A woman at a warping board and a spool rack also form parts of the scene. Photo of the original document, taken before the coloured illuminated manuscript was lost in 1914 (photo: Stad Ieper, Stadsarchief, with permission).

dating and show that they were taken into use, but do not necessarily represent the earliest use.

Most of the medieval depictions show narrow looms operated by two treadles for one shaft for plain weaves and one weaver – either male or female. Pictorial evidence from the latter part of the fourteenth century shows, however, as many as four treadles and several shafts, able to weave different types of twills. Such looms were operated by two weavers on the so-called broadloom. The earliest depiction of the broadloom operated by two weavers – a man and a woman – stems from Flanders from the Ordinance Book (*Keurboek*) from Ypres (Ieper), Flanders, from 1366[5] (Figure 3). It has been claimed that the broadloom, able to produce wider fabrics, was a Flemish innovation of the mid-thirteenth century, but without providing documentary evidence. The economic textile historian John Munro finds it reasonable that the broadloom probably evolved much earlier but that the development and diffusion did not succeed in displacing the narrow one for perhaps two centuries or more after the introduction of the single operated horizontal treadle loom in the eleventh century. Still, it did not altogether supplant the narrow, single-weaver horizontal loom and long remained the preferred implement for weaving the smaller, less densely woven woollen and narrow worsted fabrics (Munro 2003, pp. 196–197), and probably also linen fabrics of plain weave. Most of the preserved illustrations of horizontal looms are from the fifteenth and sixteenth centuries and were also only operated by one weaver, which may indicate that weaving of broader cloth was still lacking an impetus.

The horizontal loom replaced, or rather partly substituted, the earlier vertical warp-weighted and two-beam looms. On these looms, warp threads are suspended from a horizontal beam and attached either to a beam or to loomweights at the bottom. The warp was prepared by weaving a starting border fastened to the upper beam, but other types of starting borders could also be used (Hoffmann 1964, pp. 63–70, 154–156). On the warp-weighted loom, the warp is divided into front and back by means of a movable horizontal shed or shaft rod fastened to the two uprights by rod-brackets (Figure 4).

Weaving here takes place from top to bottom on the warp-weighted loom; the weft is beaten upwards by a sword-shaped tool, a weaving beater. Placing the loom at an angle allows the back warps to hang vertically over the shed rod, creating a natural shed that prevents the need for heddles on the front threads in plain (tabby) weave and facilitates some twill weaves. By using double-notched rod-brackets for supporting the shed rod, experimental weaving has shown how it was easy to also weave the unbalanced 2/1 twills on the warp-weighted loom (Baxter and Dokkedal 1992). Such double-notched brackets have been uncovered in Trondheim and dated to the

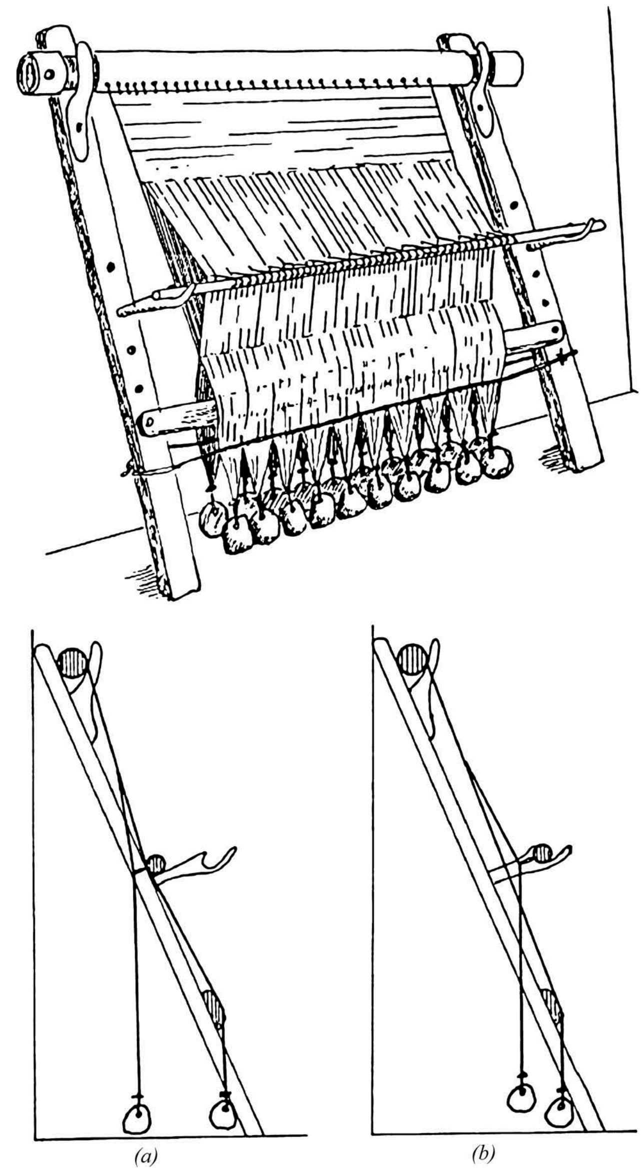

Figure 4. Schematic drawing of the warp-weighted loom in front (a) and section (b): the weaving starts at the top where vertical warp threads are fastened to the horizontal upper beam and are stretched by loomweights at their ends. The warp is divided into front and back by means of a movable horizontal shed rod fastened to the two upright beams by movable brackets.

eleventh century (Nordeide 1994, pp. 230–231, Figure 199).

When producing a tabby, the loomweights are attached to two warp thread layers; front and back rows representing two sheds (Mårtensson *et al.* 2009). When weaving twills, such as 2/2 twills and the more complex diamond and lozenge-patterned twills, the yarn was divided into four sheds, with the fourth as a natural shed. Remains of textiles, varying weave patterns (Figure 5) and widths, may then also be indicative of the tools used.

The warp-weighted loom is primarily evidenced by archaeological finds of loomweights and also archaeological textiles, and in Scandinavia often with a tablet-woven starting border. Another exceptional find of the warp-weighted loom stems from a medieval site in Greenland and revealed among others a 188-cm-long complete upper loom beam with altogether 81 loomweights clustered around it. A second beam broken at the ends and preserved in a length of *c.* 120 cm was also found, as were remains of two probable fixed shed rods and a pin-beater, all found in situ and dated to *c.* 1200–1250 to the early fifteenth century (Arneberg and Østergård 1993, Guðjonsson 1993). In many cases, rows in varying lengths or heaps of loomweights are found in situ in pit houses from the Anglo-Saxon period (Henry 2005, pp. 51–54), Viking period and Early Middle Ages in West Norse areas (Milek 2012, Øye 2015a) as well as on the Continent (e.g. Zimmermann 1982), and in medieval buildings in both rural and urban contexts. Some rows could be up to 2 m long, and in one case 4 m wide and a warp of 3.5 m in width (Zimmermann 1982), altogether indicating weaving broad fabrics by two persons. The largest medieval towns of Norway, Oslo, Trondheim and Bergen, have all revealed special buildings for textile production from the eleventh to the fourteenth centuries and in situ finds of clusters of loomweights in varying numbers and lengths along the walls. In Oslo, 26 weights were found along a wall, covering a length of 120 cm, while another cluster of weights in another building contained 61 weights and represented a much broader loom. The other towns also showed similar clusters, indicating different widths, varying from around 1–2 m and clusters of more than 60 weights (Øye 2015b, pp. 34–37). Much wider fabrics could then be woven on the warp-weighted loom in contrast to the early horizontal looms in the first phase and was clearly more flexible as for width of the fabric but more limited as for length. The separable parts of the warp-weighted loom also mean that a loom could be set-up temporarily in a domestic setting, where weaving was a seasonal or intermittent activity (Owen-Crocker 2012, p. 344), in contrast to the more stationary and space demanding horizontal loom. Mounting and dismantling of the warp-weighted loom is also referred to in various medieval Norse texts (Falk 1919, p. 15).

On the two-beam loom, the warp was also stretched vertically with the warp beam at the top and the cloth beam below, and the cloth was woven upwards, in contrast to the warp-weighted loom, so that the weaver could be seated. In England and other places, the warp-weighted loom seems to have been displaced by a two-beam vertical loom in urban contexts from the tenth century (Walton Rogers 1997, p. 1824), but remained a little longer in rural areas. When this transition happened – and how – is not so clear as the loom normally leaves no direct traces archaeologically. The only archaeological find is a small two-beam loom found in the spectacular grave mound of Oseberg in Norway from the early ninth century. It is, however, too small and narrow for weaving ordinary fabrics being only *c.* 30 cm across and is interpreted as used for fine tapestry work (Walton Rogers 1997, p. 1760, Hougen 2006, pp. 84–85). Indirectly, single-ended pin-beaters and toothed beaters for

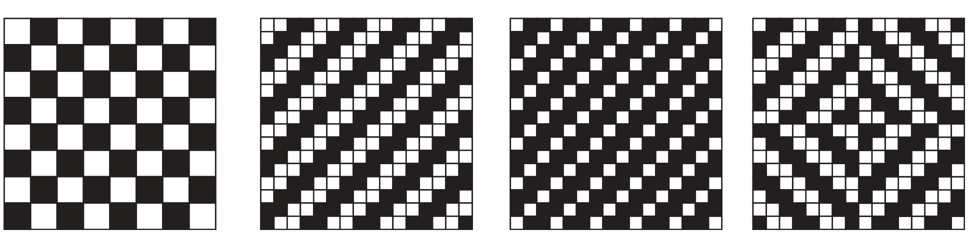

Figure 5. Weaving patterns as referred to in the text: From the left: 1/1 plain tabby, 2/2 twill, 2/1 twill and diamond broken twill. The numbers refer to the pattering of the warp and weft – twills making diagonal patterns.

compressing the weft seem to imply a two-beam looms. An early depiction of a narrow two-beam loom from the mid-twelfth century illustrates weaving and warping in progress.[6] Judging by medieval drawings, it was also used for narrow fabrics (Walton Rogers 1997, p. 1824). A decline of warp weights and an increase in single-ended pin-beaters have been seen as tentative indicators of the two-beam loom (e.g. Walton Rogers 1997, pp. 1759–1760).

The advance of the new horizontal loom provided several advantages over the vertical looms, in that it produced more uniform and densely woven fabrics, and not least, much faster. By stretching the warps more tightly on the two beams and with more even tension and by beating the wefts more firmly and evenly, the ratio of weft to warp increased in relation to weaving on the warp-weighted loom. The treadle-operated heddle harnesses further improved the control of the weaving sheds, and not least importantly, the two separate rotating beams for winding the warps and winding up the cloth made it possible to produce far longer lengths of cloth than on the vertical looms. Altogether, the horizontal loom represented a significant increase in productivity. It has been estimated to have been more than a three-fold increase compared to the warp-weighted loom (Rast-Eicher and Windler 2006, p. 32). A chief limitation though of the original horizontal loom was that it was too narrow, limiting the cloth to the arm stretch of a single weaver, while the warp-weighted loom even at an early stage seems to have been producing cloth of 2 m or more in width but then operated by two weavers, one on each side (Munro 2003, p. 196, Rast-Eicher and Windler 2006, p. 30). That two weavers were needed to lift the heavy heddle rod when changing the shift, and to hand the weft bobbin from side to side, is also observed in Marta Hoffmann's study of the warp-weighted loom (Hoffmann 1964, p. 44). Narrower weaves needed only one weaver when, for instance, weaving the standard cloth of wadmal as defined in the Icelandic law *Grágás* in the thirteenth century as an economic measure and means of currency. It should be woven in 2/2 twill technique and of two ells (at 47.4 cm) or 90 cm as the standard width (Þorláksson 1991).

A major difference between the two looms was the length of the cloth where the horizontal loom made it possible to operate 20–30-m-long threads and weave a corresponding long cloth to be rolled onto the cloth beam (Rast-Eicher and Windler 2006, p. 31). Winding woven cloth onto the upper beam of the warp-weighted loom is also documented in medieval sources both directly (Falk 1919, p. 15) and indirectly when lengths of 6 ells, *c.* 2.8 m, and 20 ells or 9.5 m became standard measures in medieval Iceland (Þorláksson 1991). Being longer cloth than the loom itself, it had to be wound onto the upper beam while the weights were attached lower down on the warp bundles. This is a method also known from later periods (Hoffmann 1964, p. 67).

There existed, then, different types of looms for producing different cloth qualities, both vertical – the warp-weighted and two-beam loom – and horizontal treadle looms, either operated by a single weaver or later by two weavers on the broadloom able to produce broader and longer fabrics. These differences should also be considered when discussing the spread of the horizontal loom in time and space, and as for gender.

It is therefore interesting to look closer at the archaeological traces, written evidence and medieval illustrations depicting both the constructions and the weavers themselves to trace the diffusion of the horizontal loom in different areas and possible coexistence of old and new technology in different areas of Northern Europe.

The advent of the horizontal loom

According to archaeological evidence, the horizontal loom driven by treadles seems to have reached Northwestern Europe during the eleventh century. It is, however, unclear how quickly this would have been adopted and quite when the vertical looms would have been phased out in different areas. Due to the fragmentary state of preservation of wooden fragments of the loom, and since loomweights generally have until recently been rather neglected archaeological artefacts,[7] it is difficult to give clear-cut and representative direct or indirect documentation of its advance. To assess the issues of adoption and adaption of the horizontal loom and how long the vertical loom was still in use, all available sources have to be taken into account and assessed contextually. Although sparse, the archaeological evidence plays a key role as for technical details and for *ante quem* dating.

The presence of the horizontal loom is marked in different ways – by direct finds of parts belonging to the loom, such as heddle horses, heddle rods and pulleys, and in rare cases also other parts of the loom, such as reeds, treadles and shuttles. An overview and map of such findings from various urban centres in northwestern and eastern parts of Europe has been presented by Dominique Cardon and Renata Windler (Windler 1994, 2008, Cardon 1999). The best-documented finds as for identification of the horizontal loom come from towns in England (York), Norway (Bergen), Sweden (Sigtuna, Lund), Germany (Haithabu/Hedeby and Braunschweig), Poland (Gdansk, Opole), Latvia (Riga), Russia (Novgorod) and Switzerland (Winterthur). Since then, however, the dating has been corrected or modified in some cases. The following updated survey is shown chronologically to better trace possible geographical patterns or changes, and focuses on the earliest and best-documented finds (cf. Table 1).

The oldest possible archaeological remains of the horizontal loom from the eleventh century come from the Viking Age town of Hedeby/Haithabu in present Germany, at that time within the Danish realm, York in England and Gdansk in Poland. Other sporadic and possible remains of the loom dating to the twelfth century come from York in England, Bergen in Norway, Sigtuna and Lund in Sweden, and Opole and Gdansk in Poland. By the thirteenth century, the finds increase in number: from among others, York, Bergen, Braunschweig, Riga, Winterthur and Novgorod.

The possibly oldest finding of the horizontal loom from Hedeby is a complete pulley made of oak, 23.3 cm long, with an intact wheel, 3.7 cm in diameter, with a groove for the string and a central hold for the transverse pin connecting it to the pulley block (Grenander-Nyberg 1984, p. 145, 1994a, p. 204). When also depicted and described among the ship-related finds from Hedeby, it appears as clearly smaller than pulleys used in ships (Crumlin-Pedersen 1997, p. 135), which substantiates the use in a loom. At York, a heddle horse/heddle cradle, *c.* 20 cm long with one central and two drilled outer holes, is dated to the late eleventh century. An incomplete wooden rod, 46 cm long and 2 cm in diameter with a knob-like terminal at the intact end, has been identified as a heddle rod and dated to the twelfth or early thirteenth century (Walton Rogers 1997, p. 1763). The identification as

Table 1. Towns with archaeological remains of the horizontal loom, chronologically ordered.

Place	Pulley block	Pulley wheel	Heddle horse	Heddle rod	Reed	Shuttle	Treadles	Beam	Side-support/posts
Haithabu	11th c.								
York			11th c.	12th– 13th c.					
Gdansk		11th and 12th c.	12th c.					12th c.	12th c.
Opole	c. 1200					12th and 13th c.			12th c.
Sigtuna	12th c.	12th c.							
Lund	12th c.								
Bergen	13th and 14th c.	12th c.	13th and 14th c.						
Riga	c. 1200		c. 1200	c. 1200	12th c.	c. 1200	c. 1200	c. 1200	
Braunschweig	13th c.		13th c.		13th c.	13th c.			
Novgorod		13th–15th c	13th–15th c	13th–15th c			13th– 15th c		
Winterthur			13th c.		13th c.		14th c.		
Turku	Late Middle Ages		Late Middle Ages			Late Middle Ages			

Note: c.: century/centuries.

a heddle rod has, however, been questioned (Windler 2008, p. 208). In Gdansk, another find of a small possible pulley wheel is dated to the eleventh century, while another pulley wheel here from the twelfth century (Kamińska and Nahlik 1960, p. 94) is interpreted as having been threaded directly on an upper loom bar in the same way as shown in an English depiction from the middle of the thirteenth century (Grenander-Nyberg 1994a, pp. 203–204; cf. Figure 2). Larger parts of a twelfth-century loom including a beam, side supports and parts of the structure were also found in situ in the ground of a wooden floor (Kamińska and Nahlik 1960, pp. 94–97).

Two pulleys were also found in Opole, dated to around 1200 and of about the same type as found in Hedeby and Bergen (cf. Figure 6) as well as four shuttles from the twelfth and thirteenth centuries (Endrei 1961, pp. 127–128, Grenander-Nyberg 1994a, pp. 203, 205).

A pulley block and a single-block wheel are found in medieval Sigtuna, both made of elk horn, and dated to the twelfth century. The pulley block, 10 cm long, is only about half the size of the Hedeby pulley, but principally of the same type (Geijer and Andersbjörk 1939, p. 236, Grenander-Nyberg 1994a, p. 205). A pulley of spindle tree from Lund, Sweden, is also dated to the twelfth century (Grenander-Nyberg 1994a, pp. 205, 211, note 3).

The excavations at Bryggen in Bergen with good preservation conditions for organic material in the damp harbour area revealed several scattered remains possibly belonging to the horizontal loom in layers dated from the late twelfth, and the latter part of the thirteenth and the fourteenth centuries (Figure 6(a, b)). The oldest is a small single wheel with a groove for the string in a pulley. It is made of birch wood, 3.4–4 cm in diameter. An almost complete pulley block of pine, 15.5 cm long, was found in layers from the late thirteenth century. The connected pulley wheel was of about the same size as the older single wheel, 3.2 cm in diameter and 1.8 cm thick, revolving on a small wooden axle. Another possible somewhat damaged fork-shaped pulley block of unidentified hardwood, 16.8 cm long, is dated to the latter part of the fourteenth century. It is more like the Hedeby pulley with a hole for suspension but somewhat smaller. A possible heddle horse of juniper, 22.5 cm long, is dated to the latter part of the thirteenth century/early fourteenth century (Øye 1988, pp. 74–75).

In Riga, one of the best-documented textile workshops has been excavated and is dated stratigraphically to the early thirteenth century, radiocarbon dated to the early part, AD 1210±. Here, charred remains of the rear part of a horizontal loom were found – parts of a warp cross beam with remains of a thick layer of linen warp ends, a reed for distributing warp threads over a certain width, a weaving comb with 11 preserved teeth, remains of 4 pulleys, a heddle horse – of the same type as found in Bergen

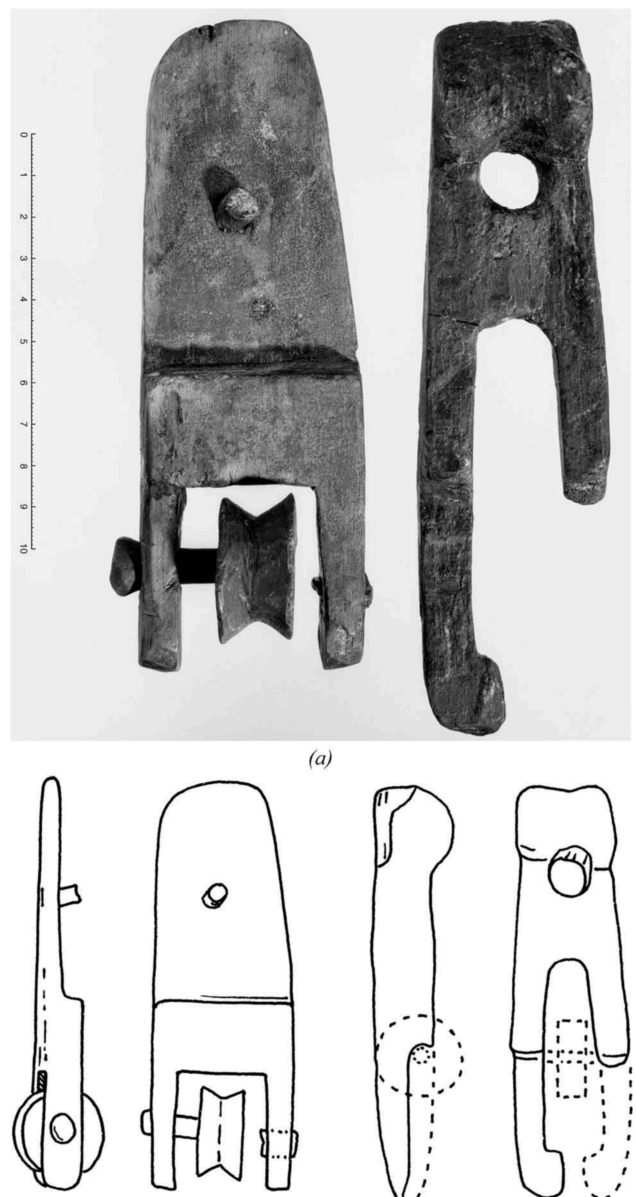

Figure 6. Pulley blocks from Bryggen in Bergen. (a) The most complete to the left, dated to the thirteenth/early fourteenth centuries, the other to the fourteenth century. (b) Drawing: seen in front and as cross section (photo: University Museum of Bergen ©. Drawing: Per Bækken).

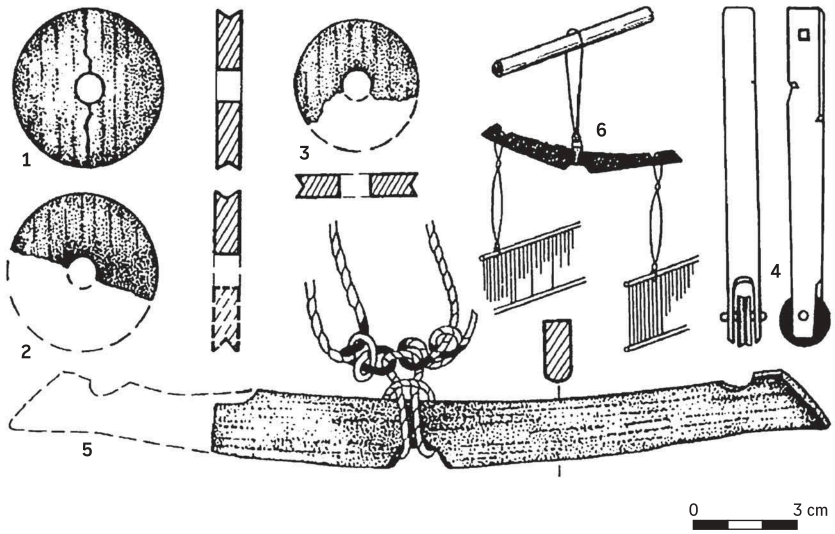

Figure 7. Loom parts found in Riga: (1–3) block wheels, (4) pulley and (6) suggested reconstruction of the loom parts.

– fragments of a shed rod, a half finished shuttle, a ball of linen yarn and remains of 2 treadles (Zariņa 1992) (Figure 7). Woven fragments of linens (1/1) were also found. This loom may have had two pulleys or two shed rods, or four of them (Zariņa 1992, Caune and Ose 2006, p. 49). This is the most complete find of a horizontal loom found in a closed archaeological context so far.

A loom with four pulleys and four treadles is shown in later depictions from the early fifteenth century, but still only operated by one weaver (Figure 8). The finds from Riga also substantiate the interpretations of the more fragmentary finds, among others the heddle horses from Bergen and Braunschweig. In Germany, the oldest evidence of the horizontal loom is found in Braunschweig in an area also called *Wevestrasse*: three wooden shuttles – the most complete 20 cm long – several heddle horses and three pulleys, all dated to the second part of the thirteenth century (Alper 2006, pp. 169–171).

Another key find of the horizontal loom besides Riga appeared in Winterthur in Switzerland, where a whole weaving workshop from the fourteenth century was uncovered. It was found in a 1.8-m-deep pit house with parts of the loom that had been in work when the building burnt. Here, strings for the shed rod, identical with the one from Riga, textiles of linen and treadles were found in a 10–20-cm-deep trapezoid pit. The loom itself had been 1.5–2 m wide (Windler 2008, pp. 209–210). In the old town of Winterthur, remains of altogether four to five workshops have been identified with traces of horizontal looms in sunken floor buildings dated from the thirteenth to the fifteenth centuries. One of them

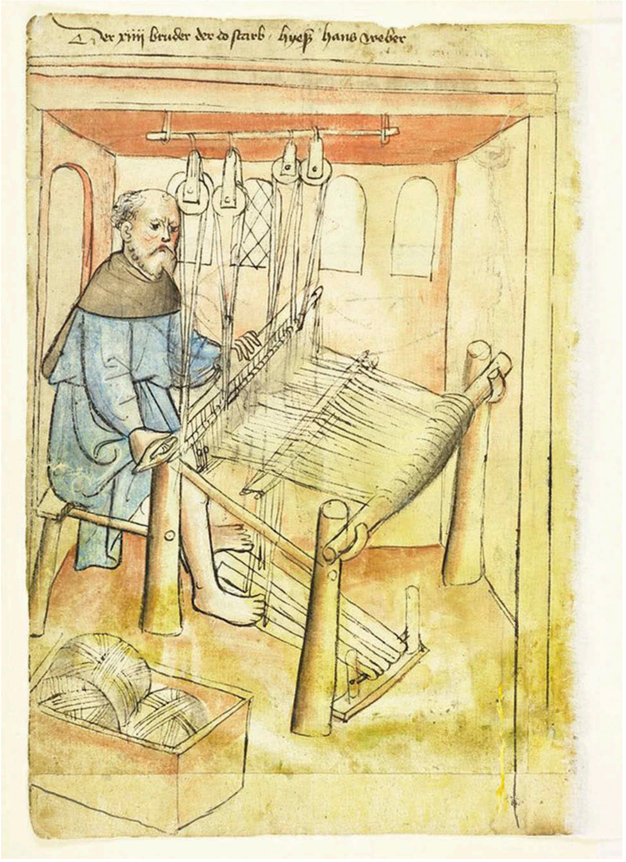

Figure 8. Wool weaver operating the loom by four treadles. Illustration from Nuremberg Mendelsche Zwölfbrüderstiftung (1425), Mendelschen Stiftungsbuch. (Stadtbibliothek Nürnberg, Amb. 317.2°, f. 4v, with permission).

had traces of four looms, one of them, dated to the fourteenth century, contained three treadles for three shafts (Windler 2008, pp. 210–211).

Excavations in Novgorod with its good preservation conditions for organic material have revealed the largest number of remains of the horizontal loom dated from the thirteenth to the fifteenth centuries: possible block wheels, treadles and heddle rods and heddle horses (Kolĉin 1968, p. 70, Thompson 1968). In Åbo/Turku, presently in Finland, fragments of treadles and other parts of the horizontal looms, part of heddle horse, a pulley as well as a shuttle were also found in late medieval layers (Hiekkanen and Harjula 2006, pp. 529–530).

Altogether, pulley blocks, and especially wheels, probably belonging to the pulley, heddle horses and remains of heddle rods, sometimes with preserved threads attached, are among the most frequent finds from the twelfth and thirteenth centuries. But as a whole, the direct traces of the horizontal loom are few and date from the eleventh century into the Late Middle Ages. The oldest finds from the eleventh century come from York furthest west to Gdansk in the east, but are more solidly represented in the twelfth and thirteenth centuries. They reveal different types of looms from a simple horizontal loom with two pedals to a more advanced loom with four treadles in the early thirteenth century.

Substitution or concurrence in weaving technologies?

In many places, the finds of the horizontal loom coincide with traces of the vertical loom in the same surroundings. In Hedeby, the warp-weighted loom seems to have been the main type of loom, judging by the more than 3000 fragments of loomweights, representing different weight groups able to produce different qualities. They were found from the whole occupation period from around AD 800 to the middle of the eleventh century, but without a closer chronology for their temporal distribution and a possible decline (Andersson 2003, pp. 121, 124, 131). The pulley then indicates that the two types of looms have overlapped in time.

In York, the number of excavated loomweights also declined considerably from the early tenth century. At that time, the warp-weighted loom seems to have been displaced by the two-beam loom for a shorter time before the introduction of the horizontal treadle loom in the eleventh century (Walton Rogers 1997, pp. 1751–1753). A similar pattern is also revealed in London where loomweights disappear from the archaeological record between the ninth and eleventh centuries (Prichard 1984). A technological change attributed to the horizontal treadle loom has also been seen by a marked change in archaeological textiles of fabrics of threshed 2/1 twills spun with z-spun (twisted to the right) warp and softer s-spun (twisted to the left) weft and replaced the mainly 2/2 twill and z/z spun yarn that was produced on the warp-weighted loom (cf. Figure 5). This interpretation may, however, be too one-sided as also warp-weighted looms with two-notched brackets could just as easily be used as on the counterbalanced treadle loom (Crowfoot *et al.* [1992] 2001, p. 27 with references).

Various looms, both horizontal and vertical, seem to be also in use in urban areas. For instance, Beverly in northeastern England, where cloth production formed the town's major craft in the Middle Ages, finds of one-ended pin-beaters used at the two-beam loom were still present in twelfth- and fourteenth-century contexts and suggest that some of the vertical loom was still in use as late as in the fourteenth century (Evans 2006, pp. 71, 76).

It has been a common conception that the foot-operated horizontal loom quickly spread from the west eastwards to the newly established Hanseatic towns (Tidow 2009). The finds from Gdansk, Riga and Opole are, however, just as early as, and even earlier than the earliest documentation from both English and German towns. In Germany, a similar shift of looms is observed but not always synchronically and where the two technologies could overlap. In Braunschweig where weaving on the horizontal loom is documented in the thirteenth century at the latest, weaving on the upright loom is also evidenced by remains of loomweights from the oldest phases into the eleventh and twelfth centuries, thus indicating a technological shift first into the High Middle Ages (Alper 2006, pp. 169–171). A similar time frame for the presence of the vertical loom is also evidenced in Göttingen, where weaving on the horizontal loom is first proven by documentary evidence and textiles from the first half of the fourteenth century (Arndt 2006, pp. 187–189). In Stade, the vertical loom was used only into the eleventh century, and where loomweights were found close to the market and in an area where textiles were later sold (Lüdecke 2006, pp. 227–228). In Bremen, loomweights occur even later, into the thirteenth century, and the warp-weighted loom seems to have only gradually been replaced by the horizontal loom (Rech 2004, pp. 290–291). A similar scene emerges in Konstanz, which developed as an important town in international trade as early as in the twelfth century and where textile production became a major craft, especially based on flax and hemp (Storz-Schumm 1993). Judging by these cases, it may seem that the transition from vertical to the horizontal weaving was not altogether synchronic and the warp-weighted loom was used well into the High Middle Ages. The transition represents a longer process and period of overlap than often considered.

In Bergen, as in other Norwegian medieval towns, the upright warp-weighted loom was used even longer than on the Continent and was a common tool from the early twelfth century well into the fifteenth century but in very small quantities and evidently on a small scale after around 1400 (Øye 1988, 2014, 2015b). This was also the case in other excavated medieval towns, such as Oslo and Trondheim (Gjøl Hagen [1988] 1994, Rui 1991; Øye 2015b). Still, textiles in 2/1 twills and z/s spinning also became more frequent by the Early and High Middle Ages in these towns. Some of the archaeological textiles have, however, remains of starting borders, which indicates that 2/1 twills were also woven, and could be woven, on the upright loom. The presence of 2/1 twills is therefore no evidence or clear proof of the horizontal loom in itself – as earlier often suggested. Textiles moreover were to a large extent imported (Øye 2015b). In Swedish towns too, weaving on the warp-weighted loom lasted into the Late Middle Ages, such as in Malmö, where loomweights are found in layers as late as from the fifteenth century (Reisnert 2006, p. 562). In Norway, the upright loom has been used into the twentieth century in some rural areas, but mostly for weaving wall hangings (Hoffmann 1964), while in Iceland it has been used into the nineteenth century for producing *vaðmál*, 2/2 twill, of various qualities and on a larger scale. In the Middle Ages, weaving on the upright loom was also carried out on a commercial level for export (Þorláksson 1991).

Studies of textiles from a medieval graveyard from the Estonian countryside indicate that the development within textile production differed in urban and rural areas in the Baltic areas and show that old traditions were kept alive through the Middle Ages, from the eleventh to the seventeenth century, in spite of rapid social and political transformations in this period. The continuity in rural textile types also indicates a persistence of old technologies on the upright loom as well in contrast to the development in the new towns, and a spatial difference between traditions and transformations. In the Late Middle Ages, textiles were still obviously woven on a warp-weighted loom as indicated by the tubular selvages, 2/2 diagonal twill and 2/2 herringbone twill weaves and z-spun combed wool. This is probably evidence of a domestic handicraft and a textile culture well established centuries earlier and lasted with little change until the seventeenth century, at least in some areas in Estonia (Rammo 2014).

It has also been suggested that the reason why the two types of looms coexisted well into the High Middle Ages was due to the functional properties of the fibres used – where the upright loom was especially suitable for the elastic qualities of wool, while the treadle loom was better suited for the firm and rigid linen. Therefore, the two looms were used side by side (Grenander-Nyberg 1994b, pp. 75–76). The preserved textile remains and threads from Riga and Winterthur were also made of linen, the latter in a pit house, with a humidity especially suited for production of linen textiles. Early evidence of the two looms used side by side is also recognised in northern parts of Switzerland, where remains of a horizontal loom were found close to a vertical loom in a pit house dated to the twelfth century. Such coexistence seems to have lasted over a long period in this region. Also here, their concurrence has been explained by their different qualities for weaving linen and wool (Windler 2008, p. 215). A distinction between weaving in linen and wool is also expressed as different specialisations in later sources. In Germany and in other areas, literary sources distinguish between weavers of wool and flax, the former denoted *der Lakenmacher* and the latter expressed in the feminine *die Leinenweber*, which was allegedly less prestigious and also included women (Alper 2006, p. 170).

Who were the weavers?

That the shift of looms also represented a shift of gender roles tends to have become a common conception, often with reference to the previously mentioned citation of Rashi of Troyes in the late eleventh century as well as later guilds and guild regulations – rules that often were laid down in the later Middle Ages by organisation of master craftsmen (Rosser 1997, p. 16). Although the role of guilds has been much debated, the issue of gender has largely been a non-issue for most historians as male dominance has been taken as a precondition. However, historians of women and gender have questioned the previous assumptions of the guilds as an all-male terrain, especially related to the rise and early period of the guild system. Underlining its emphasis on household production especially in the early phase meant that women could play crucial roles as wives, daughters and widows as participants in the family business (Crowston 2008, pp. 20–22). Although guilds prevented women from getting status as craftspeople, it still happened but often without a juridical and fiscal identity. It has therefore been warned against a too simplistic reading of craft rules, also because guilds were not one single hierarchical structure. They could also entail a complex collaboration between craftsmen and women which has not been sufficiently acknowledged (Rosser 1997, p. 14). Taking into account the long-established competence and know-how within textile production transmitted over generations predominantly within the female sphere, where gender identities in the archaeological record most prominently are expressed through burial rites[8] and in various early medieval written accounts conveyed both explicitly and symbolically (e.g. Herlihy 1990, Jesch 1991, Þorláksson 1991, Walton Rogers 1997, pp. 1821–1822, Henry 2005, pp. 51–54), the issue of gender should be looked into more closely.

In many regions, guilds were established rather late in the High Middle Ages, but some are also relatively early. In England, guilds for weavers were already established during the twelfth century, such as in York, Lincoln, Winchester, Oxford, Huntingdon and Nottingham (Oldman 2012, p. 252 with references). In 1165, the weavers' guild in York was second only to the London weavers for the fees paid to the crown (Evans 2006, p. 71, Hall 2006, p. 95). The earliest specific mention of weavers themselves comes from Beverly and York in 1163 and 1164. Here, the notion weaver needs not even be an exclusive male indicator. In Norwich, a certain Elizabeth Baret was enrolled as a *freeman* of the city in 1445/6 because she was a worsted weaver, and in 1511, a riot occurred when the weavers here complained that women were taking over their work (Ayers 2006, p. 32). That women even in the Late Middle Ages could play an important role within guilds of weavers as family members and employed staff is documented in guild and borough ordinances both directly and indirectly through rights and restrictions. An ordinance from Shrewsbury, 1448, for example, indirectly tells that women could occupy the craft of weavers within guilds by proclaiming that on the death of their husbands, wives from then on should be ruled and governed by wardens and stewards of the guilds. Another ordinance from Bristol 13 years later forbade master weavers to engage wives, daughters and maids who wove on their own looms as weavers but made an exception for wives already active before this act. This restriction was explained by male unemployment at the time (Goldberg 1995, pp. 204–205, citing the documents). Indirectly these restrictions demonstrate that female weavers within guilds were far from uncommon.

In Germany, guilds of weavers seem to appear later than in England. In Göttingen, for example, a guild for wool weavers was established in the first half of the fourteenth century (Arndt 2006, pp. 187–189). This is about the same time as a guild for weavers of linen was established in Braunschweig – again underlining the differences in textile production. In Bremen, several professional male weavers are recorded in the early fourteenth century, but evidently alongside female weavers, who are documented even later, in 1440 (Rech 2004, pp. 290–291).

In Scandinavia, guilds for weavers are only known from medieval Danish areas with the highest urbanisation. They appear, however, rather late. In 1432–36, a female weaver, *Mette Weuersk*, is referred to as a member of the Gertrud's guild in Flensburg, presently Germany. The first reference of a male weaver comes 50 years later, from 1483, referred to as a member of a guild in Roskilde. From the 1500s onwards, weavers appear in sources from Copenhagen, Odense and Malmö (Søgaard, 1975, p. 680 with references). The guild of weavers that was established in Copenhagen in 1500 also accepted female weavers as independent members and the rules were recorded in the guild's statutes. Similar rules also appear in the statutes of the Malmö guild later in the century (Jacobsen 1995, p. 230 with references).

The oldest documentation of a male weaver (OS *vävare*) in medieval Sweden, mentioning a *Hans weffar* in Stockholm, is from 1517. From Finland, a special term for a male weaver, denoted in German as *Wandmacher* or pl. *Wandtmakari*, also appears rather late, and where some Finnish and other German weavers worked at Åbo castle (Turku) employed by the King. Here, canvas was primarily woven. From the same time, female weavers are also mentioned, denoted in Swedish as *wäfwerska* (Kaukonen, 1975, p. 680 with references). At this time, weaving still seems to be regarded as an unmanly profession in Sweden, and according to the Swedish Bishop, Peder Månsson, weavers and other artisans of mainly female crafts could and should not be used as soldiers (Granlund, 1975, p. 680 with references).

In Norway, weavers in plural (ON *vefarar*, pl.) are first mentioned together with other artisans in the Urban Code of 1276, specially designed for Bergen and related to the urban taxation (levy) (*NgL* II, p. 204) but without further specification. This is about the same time as the archaeological remains of the horizontal loom from Bergen are dated. The first mention of a named weaver in Norway turns up in the 1570s, also in Bergen, and according to the name, evidently an immigrant male craftsperson (Hoffmann, 1975b, p. 679).

In Iceland without any towns in the Middle Ages, a large-scale textile production of *vadmál* also for export was based solely on the use of the upright warp-weighted loom, but still on a professional, specialised basis. Here it was organised within a rural household structure and carried out by female weavers of subordinate status, denoted as a *vefkonur*, pl. (Þorláksson 1991). The scanty documentary evidence of weaving and weavers from the Nordic countries, then, indicates that weaving had still not become an exclusive male sphere in urban contexts by the end of the Middle Ages.

The iconographical evidence of weaving scenes further substantiates the same trend, although it is rather scanty and dates mainly to the Late Middle Ages. In spite of often alluding to biblical or mythological persons, such as Eve, Mary, Penelope and Arachne, they also seem indirectly to reflect contemporary well-known work and gender domains. The earliest illustration of a broadloom from the Ordinance book of Ypres, the so-called *Keurboek*, from 1366 (cf. Figure 3) shows two weavers at the loom, a man and woman, and another woman warping. Together with a child at the spinning wheel, it may also signify a workshop within a household setting. Altogether, medieval illustrations from both England and the Continent, mostly dated to the Late Middle Ages, show both men and women at the loom. The many depictions of weaving scenes that appear in European manuscripts, on glass windows and in other contexts from the middle of the thirteenth century onwards in England, France, the Netherlands, Belgium and Germany clearly display that not only men but also women participated in the weaving on the horizontal loom (Figure 9). They also represent different types of looms – broad and narrow – and show that the horizontal treadle loom could be more or less advanced and that female weavers could operate the loom and not only male weavers. Such illustrations are relatively common in the High and Late Middle Ages but scarcer from the sixteenth century onwards.

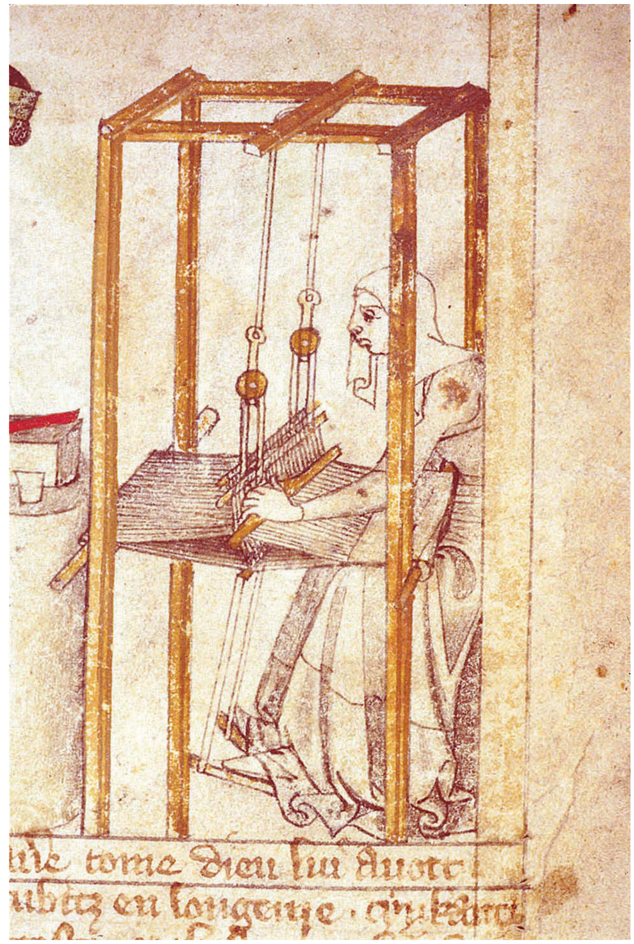

Figure 9. Woman at a two-treadle loom *c.* 1360 (Egerton Genesis Picture Book, British Library, Egerton 1894, fol. 2v, with permission).

In the Middle Ages, extensive production was connected to the households, both rural and urban, in different ways. Regardless of status, women generally were legally and economically subjected to the head of the household, normally a man. This also explains why the written sources are usually quite tacit about the women in economic and juridical matters.

This was also the case for workshops connected to guilds, where women could also participate and have a role as craftspeople (Kowaleski and Bennett 1989, p. 479; Epstein 2008, p. 162). However, reassessments of women's role in the guilds have shown that even here women could play an important role by working with master weavers as wives and children. Although their training was informal, they benefitted from a long-acquired competence and know-how transmitted as tacit and embodied knowledge (Epstein 2008, p. 162). In the household-based guilds, they could play crucial roles as wives and daughters of the master and even be regarded as partners, and there were opportunities available for women to be employed as paid workers (Kowaleski and Bennett 1989, pp. 477–480). Women also then appear as producers within guilds and the masters largely as organisers and entrepreneurs within the urban textile trade (Soly 2008). Widows could also inherit privileges (Crowston 2008, p. 19). Even as late as in the Early Modern period, widows could have inheritance rights to workshops and do guild work under the guild licences of their fathers and masters. They could also hire non-guild female labourers (Ogilvie 2004, pp. 339–341). Pure female-dominated guilds also existed in major textile-producing towns, such as in Paris, Rouen, London, Cologne and others. These were rather rare and also specialised in skills of luxury-oriented production, mostly related to silk (Kowaleski and Bennett 1989, p. 475). It is, then, noteworthy, that the most specialised and demanding branch was organised as female guilds.

Women also seem to have been able to carry out their crafts more independently outside guilds and also transgressing the household sphere more independently when they appear in the sources more or less accidentally in matters needing records caused by disputes. Such was the case when in 1278 a Felicity is denoted as weaver at Halesowen manor in Lincolnshire, and again in 1388 when Cecily de Malberthorp is referred to as linen weaver working on commission appears at court. Others act on the public scene when breaking agreements and norms. This was, for instance, the case in 1361 when Beatrix de Bedford, also a weaver in Lincolnshire, was recorded for not being willing to serve her neighbours, and when the two weavers, Matillas Swan and Alice de Skerne, were charged for taking too high prices for their weaves (Goldberg 1995, pp. 172, 177, 178 with citations). These women, however, seem to have operated on a smaller scale. The sources reveal though that 'weaver' did not necessarily stand for a man.

Concluding remarks

Altogether, the long-established dichotomy between male professional craftsmen and weavers and women as homework producers of textiles should be modified, not only as for the first phases of the introduction of the horizontal loom and prior to the establishment of guilds but also later. Here, various source categories – documentary, iconographic and archaeological evidence – substantiate that the conception of the medieval weaver as a male craftsman should be adjusted.

The change from a domestic household-based production to a more commercially based industry took place at different times and scales in various areas of Europe and did not only involve men. The presence and coexistence of the vertical and horizontal looms for many generations in many cases indicate a longer transitional phase where women played an important role in textile production not only in rural households by weaving on the warp-weighted loom but also in towns on the horizontal loom. The faster horizontal broadloom, able to produce broader and longer textiles, must clearly have ousted the vertical loom in the larger textile-producing centres, making textile production and weaving into a major urban industry. Reorganisation of manufacture and marketing within guilds were central elements in the medieval economy, where new and more advanced tools such as the horizontal loom played a central role. As Bray (2007) has pointed out, new technologies may promote processes of boundary work and renegotiations of which is considered masculine and feminine. This also seems to be the case with the establishment of urban crafts such as weaving. Still, the production continued to rely on a large female workforce throughout the Middle Ages – based on a long-achieved embodied technological expertise, know-how and constituted an important economic impact – a contribution that has largely been neglected and disregarded in the shadow of formal male apprenticeship within male-dominated guilds.

Notes

1. I am indebted to Professor Einar Thomassen, specialist on ancient religions, for this contextualisation.
2. The textile researcher G. Crawfoot thought, for example, that the Talmud here refers to the Middle East (Hoffmann 1964, p. 260).
3. For more information and discussion about its origins, see Broudy (1979).
4. Heddle horses have also been denoted as heddle cradles (Walton Rogers 1997) but basically have the same function as balances for strings connecting pulleys, heddle bars and treadles when making a shed. Some have only notches to fasten the string, others holes.
5. The original manuscript was lost in 1914 during the World War I, but photos had been taken earlier and reproduced in paper, being published in 1904 as illustrations in an article. An accurate reproduction the original *Keurboek* of the same scene was made in 1861 as a diploma showing the original colours (photos and information: Kenniscentrum, Musea Ieper and Stad Ieper, Stadsarchief). In many publications, this weaving scene has been redrawn without the same precision as in the original and seems to present the weavers as males.
6. Edwine Psalter, Trinity College, Cambridge MS R 17.1.
7. Cf. Mårtensson *et al.* (2009) underlining the importance of loomweights as sources to textile production.
8. Textile tools, including loomweights and weaving beaters, are common finds in prehistoric female burials expressing an almost hegemonic femininity. In Norway, textile tools may also occur in male burials from the Viking period in small numbers (Petersen 1951, pp. 293, 296) but find conditions and contexts are often uncertain due to early and imprecise recorded finds, and not being excavated professionally. A possible connection with production of sails has been suggested (Rabben 2002). This is an issue the present author looks closer into in a wider project related to tools and textile production in West Norse environments.

Acknowledgements

The author thanks Associate Professor Eva Andersson Strand for reading and giving competent and constructive comments to an earlier draft of the manuscript, and likewise, Professor Else Mundal for valuable and supportive feedback, and Marta Kløve Juuhl, professional weaver and curator at The Museum Centre in Hordaland, for kindly reading through the manuscript as for weaving details. The author also thanks an anonymous reviewer for useful comments, making the author see and clarify ambiguities and further substantiate arguments. The author is also indebted to conservator Jan Dewilde, Kenniscentrum, Musea Ieper, and archivist Rik Opsomer, Stad Ieper, Stadsarchief, for their generous help and valuable information about the history of the medieval *Keurboek* from 1366 and for providing photos of the original document.

Disclosure statement

No potential conflict of interest was reported by the author.

Funding

This work was supported by the Department of Archaeology, History, Cultural Studies and Religion, University of Bergen.

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DANISH JOURNAL OF ARCHAEOLOGY, 2016
VOL. 5, NOS. 1–2, 52–71
http://dx.doi.org/10.1080/21662282.2016.1248592

Routledge
Taylor & Francis Group

RESEARCH ARTICLE

Towering above – an interpretation of the Late Iron Age architecture at Toftum Næs, Denmark

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ABSTRACT

The newly excavated sites of Toftum Næs, Jutland (Denmark), will be presented, and the special features that have been registered here will be discussed. In particular, the conspicuous architecture will figure prominently; a very sturdily built and thus high structure that can only be interpreted as a tower placed along with a succession of larger hall-type buildings, and a possible ritual building. This 'aristocratic quarter' is in direct contact with another area characterized by a larger pit-house cluster of more the 100 units, and placed in the vicinity of two conjoining streams. The different structures mentioned and their internal, topographical distribution as well as architectural features will be incorporated as the main base for a functional interpretation of and motive behind the buildings and the activities pertaining to the site in general. The topic of commercial control and what type of influence the aristocracy had on the early development on these types of sites will be included. Furthermore, the structural fluctuation of the site at Toftum Næs, and in particular the changes that seem to have taken place during the main use-phase both at the site in question and with regard to the overall development of aristocratic sites with production areas and at the Viking Age towns, will be debated in this paper.

ARTICLE HISTORY
Received 19 May 2016
Accepted 12 October 2016

KEYWORDS
Iron Age; architecture; hall-building; Viking Age hall; production site; tower; central place; pit-house; ritual; hov

Toftum Næs – the site

A promotory, where Mønsted Å and Jordbro Å conjoin, forms the natural borders of a spectacular site from the Late Iron Age and the Viking Age. The site lies in the middle of Fjends Herred at the cross-section of five parishes (see Figure 1). The name itself – Toftum – can be dated back to the Viking Age and several other place-names suggest a high level of activity in this area (Laurine Albris pers. comm.). To the west, on the far side of Jordbro Å the Tinghøj mound is situated, which denotes a judicial function. To the east, on the other side of Mønsted å, we find Lundgård Manor. Lund denotes a small grove and is often associated with sacral activities (Vikstrand 2004). Along the same line, the site Gundelund appears, which not only again refers to the 'lund' concept, but with a prefix Guthen, seemingly refers to Mønsted Å as a sacred stream with a scared grove close to it. Another interesting place is Bryrup, possibly deriving from *bryde*, which denotes a bailiff. The presence of a bailiff points towards the elite and major landowners with a higher authority. The same interpretations apply for Drenggaard, which indicated the presence of *drengir*, a class of warriors or servants in a loosely organized manorial structure (Christensen 2010a, p. 130). In combination, the place-names surrounding Toftum Næs specify several central functions as well as a stratified society appearing in the Late Iron Age where sacred, military and judicial denotations cluster together.

In 2009 initial attention to the site was made due to a series of metal detector finds, and the registration of several conspicuous structures identified on aerial photos. The two streams demarcate the sites at the eastern and western sides, respectively, and where they conjoin it marks the sites' northern border. Southwardly, the landscape rises slightly only to be cut through by a deep sunken road. On this rise, the layout of walls and roof-bearing posts could be seen on the overview photos, whereas the majority of the pit-houses are placed further north and close to the conjoining streams. A trial excavation revealed a high frequency of features, confirming the presence

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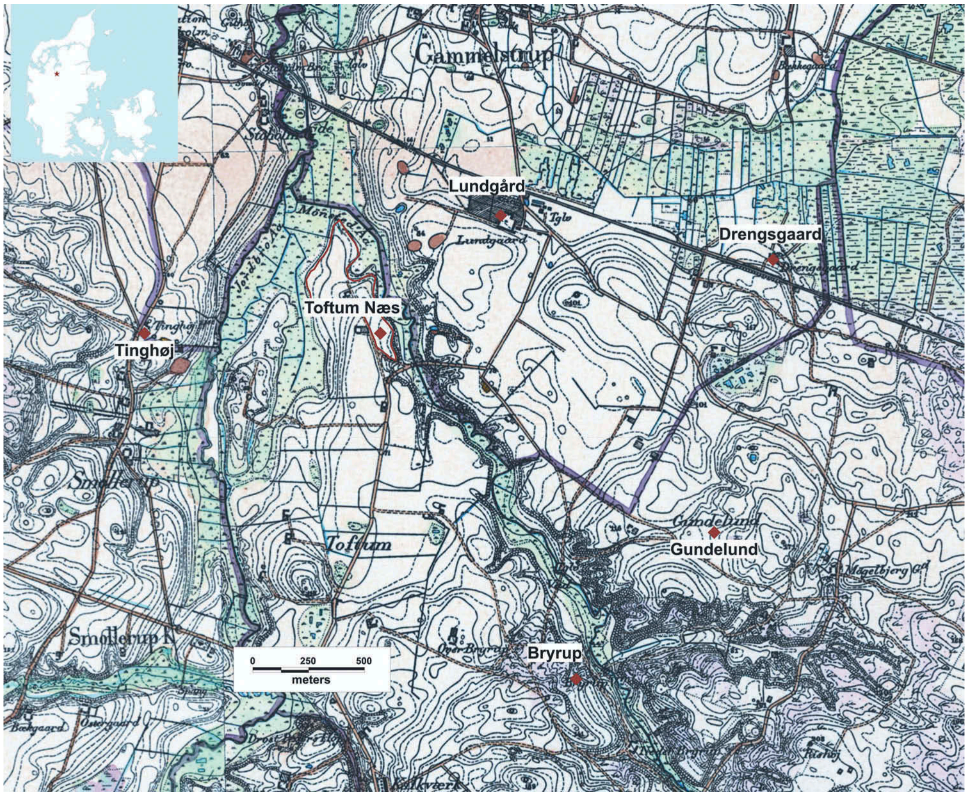

Figure 1. Toftum Næs is situated around 10 km south of Hjarbæk Fjord/Limfjorden where the two streams of Mønsted Å and Jordbro Å conjoin. Nearby interesting place-names are plotted on the map. Map: © Styrelsen for Dataforsyning og Effektivisering.

of a continuous settlement, and at the same time several conspicuous structures were revealed. Among these, a very sturdy, quadratic building of a unique architecture figures prominently. In 2014–15 Viborg Museum, in cooperation with the National Museum and Aarhus University, excavated ca. 7000 m^2 – less than 10% of the site. However, the results already provide strong evidence of a remarkable site. The registered structures can be interpreted as a chieftain's manor with numerous noticeable buildings, and a main use-phase between AD 600 and 1000. During the excavation 20 wooden buildings in different sizes, seven pit-houses, numerous fences and 12 older graves from the Roman Iron Age were investigated (Terkildsen 2014, 2015). The amount of overlapping structures and numerous phases challenges the recognition of the function of the individual buildings as well as when establishing which buildings are concurrent. Some of the more notable structures will be presented here (see Figure 2).

In the northern part of the excavated areas, two adjacent buildings have been registered and both are of a hall-type construction.[1] The oldest is approx.

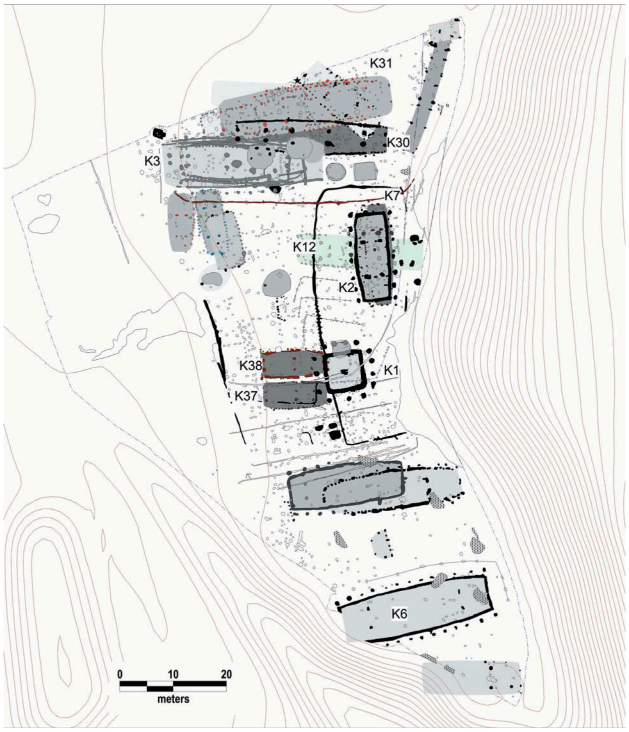

Figure 2. The excavated area with the major structures outlined in solid, and the house plans in a shaded outline. Major constructions mentioned in the text are numbered.

Figure 3. The northern residential area contained two hall-type *houses*. The leftmost is a palimpsest of at least three phases (K3) in the exact same spot, whereas the stratigraphically earlier hall slightly further to the northeast is single-phased (K30).

28 m long and 6 m across (K30), and the walls are made up by ca. 40-cm-wide cut timber founded in a wall-trench (see Figure 3). The fence just south of the hall is presumably contemporaneous with this building. The youngest of the houses has three phases, almost placed exactly on top of each other (K3). All the house-phases are around 28 m long, whereas the width seems to differ and grow over time. Thus the earliest phase is 6.5 m wide and the younger one, almost 9 m wide. Furthermore, the latest phase has a characteristic type of architecture in the wall, with sturdy and inclining outer supporting posts. This later phase is the only one with this type of walling. Owing to the repeated use of the same building area, the gables are particularly hard to unravel, but seemingly a single set of roof-bearing posts is placed in each gable, and often with a centrally placed 'sule'-post, in one of the sections, and one to two more sets inside the house. Both these buildings showed very robust roof-bearing posts, often dug into the subsoil as much as 1.5 m. Typologically as well as dating-wise, these houses belong to the late Germanic Iron Age and into the early Viking Age (i.e. AD 600–800). A third building in the area needs mentioning as well; the house is 32 m long and 6.5 m wide, which suggests yet another hall-building (K31). However, the posts are not quite as deep (26–70 cm) and the walls consist of doubly-set post. Stratigraphically, the house is younger than K30 and possibly also K3, which promote the possibility of another hall-building.

Furthest to the south on the plateau yet another hall-building appeared (K6), and covering 28 x 8.5 m, which is also of a similar proportion (see Figure 4). However, this building had a distinct architecture with one very big central room with no internal posts, and only two internal sets of roof-bearing posts as well as one set in each of the gables. A curved, rather deep trench held the wall-posts, which was supported by outer inclining posts. Such architecture is reminiscent of the style and size of the symmetrical Trelleborg houses (Nørlund 1948, Skov 1992, Schmidt 1994), but of a later type belonging to around AD 1000.

Between the mentioned hall-buildings, a series of more diverse structures can be found. Of these, one in particular is very notable, namely the quadratic building visible on the aerial photos, which had an unusual appearance as well as mode of construction (K1). First, the building forms part of a complex of structures where a fence connects this building and another building (in two phases – K2 and K7) placed closely to the northeast. The fence itself is a rigid type with smaller posts placed at regular intervals on either side of the fence, thus paralleling 'aristocratic

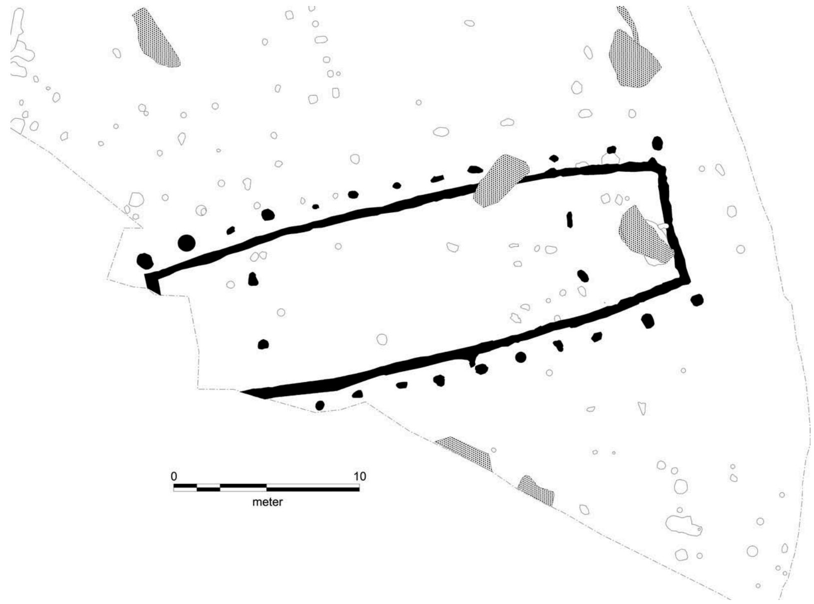

Figure 4. The southern residential area exhibited only one hall-type *houses of a late Trelleborg-type* (K6). An interesting parallel can be seen at the nearby Lundbro site, where a house of a very similar ground plan was excavated. One of the roof-bearing posts at Lundbro containing a set of spurs from the first half of the eleventh century (Mikkelsen 1991).

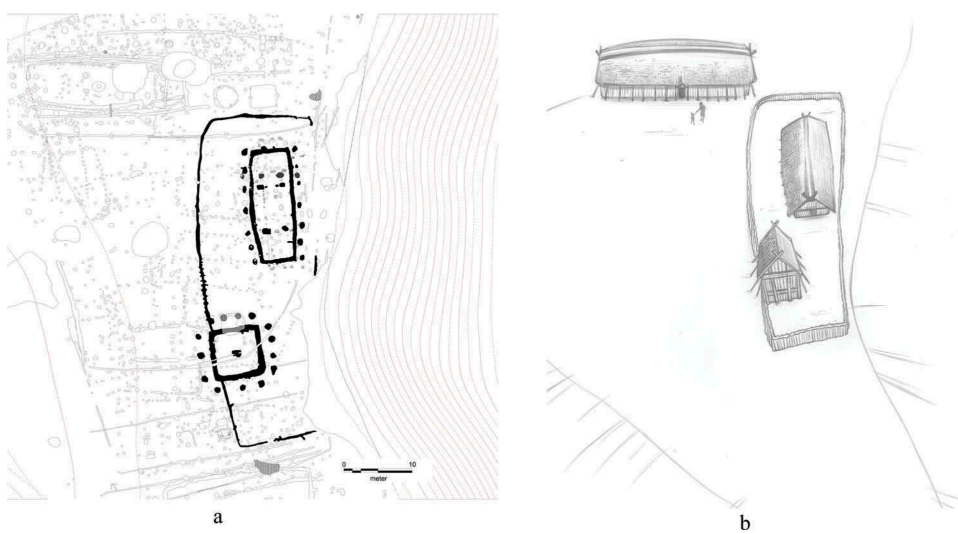

Figure 5. (a,b). Combining one of the northern halls with the fenced area, the north–south-oriented house (K2) and the tower (K1) provide a sort of possible minimum settlement overview in the first half of the eighth century. The lighter areas in the northern wall and two posts of the tower were found underneath a pit-house, which bear witness to the depth of the supporting parts of the structure. To the left is a reconstruction of that particular phase. Drawing: Tom Lock.

fencing' as seen in Tissø and Jelling (Jessen *et al.* 2011, 65ff.; Holst *et al.* 2013, Bican 2014), but of lesser proportions (see Figure 5(a,b)). The fence fades out towards the east, where it hits a small gulley towards Mønsted Å, which is currently damaged by and filled with ploughed-in material from the modern working of the fields. Inside the fencing a house-structure in two phases and turned north/south has been registered. There is no direct contact or stratigraphy between the fence and the buildings, but the overall layout and orientation strongly suggest a cohesive planning of the two buildings and the fence. In its initial phase (K7), the building is 18 × 5 m, but somewhat disturbed by the later building. However, besides the posts in the gables, three sets of posts run along the house and towards the west a series of supporting posts seems to have been placed on the outside of the wall. The younger building (K2) is 16.75 × 6.5 m and presents a very sturdy wall-trench with outer supporting posts, whereof several in the western section have a stone-built foundation. There are two internal sets of roof-bearing posts, and the northernmost could have been replaced. A bead divider with ornamentation characteristic of the late Germanic Iron Age was excavated in the eastern wall-trench (see Figure 6). Fortunately this coincides very well with the C14-dating, thus indicating a use-phase between AD 700 and 780 (see Figure 7). A third house should also be mentioned; it is older and oriented east/west, but it informs us that there were three buildings erected at almost the same spot, and similar to the sequence of hall-buildings outside the northern fence. Connection between these structures is indicated by the reuse and apparent veneration of this exact building spot.

Figure 6. A well-preserved bead divider with ornamentation characteristic of the late Germanic Iron Age was found in the eastern wall-trench of the north–south-orientated building. This find correlates very well with the C14 dates from the same structure.

As mentioned, less than 10 m southwest of this building the square structure is positioned. Also in this case, the building consists of a wall-trench; however, the dimensions are but 7.5 × 7.5 m. The trench is very regular and approx. 90–100 cm wide and between 80 and 100 cm deep. No clear signs of post are registered in the trench. A large central post is placed inside the trench, which is to 40 cm in diameter and nearly 135 cm deep. Furthermore, 14 remarkable posts were orderly placed on the outside of the trench – four on the north and east sides, and three on the south and west sides. The distance from trench to posts varied between 70 and 110 cm, and they were between 90 and 120 cm deep, with the deeper posts usually located near the corners. Almost all of the postholes had visible, reminiscent markings of the actual posts (see Figure 8), and in five cases the inclining angle towards the trench could be registered (see Table 1). With all inclinations measured to be between 81 and 82°, these angles showed an extraordinary convergence, wherefore there can be no doubt that all the postholes must have contained posts of very similar orientations.

Furthermore, such regularity permits a calculation of the height above ground where the posts will meet

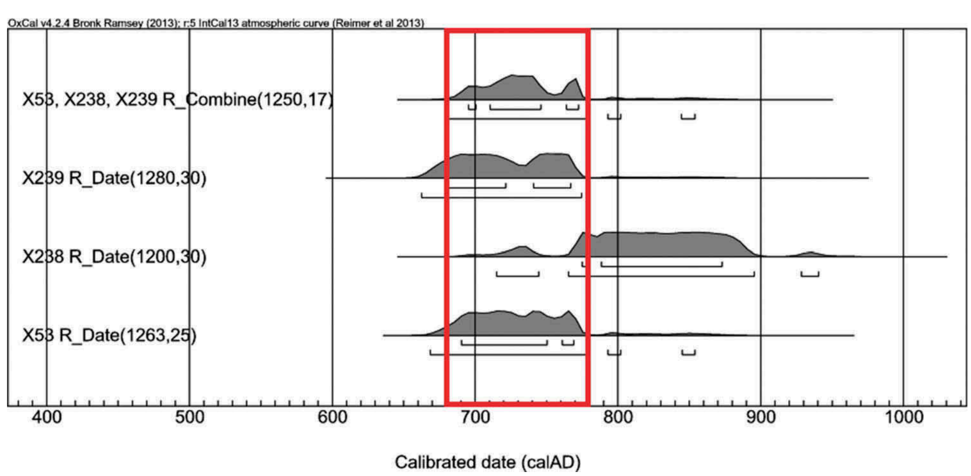

Figure 7. C14-datings from the tower, with the frame denoting the main use-phase. X53 (Barley): 669–810 AD (AAR 18,679. Conv. C14: 1263 ± 25 BP); X238 (Barley): 720–895 AD (Beta – 406520, Conv. C14 1200 +/- 30 BP); X239 (Heather): 665–775 AD (Beta – 406521, Conv. C14 1280 +/- 30 BP).

a b

Figure 8. (a, b). Section of two of the outer inclining posts by the tower, with one (left) only showing the untouched profile of the posthole, and the dotted line marking the inclination. To the right there is another sectioned posthole with a visible imprint from the rotted post and with the different layers marked in the profile. Also, this post has an easily recognizable inclination.

Table 1. Based on the inclining posts and the excavated features of the tower, the formula and measurements used in calculating the height of the tower can be read here.

CALCULATION OF THE HEIGHT: TAN(RADIANER(A))*b	Post	b	A	C
	688	1.49	82	10.6
b = the shortest distance in metres from the edge of the imprint of the post to the middle of wall ditch.	680	1.73	81	10.92
A = angle of the post, measured at the side closest to the ditch	700	1.55	82	11.03
C = calculated wall height	668	1.5	82	10.67
	671	1.61	81	10.17

the wall placed in the trench. If the wall is placed mid-trench (which is usually the case), then a tangent relation reveals a contact point more than 10 m above ground for all the measurable posts. As a consequence of the unparalleled sturdiness of the building, this must be regarded as the least expected height, and more floors above the contact point could be probable. In combination, the proportions and distinct architecture of this building leave behind no doubt that we are dealing with a high tower, and the first of its kind in Southern Scandinavia in this period.

To the west of the tower, two small buildings of around 12 × 5 m were registered. The northern one is stratigraphically older (K38) than the tower and the southernmost one (K37) is typologically the oldest. Having the posts dug in more than 50 cm, they are interesting because such small buildings are only rarely built quite as solidly. Most likely they replaced each other and at the same time transformed into an even sturdier (and higher) structure, just like is witnessed by the architecture of the northern houses. So again, this seems to be an example of three buildings replacing each other at (almost) the same spot.

Contemporary towers and other parallels

In the archaeological record, towers are indeed difficult structures to register. However, a few noteworthy structures have been excavated, which might bear resemblance to the Toftum tower. Such is the possible tower that has been excavated at Møllemarksgård, Southern Jutland (see Figure 9). The settlement is

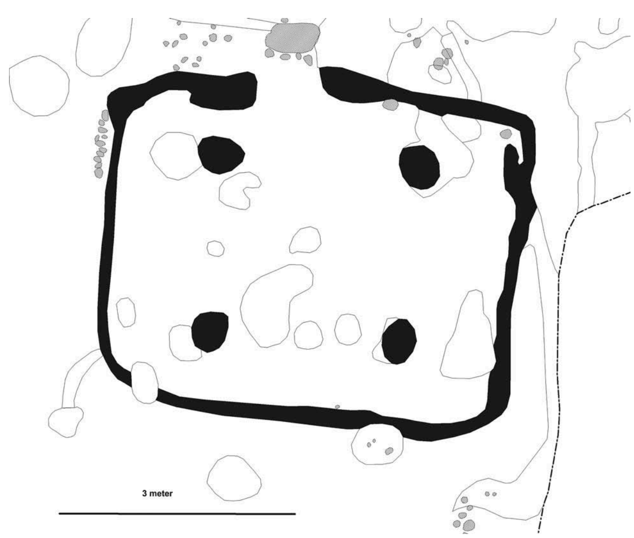

Figure 9. The tower of Møllemarksgård. Posts marked in solid black (from J.nr. VAM 1302, SB 190, 714–142).

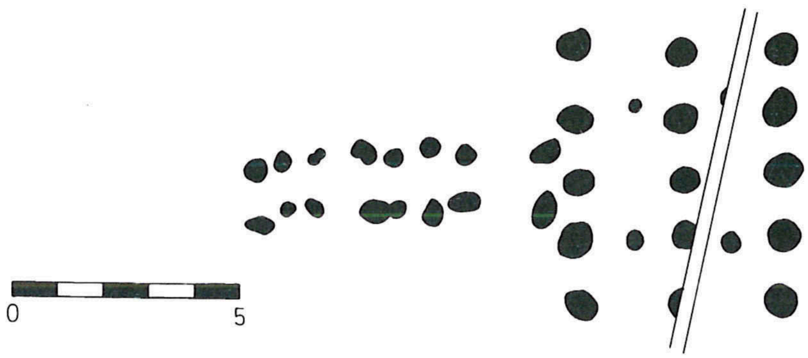

Figure 10. The tower at Tystrup I. Posts marked in solid black (from J.nr. SMV 7451, SB 050302–36).

characterized by several buildings from around the year 0, and amongst these is a rectangular structure of dimension 5.2 × 4.3 m with a wall-trench and a northern opening. Internally, four deep posts (between 80 and 89 cm deep) were excavated, thus indicating a building of some height. However, this tower is almost 700 years younger and of lesser dimensions than Toftum Næs (L. Frandsen, pers. Comm.).

Another and very convincing example of a prehistoric tower is the feature Hus X from the site of Tystrup I (see Figure 10). This building was rather well-preserved and did not see much disturbance from other constructions, wherefore the collection of post-holes was easier to decipher. A total of 15 regularly placed posts in three rows of five constituted the main bearing part, and covered 6 x 5 m. Inside these, four additional and more slender posts were erected. All of the posts were around 40–50 cm deep, and the central ones tended to be the more shallow posts. Furthermore, a marked ramp seems to have been attached to the western wall, which led the excavators to underline the similarities to the towers built along the Limes wall, which is supported by the found artefacts (mainly pottery) dating the structures to AD 200–400 (Staal 1999). Investigation of the load-bearing capacity of the building was carried out by the Technical University of Denmark (Bent Hansen, unpublished report), leading to the estimation of the height being between 11.5 and 15 m. The dating differs significantly from Toftum Næs and so does the ground plan, and bears more resemblance to the large storehouses also found at Tystrup I. The same can be said about the measurements of the posts, which are not nearly as deep as those excavated at Toftum Næs, thus making a direct comparison difficult.

Suggestions have also been put forth about the tower-like structures at the entrances and inside the Viking Age ringfortresses, but the recent re-investigation of Aggersborg suggests that the height of the gate would not have surpassed that of the crown of the earthen ramparts. The excavated postholes are simply too shallow to uphold a high building (Roesdahl *et al.* 2014, p. 208f). Four central posts at Aggersborg and a square ditch at Trelleborg are two further features that have been identified as possible towers. However, both have been dismissed due to their too shallow foundations and since they are no longer viable as parallels (Nørlund 1948, p. 92f, Ulriksen 1993, p. 190). Also in a broader geographical perspective, the parallels are scarce. As these types of structures are absent from ordinary settlements, only more distinctive building complexes, such as fortifications, do at times contain remnants of earlier phases with wooden constructions. Such sites have often been rebuilt repeatedly (or purposefully demolished), thus leaving shattered the more vulnerable wooden sections and consequently only partly recognizable to archaeological investigation. However, similarities can be found in structures dating from the early Carolingian expansion (i.e. the latter half of the eighth century), and thus being contemporaneous with the main phase at Toftum Næs.

Esesfeld

At the Carolingian fortress Esesfeld, near Itzehoe/Germany, the sole excavated entrance displays some of the same features as at Toftum Næs (Schäfer 1978, 1980, Kühn 1995), which is a seemingly awkwardly placed central post. In Esesfeld, the combined layout of the earthworks, embankments and moats dictates a

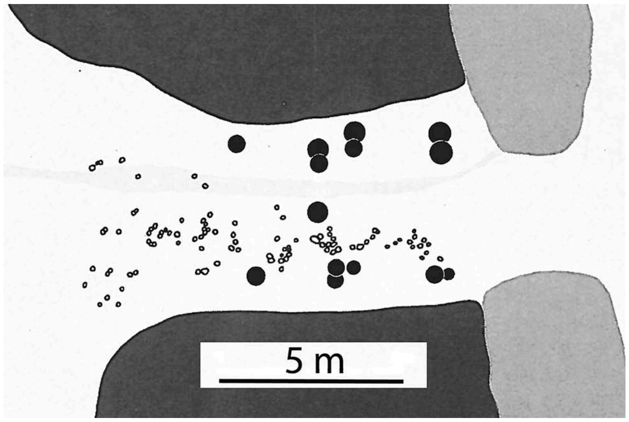

Figure 11. The tower at the gate of Esesfeld. Posts marked in solid black (after Kühn 1995).

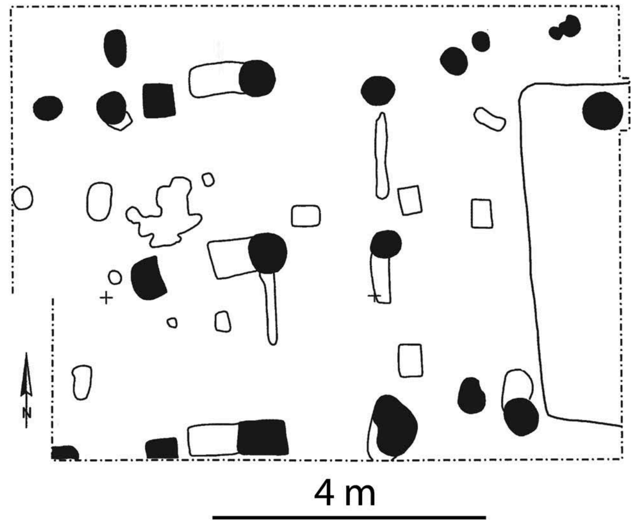

Figure 12. The tower at Hünenburg. Posts marked in solid black (after Ruhmann 2004).

very limited way of access to the internal areas of the fortress, and the entrance has a layout of two 6-m-long parallel lines placed 3 m apart and consisting of massive posts (ca. 60 cm deep), but no wall-trench (see Figure 11). Just in the middle of these, a central post was excavated, and one that was even supported by stones packed around it. An encircled area of at least 1 ha thus revealed an entrance allowing no more than two times 1.5 m of passage around the central post. According to the diary notes made by the excavator Gottfried Schäfer, there really were no architectural reasons for placing such a sturdy post here, as the two outer lines of posts should suffice as support for the tower. He believes its sole purpose was to function as a deliberate hindrance when passing through the gate (Lemm 2011, p. 468ff.). However, the central post seems to be a significant feature of tall, slender buildings of the period (see below).

Hünenburg

Many of the same features can be seen in the layout of the Hünenburg fortification (see Figure 12), near Stadtlohn, which presumably also belongs to the Carolingian expansion.[2] In the eastern and sole entrance through the embankments, a tower-like structure was excavated. Again a rectangular layout with a width of 6 m and perhaps as much as 10 m in length was registered (Ruhmann 2004, p. 10ff.) The structure is dominated by nine main posts in three lines, which therefore make up a similar division of the entranceway as seen in the former example. A previous phase in which a trench-like formation might have connected the individual post in each of the three lines is possible. This initial (and sporadically preserved) tower also seems to have had a central post, which was, as the only one, wedged in with larger stones. Again, the limitation and control of access to the enclosed area are demonstrated in the actual layout and architecture of the gate.

The strength of wood – Stellerburg

Even if the timbers used at Toftum Næs appear overly sturdy to the naked eye, another comparison to contemporary tall wooden constructions provides essential information about the magnitude of the Toftum tower. While also being of a more box-like construction,[3] the gate and tower leading into the substantial Stellerburg in the Dittmarsch of Schleswig-Holstein are very well preserved and provide information about the timber dimensions needed to build a protruding structure of the given magnitude (see Figure 13). When combining the dimensions from the preserved posts from the Stellerburg gate with the measurements of the postholes at Toftum Næs, some of the dimensions are comparable. At Stellerburg, the larger of the bearing posts exhibit a rather uniformly sized profile of approx. 35 × 35 cm, whereas the smaller posts are rectangles of around 40 × 25 cm (Haseloff 1942: Tafel 2.1). As the earthen ramparts are believed to have been at least 4 m high, the gate and tower would logically have had to surpass that height and support another storey and perhaps also a top level

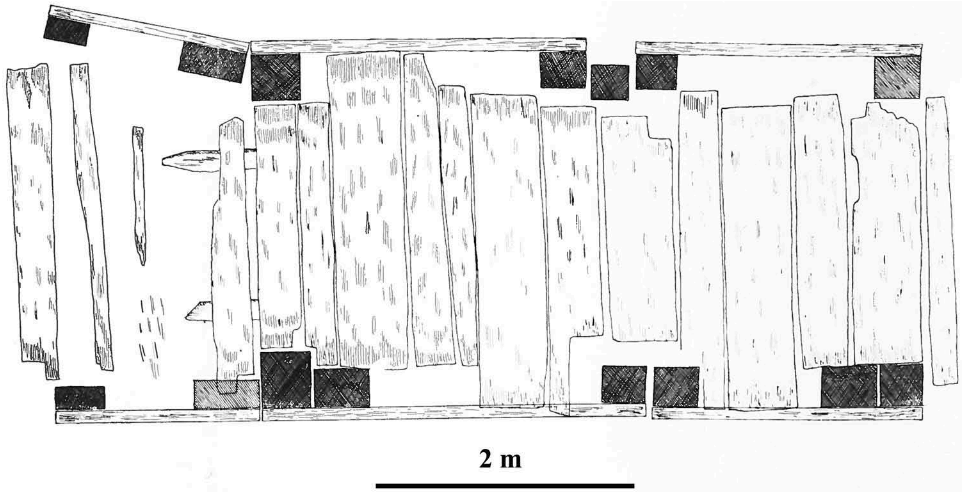

Figure 13. Northern gate at Stellerburg. Posts marked in solid black (after Haseloff 1942).

with an embrasure or a walkway (ibid.: 147). A total height of around 6–8 m seems to be a reasonable, minimum estimate. These dimensions agree well with the 35–40 cm width of the timber markings registered in the postholes of the Toftum tower; however, a noticeable difference is the inclining outer post, which indicates a higher load-bearing capacity than is permitted by the more traditional box-type construction of the Stellerburg Gate.

Reasons behind the sturdiness of the Toftum tower might be two-fold: first, that the construction simply is higher (as indicated by the angle of the inclining posts) and thus heavier, and second, that the slimness of the building and the absence of encasing earthworks would make it more prone to wind pressure, and the inclining posts guaranteed a much more rigid and stable architecture. Most likely a combination of the two points resulted in the registered architecture. In conclusion, even if the timbers are comparable between the tower at Toftum Næs and the presumably lower Stellerburg gate, the more advanced architectural craftsmanship with inclining and securely tenoned outer posts (which hereby lock and bind the individual parts of the tower frame to each other and anchor them to the ground) makes viable a building that could have been of a significant height, and easily doubly that of the Stellerburg case.

Abinger – a later case

A frequently cited tower-site is the later Abinger motte-and-bailey (see Figure 14). In the present context, the Abinger Motte is interesting due to the fact

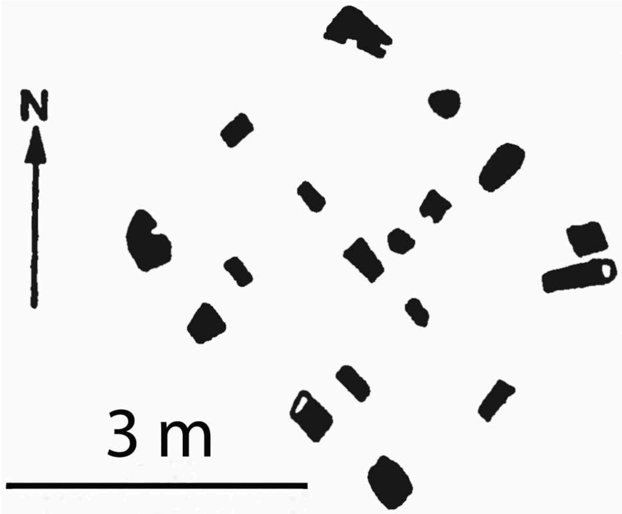

Figure 14. The ground plan of the Abinger. Posts marked in solid black (after Hope-Taylor 1950).

that the construction itself is entirely intended to function as a towering structure with the ability to withstand at least some kind of defacing and backpressure to the bearing elements of the building. In essence, the principle behind a motte-and-bailey is maintaining constructional simplicity, yet being functionally formidable – easy built, easily used – and thus epitomizing the idea of a defensive tower with surveillance capabilities. What is interesting regarding the Abinger tower is its rather limited size of just over 3 × 3 m. The main feature of the timber tower seems to have been the four corner posts on which the whole construction rested, and amidst these a centrally placed post would have provided further stability to the structure.[4] All five postholes are registered as around 4 ft (i.e. 120 cm) deep (Hope-Taylor 1950, p. 28f) and clearly confirm the central post as being an integral part of the overall architecture, and an inherent feature of high buildings as they were constructed in the later centuries of the first millennium. However, compared with the Toftum tower, it is striking that the actual floor plan at Abinger is only a quarter of the former, and still would have had at least two storeys (with a total height of 5 m or more), which lend argument to the conspicuousness of the Toftum tower. Where the traditional understanding of the wooden version of a motte-and-bailey leaves out the structure being used as living quarters because it was simply too narrow (Beresford 1987, p. 96ff.), the sheer magnitude of the Toftum tower places it in another category; if each storey takes up perhaps 2.5 m vertical space, there would have been available a considerable and roofed area in three floors (ground floor and rooftop excluded) of around 100 m^2. *Albeit* a divided mode of room structure, a combined area of this size actually surpasses the main room of either of the main halls. Conclusively, while the architecture of the Abinger towers' small ground plan shows that its vertical extent was of principal importance, the capacity of the Toftum building also seems to have been a valued feature. Why else an incomparable 6x6 m in each floor? As a consequence of this copious architecture, it seems fair to conclude that not only building high figured prominently in the plans of the Toftum proprietor, but equally so to have available a solid structure easy to defend, and a structure that could contain a considerable amount of goods or people, and even function as living quarters if needed.

Mono- or multifunctional

Hardly ever do buildings of this period see only mono-functional use, but at this point in time such buildings do start to appear, and with the unique architecture the tower exhibits, a unique use must be contemplated. However, the connection with the fence and adjacent building could indicate that the tower is placed near an entrance to the area. As no regular openings have been registered in the fence, access could even have been through the ground floor of the tower. Just south of the tower, a small entrance through the fence might have existed, but disturbances prohibit any final conclusions about this possibility. An entrance at this position would in any case have to be regarded as part of the core functions of the tower. The entrance hypothesis is also relevant when considering the mentioned smaller and filled-in gorge leading down towards Mønsted Å. As mentioned, just south of the southernmost hall-building, a deep sunken road is still in use. The long-term traffic-erosion of this road has actually swallowed the southwestern corner of the eleventh-century hall-building, thus demonstrating that the road was in use after the (so far) latest building in the vicinity. Even if contemporaneous use cannot be ruled out, a possible predecessor to this late sunken road could therefore have been the small gorge that leads directly towards the tower. Visitors to Toftum Næs could see the tower from a distance and would eventually have been funnelled to its foot by the configuration of the natural landscape in combination with the immediate road system. This is exactly the function recognizable at the Esesfeld, Hünenburg or Stellerburg examples, where the visitors need make entrance through and in between the posts of the gate *cum* tower itself. Conclusively, at least two of the sidewalls needed to have been unboarded for people to pass through. However, although the narrow space as witnessed at the different gates evidently posed no logistic problem, so does the indication of an enclosing wall-trench at Toftum – there are no obvious 'gaps' in the walling, which suggests that passing through the tower would not have been such a clear-cut option. In actual fact, there is no obvious place for an entrance into the tower, and access via some kind of ladder or ramp into the second floor is a real possibility.

Why high – the character of Toftum Næs

In essence, the tower at Toftum Næs shares several features with contemporaneous high structures (i.e. a central post), while exhibiting its own architectural solutions (inclining posts, deep wall-trench). However, the tower's context is an atypical scenery, which seems to be a specialized settlement with production capacity. In total, the settlement might cover as much as 70,000 m^2, and has revealed several detector finds and areas of high levels of phosphate indicative of long-term or intense use. The find material ranges from weights, lead spindle whorls over bronze fibulas, but also cover preserved silver coins, silver and gold

Figure 15. (a-d). Two coins from the site. The topmost is from the Carolingian area, released during the reign of Louis the Pious AD 814–840 – also known as a Temple Dinar. The other coin is a very unusual and rare English coin minted under King Ceolwulf of Mercia 821–823.

jewellery as well as high-grade and elaborate gilded objects. Several of the finds are more ordinary and appear in similar localities, whereas the coins and jewellery have been of extraordinary quality and origin (see Figure 15(a–d)). There seems to be a slight tendency for the finds to cluster in the southern, elevated foreland near the hall-buildings, which might, however, be related to the higher intensity of investigation in this particular area. The find material indicates a wide network of trade and import of unique objects, which seem to mirror the unique and distinctive architecture of the buildings of this same area. Clearly, exchange of both ideas and objects between Toftum Næs and other parts of Northern Europa must have taken place during the sites' main use-phase.

However, the lower area to the north (3), as far as to the wetland where the two streams conjoin, seems virtually covered with pit-houses. In the aerial photos of different operators such as Cowi, KortCenter.dk or archaeologist Lis Helles Olesen (Olesen and Mauritsen 2015, p. 133ff), the pit-houses stand out and can be estimated to surpass 100 entities or more. The autumn of 2015 provided the opportunity to perform a geomagnetic survey of the areas (Fuglsang 2015), and the results support the aerial reconnaissance, and indicated an even higher number of pit-houses, and a distribution of more regular pits containing stones and signs of heating and the use of fire. In order to verify these different results, a series of trial trenches in combination with more detailed investigation was laid out. As a result of these, in the area immediately north of the hall-areas several pit-houses and postholes were registered, but they faded and almost disappeared shortly thereafter, as the area starts to slope to the north. In the lower areas further to the north, a greater amount of structures was initially registered, and here the trial trenches supported the survey results. Furthermore, and in addition to the pits and pit-houses, several clusters of more ordinary postholes were registered. These were not as sturdy and easily ordered into separate ground plans as for the southernmost area, but indicate an area of intense and diverse activities, which might cover production units in the pit-houses and post-built housings spread amongst each other. The area has not yet been fully excavated, wherefore detailed dating and subdivision into different phases were not possible; however, the clustering of pit-houses and the proximity to the Limfjord do link the site to several similar localities along the Limfjord coast, which has a corresponding dating and structure (Christiansen and Sarauw 2014; Roesdahl *et al.* 2014). However, if these pit-houses and postholes are indeed contemporary structures, such a juxtaposition of features is quite rare, and could indicate another unique trait of the Toftum Næs settlement as a whole.

In total, the combined investigations at Toftum Næs reveal a succession of activity zones (see Figure 16), which are dispersed topographically and also to some extent chronologically.

(1) **Primary residential areas.** It covers the highest position on the southern part of the promontory.
(2) **Secondary activity zone.** It is delimited as an area covering the southern field immediately around/north of the hall-area. This seems primarily to be in the late phase of the site – later than the tower and northern halls – and indicates that this part of the site changed its character and perhaps also functions.
(3) **Primary activity zone.** On the northernmost tip of the promontory, an area of approx. 18,000 m^2 shows intensive signs of a diverse range of activities, whereas the area around is more extensively used. At first glance, the production taking place in the pit-houses

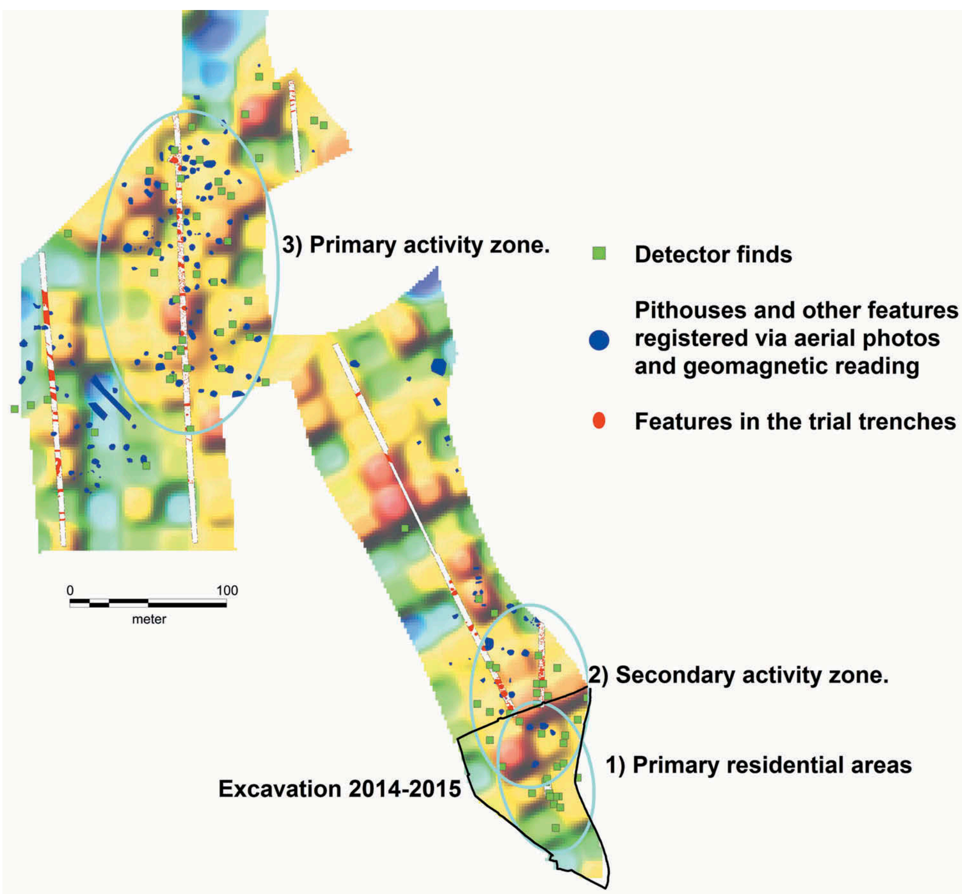

Figure 16. Map showing all the different surveys carried out at Toftum Næs. The difference in saturation indicates the levels of phosphate where the darker areas represent higher concentrations of phosphate. To the west and south of the site, several years of clay extraction have removed the surface soil. However, the indications of different types of activities seem to demonstrate that fortunately the site did not continue into this area. Map: © Styrelsen for Dataforsyning og Effektivisering.

seems the more dominant feature, but the novel registration of post-built structures has added another dimension, and possible living quarters should perhaps be comprehended as well.

Functional backdrop

It is this areal division of function that the Toftum tower has to be understood against, and in combination with the absence of find material, only architecture and topographical position provide the more tangible indicators for the actual function of the tower. What first comes to mind is the possibility of overlooking a larger area from the higher position the building permits. In this respect, the rather restricted topographical possibilities and outlook conditions the small promontory grants the Toftum tower become pertinent. To illustrate this situation, three viewsheds (at 2, 12 and 24 m above ground) have been generated and a rather concise picture emerges (see Figs. 17, 18 and 19).

If standing directly on the ground where the tower is, your westward outlook would be severely impaired, and from a few metres away until the hills start rising again on the other side of the Jordbro Å, virtually all of the riverbed as well as the northernmost pit-house area is out of sight. The viewshed changes completely at 12 m (i.e. standing atop the tower), where the entirety of the two rivers, all of the different areas described above as well as a good part of the lowland area of where the conjoined rivers flow towards the Hjarbæk Fiord become visible. However, even though Toftum Næs in the most local sense is positioned at a high spot, at a near distance the higher ground will block almost all visibility outside a 2 km radius. As witnessed by the 24 m viewshed, this situation hardly changed when doubling the height and the local visibility still dominates the picture. Thus, even if the building does tower above the other structures, it seems rather clear-cut that it was not intended to function as an outlook platform where, for example, arriving (and unwanted) groups of people would have been detected from afar. Rather, the attention seems to have been directed towards the local environment and in particular the northernmost production area with its many pit-houses. For this reason, a brief look at the topographical ordering of contemporary sites that contain areas of production and/or related commercial functions could clarify the purpose of the tower.

Commercial control

At this point in time, the Jutland peninsula witnessed the arrival of a new type of settlement

Figure 17. Viewshed showing in light colouration how far – or how close – you could see from the ground, at the spot where the tower was built. © Arjen Heijnis.

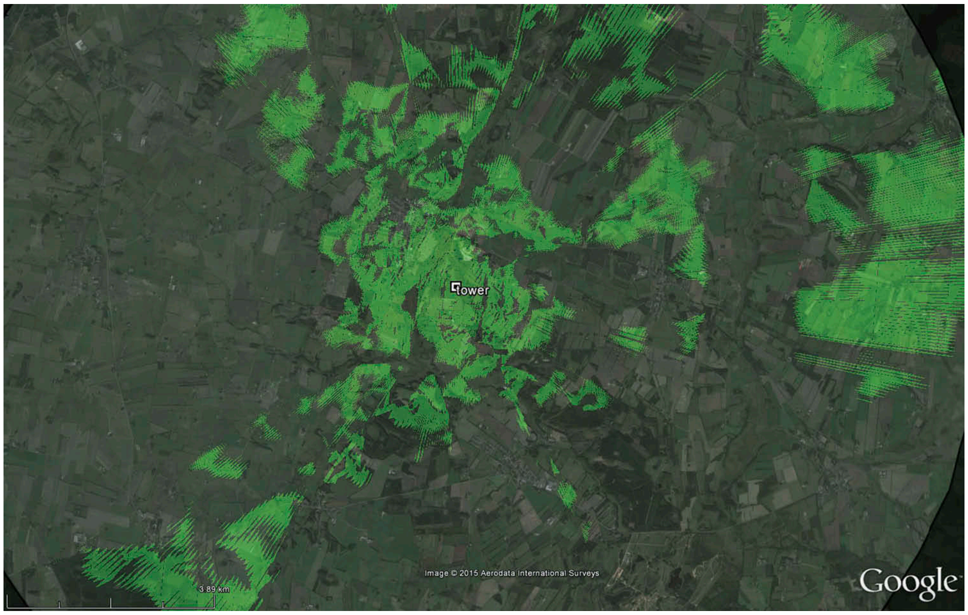

Figure 18. Viewshed showing in light colouration how far you could see from the tower if you were positioned 12 m above ground level, i.e. standing on the top level of the tower. © Arjen Heijnis.

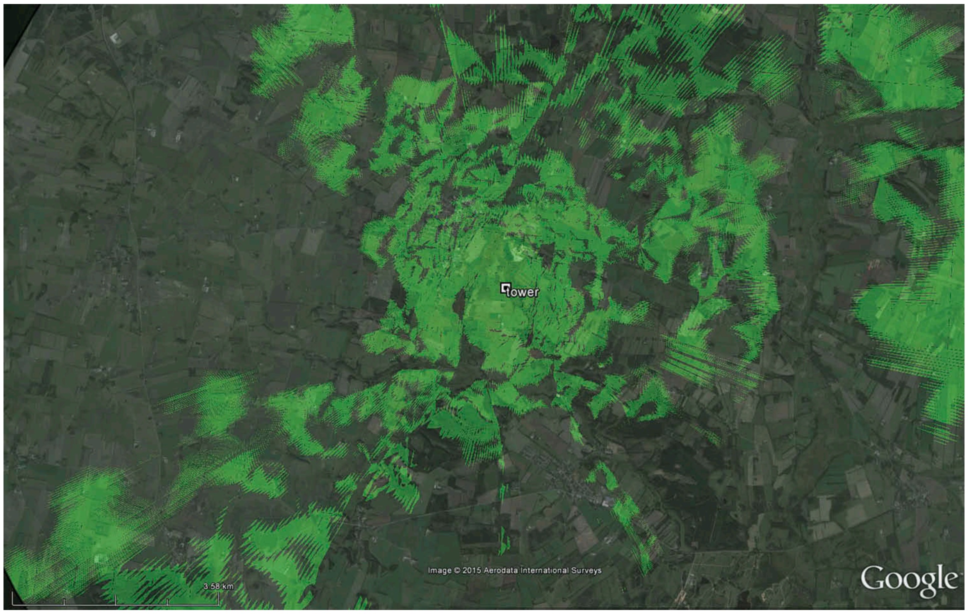

Figure 19. Viewshed showing in light colouration how far you could see from the tower if you were positioned 24 m above ground level. © Arjen Heijnis.

organization, namely the proto-towns as they developed in Ribe, Aarhus and Hedeby. These are very often organized into a plot-like structure (Feveile 2006, Pilø 2007), inside an easily recognizable demarcation zone within which the commercial life can proceed in a topographically regulated, socially embedded but otherwise presumably rather free economic setting organized around fixation of value by tradition and custom (Sindbæk 2007, Dobat 2012, Skre 2015).

However, a closer look at the dating of the different localities in comparison with Toftum Næs informs us that the tower had a primary use-phase that predates the establishment of the more regular *emporios*, and instead falls within the period (i.e. the eighth century) in which the first larger, seasonal markets with clear indications of long-distance trade started to appear. This situation would entail that not only local traders journeyed the South Scandinavian markets, but likewise foreign merchants with no apparent social relations to the other traders (or local powers) and whose commodities were sufficiently exotic to not be enrolled in any traditional means of value estimation. Combined, this situation gave rise to a much higher degree of independent economic agency than previously (Skre 2015, p. 167ff., for a thorough definition), and which must have necessitated a need for a continuous increase in regulated commercial sites – sites that were specialized not only in production but also in trade per se, and at the same time could guarantee safe passage for the potentially vulnerable foreign traders. Eventually, and as a result of this move towards certified commercial localities, the systematized and well-regulated emporios did finally emerge. Consequently, the Toftum tower was erected at a time in which commercial sites witnessed a marked intensification in regulation and topographical control, and especially those that garnered foreign traders and commodities.

What is interesting in this respect is the similar and easily recognizable structure many of these unique localities have, often a double organization of the area with the mentioned demarcation zone close to the seashore, and a more removed residential area, which is positioned higher and contains fortifications, aristocratic seats or both. In Jutland the most prominent is the Hededy scenario, with the ringwall and commercial area *cum* harbour inside, and the rather suspicious Hochburg on a higher plateau to the south (Kalmring 2014). In the large ports-of-trade excavated at Kaupang and Birka, this bisected organization is even more pronounced and the Huseby behind Kaupang (Skre 2007, p. 446ff.) and the constellation of the Birka/Sorte Muld with the fortification at the nearby and higher outcrop placed in close vicinity to the enwalled commercial area near the water bear close resemblance to Hedeby (Kalmring 2012). Furthermore, the residential area at the royal site of Hovgården at Adelsö just opposite and overlooking Birka underlines the presence of a 'distant' aristocracy, possibly taking care of the administration of the commercial area on Björkö (Rydh 1936, Brunstedt 1996).

A similar topographical orientation can be witnessed at the larger aristocratic sites such as Lejre (Christensen 1993, 2010b, 2015, p. 55), Tissø (Jørgensen 2003, Thomsen 2009) or Järrestad (Söderberg 2003, p. 45ff.) or more production-oriented sites such as Bejsebakken (Nielsen 2002, Christiansen and Sarauw 2014) or Löddeköpinge (Svanberg 2000), all of which reserve the higher ground for the bigger hall-type buildings, while the surrounding and low-lying areas (and often with closer proximity to the nearest waterways) are filled with a considerable amount of pit-houses. Whereas the scales of most of the commercial proto-towns and the aristocratic sites surely surpass those of Toftum Næs, the intra-site organization with separate areas for more specific functions is recognizable also at Toftum Næs. Especially the repeated tendency to position the higher strata of society on an equally high physical position is evident (and often accompanied by some kind of fortificatory structure), and even seems to have been a recurring method of underlining and legitimizing supremacy throughout the late Iron Age and into the early Middle Ages (Näsman 2001, Heimer 2009, Jessen 2012). Furthermore, in later periods a very notable type of building might provide a functional parallel (at least partly) to the Toftum tower. As recently pointed out by a number of scholars (Olsen 1967, Nilsson 2003, Anglert 2006, Sundqvist 2006), there are certain architectural features appearing in the early Romanesque churches that are not strictly related to any type of divine worship or to the Catholic liturgy either. In particular, the western towers of the early Romanesque churches take such a position, as the different uses of this part of the church often can be related to more profane activities, without any apparent relation to the otherwise clerical life in the church. Storage of seeds collected through taxation, place of refuge in times of conflict or even as a private area for the patron family has been suggested. These western towers could also have been used in connection with private sanctuaries or perhaps even more elaborate banquets (Anglert 2006, p. 171ff, Sundqvist 2006, p. 20f). For these reasons, it seems clear that the west towers of the churches indeed did leave open the possibility of non-liturgical activities, and instead were oriented towards activities associated with older traditions, which used to take place in the Iron Age halls – the public exhibition of power and establishment of a palpable hierarchy (Jessen 2012, p. 29f).

Conclusively, and with both the site-situational context and different 'towering' parallels in mind, it seems evident that the Toftum tower is a type of building not registered before in South Scandinavia, but which seemingly fullfils a series of functions required by many aristocratic, production-site with potential ambition for foreign trade. First is the organizational aspect, where a patron character of some kind administers the production areas (the pit-house assemblages of area 3), and would need a tool for that purpose. A high building at the right spot, such as the Toftum tower, would do the job brilliantly at overlooking and keeping the area under surveillance. Second, the actual produce needs be taken care of, and a reasonable interpretation of the exaggerated available space inside the tower could be explained as being used for the storage of valuable trade-goods, or even some kind of toll, duty or taxation profit.[5] Third, when an unfamiliar crowd gathers at small places with the specific purpose of maximizing personal revenue, it seems to be a universal truth that trouble is bound to happen, either because locals get at each other (or their masters) or because outsiders would want to take advantage of the situation. For whatever reason, and all of the here mentioned could be relevant for Toftum Næs, the possibility of upgrading your defences with a tower would be an intelligent initiative, and the Toftum tower could certainly have fulfilled the same functions as the later motte structures. Last, the architecture itself, being of such a unique type, would to a great extent underline the ingenious and dynamic character of the proprietor. In combination with the magnificent halls nearby, both visitors and regular dwellers would constantly be reminded of the powerful proprietor at the top of the hill. In total, through the tower, halls and their position, the material manifestation of the local administration in this way becomes quite obvious, and the intertwined character of person, function and building roots itself in the overarching tendency for the Iron Age aristocracy to build high and build big.

Ritual landmark?

Another possible rendition of the towering structure relates to the concept of the pre-Christian cult building, the so-called *hov* (Olsen 1966, Sundqvist 2009, Andrén 2013). Numerous ritual localities in the written record of the Norse sagas include a notification of their elevated position compared to the surrounding buildings, which, as mentioned above, is a conceptualization resting deep in both the social and religious life of the Late Iron Age and the Viking Period. This has led to a century-long debate, particularly in the early twentieth century, about whether the pre-Christian temples in Scandinavia would have followed the same format (Boëthius 1931, p. 31ff; Lindqvist 1923, Palm 1937, versus Oelmann 1933, p. 174ff; 1940, De Vries 1935). In addition, the archaeological record shows that important structures (including possible pagan temples) are built almost as high as possible and that they are also positioned in a topographical setting underlining their magnitude (Holtsmark 1970, Gräslund 1992, McNicol 1997, Anglert 2006, Larsson and Svanberg 2006, Jessen 2012, Christensen 2015). Owing to this inclination, the reconstructions of the few ritual buildings of the period tend to have been made very high (Lindqvist 1923, Rosborn 2004, Jørgensen 2005), wherefore an interpretation of the tower as being of a ritual ilk might seem straightforward. Conversely, several of the already-mentioned settlements (Tissø, Lejre, Järrestad, Bejsebakken, Erritsø a.o.) all seem to follow the same template, with a larger, prominent hall-type building and a smaller sidehouse, which in several instances are enclosed by fences and seem to indicate special ritual functions. The appropriate interpretation to this constellation would be that the main residence is equipped with some kind of building with a temple function. Accordingly, if this constellation is to be transferred to the situation at Toftum Næs, then the building just north of the tower needs be the one regarded as of a ritual kind. Please keep in mind that also this house has a conspicuous architecture with the western wall (in the latest phase) having a very sturdy type of foundation and one capable of upholding a significant and tall wall. Furthermore, the ground plan, with two sets of main roof-bearing posts, bears a clear resemblance to the Uppåkra temple, and the north/south orientation follows the layout of the mentioned hall-buildings *cum* sidehouse. Conclusively, the tower still stands as an exceptional structure and seems to expand the operations of the settlement rather than fulfilling the role as a ritual landmark or *hov*.

Concluding remarks

As it can be seen from this preliminary presentation of Toftum Næs, after only about 10% has been excavated, the site stands out compared with more regular settlements from the period. The most obvious reference seems to be the chieftain sites in East Denmark and Scania; the long continuity and several hall-buildings following atop one another have parallels at e.g. Lejre, Tissø, Toftegård or Järrestad (Jørgensen 1998, 2003, Tornbjerg 1998a, 1998b, Söderberg 2003, 2005, Christensen 2010b, 2015) and that includes several central building details in the halls. Especially the principal hall-building from the first half of the seventh century, with a very slender length/breath ratio and sturdy roof-bearing post with regular intervals from gable to gable, presents an 'eastern' type of hall-building. The fenced area with a smaller building and the tower also indicate the site's significance. The tower is a unique building with possibility of overviewing the area, retreat and storage, but perhaps above all meant to cause admiration and respect by those who visited the settlement. The many pit-houses at the tip of the promontory suggest an activity area for gathering and/or production, where people could meet up and goods could be produced and exchanged. The finds are of high quality and the coins show contacts reaching beyond the Scandinavian area. Consequently, a significant chieftain lineage with the ability to maintain power for several centuries while continuously constructing innovative and unique buildings inhabited Toftum Næs.

Notes

1. A dendrochronological dating has been made of the remains of a roof-bearing post. The youngest preserved year ring was formed in AD 585; with the missing sapwood it can be calculated that the timber was felled after about AD 605.
2. Since the initial excavation in the early 1950s, the find material has been lost, wherefore the dating of the posts and tower rests on the drawings and diary made by the excavators. The majority of pottery finds do, however, belong to the eighth century, as does a culture layer found in connection with the tower (Ruhmann 2004: 19–20).
3. In this respect Stellerburg, as well as the other Carolingian examples, bears clear resemblance to the very simple, four-post structure (i.e. a box) upholding the central tower, which has been excavated at numerous, small Roman fortifications spread virtually all over the Roman Empire (Baatz 1976, Hanson and Friell 1995).
4. Whether the sides are open or closed has been debated (Ericsson 1992:37ff), but since part of the surface was removed by modern earthworks, no clear-cut answer can be given.
5. The collection of taxes is generally accepted as a means to establish the extended network of commercial sites of the Viking Age, where a patron guaranteed safety and a place to rest, whereas the trader paid to obtain this protection. The only contemporary reference to income by taxation is the *Annales Regni Francorum,* which states that the Danish king Godfred (Godofrido) sacks the merchant town of Reric, which allegedly was a town that had provided him with great wealth (via taxation). Also the place-name Ribe (Ripensis) seems to indicate a toll-reference as the merchants' payment for their lots in the mercantile town of Dorestad is called Ripensia. Thus, the name Ribe could have a direct link to toll payment at this place (Sawyer 1986, Middleton 2005).

Acknowledgements

The Agency of Culture and Palaces financed the greater parts of the excavations, and a generous grant from the Beckett-Foundation made possible the Geomagnetic Surveying. The authors are grateful for the support of the involved students and employees at Prehistoric Archaeology, University of Aarhus and Pre-Christian Cult Sites, National Museum of Denmark. Also many thanks to Maria P. Baastrup, who provided the more exact dating of the different ornaments, Katrine Vestergaard for solving several of the post-holes conundrums, and Arjen Heijnis for his detailed viewshed analysis.

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DANISH JOURNAL OF ARCHAEOLOGY, 2016
VOL. 5, NOS. 1–2, 72–85
http://dx.doi.org/10.1080/21662282.2016.1256099

RESEARCH ARTICLE

The hydrology and preservation condition in the flat-topped burial mound – Klangshøj at Vennebjerg in Vendsyssel

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ABSTRACT
Klangshøj is a flat-topped burial mound similar to the Royal Jelling mounds, although smaller. The myths tell that a well has existed on top of the mound as at Jelling and a spring had flown at the base of the mound. In order to verify the myths and a similar hydrology in Klangshøj as found in Jelling, several borings have been carried out in a north-south line across the mound.

The investigation showed that Klangshøj is built of sods mainly harvested from heathland. The sods are of different grain sizes from fine sand to clay. The preservation conditions were excellent in three of the six borings, where undecomposed plant remnants, occasionally greenish, were observed. A ^{14}C-dating showed that the mound was built in the Viking Age. The hydrology in Klangshøj is the same as in the Jelling mounds, with a permeable bioturbation zone covering almost impermeable, distinct sod layers. This form a perched groundwater table in the transition zone, which keeps the distinct sod layer below anaerobic, i.e. the preservation conditions extremely favourable. The perched water table drains internally as in the Jelling mounds, and there are no current nor fossil evidence to suggest a spring was ever present at the foot slope, as the local legend suggests. Moreover, it seems unlikely that a well, similar to the one on the Jelling mound, has existed on the top of the north-facing slope, as the amount of water the well would have been able to collect is little.

ARTICLE HISTORY
Received 5 April 2016
Accepted 26 August 2016

KEYWORDS
Burial mound; hydrology; borings; Viking Age

1. Introduction

More than 80,000 burial mounds have been constructed in Denmark in the period 1500 BC to AD 1000. Most of the burial mounds are located in the higher part of the landscapes and are relatively well drained, but in some cases, a perched water table has developed in the mounds. The documented mounds with perched water table are mainly built in the Early Bronze Age about the 13th century BC (Randsborg 1996, Holst *et al.* 1998, Breuning-Madsen *et al.* 2001) but examples from the Viking Age about the 10th century AD also exist (Breuning-Madsen *et al.* 2012). They were in average about 15 m in diameter and 3–4 m in height, though some were much larger with diameters up to 70 and 9-m high.

The development of perched water tables in burial mound seems to follow two different routes:

i: The burial mounds from the Bronze Age were built of sandy or loamy sods over oak log coffins containing deceased persons. In some cases, iron pans due to redox processes have developed in the central part of the mound close to the base and formed a perched water table sustained by precipitation surplus (Breuning-Madsen and Holst 1998, 2003, Holst *et al.* 1998, Breuning-Madsen *et al.* 2000, 2001). This water table has formed an anaerobic core sometimes totally encapsulated by iron pans. Upon excavation, the core appears bluish or black, anaerobic, and contains substantial amounts of water, while the surrounding mantle is normally brown or yellowish brown and aerobic. In the mantle, the plant material on the sods is decomposed whereas the core contains large quantities of undecomposed organic matter including well preserved plant remains (e.g. Henriksen 2005). The primary burials are normally found within the core, and when excavated more than 3000 years after interment, well-preserved oak log coffins have been uncovered. In that way, some of the most

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remarkable discoveries from prehistoric Denmark have been made inside such burial mounds, as corpses, costumes, food, weapons and other implements are extremely well preserved.

ii: In the Viking Age, during the second half of the 10th century, perched water tables were formed in the two huge mounds constructed as a part of the Royal monuments in Jelling, East Jutland, Denmark (Breuning-Madsen *et al.* 2012). The North Mound is approximately 60 m in diameter and 7.5 m tall and built of more than 2,000,000 mainly sandy loamy sods. It contained a large wooden chamber about 7-m long, 3-m wide and about 1.5-m high. The South Mound is 65–75 m in diameter and 9.5 m tall and built of more than 2,500,000 loamy or sandy loamy sods. There were no burials in that mound. Information on the burial mounds can be traced from an engraving made by H. Rantzau at the end of the 16th century showing that at the top of the North Mound, a pond is depicted (Lindeberg 1591). In the explanatory text, Rantzau states that there was a stone-built well at the bottom of the pond. Later reports describe the form of the well as a funnel where the well is the tap. The top of the funnel had a circumference of about 30 m or a diameter of 9–10 m (Krogh 1993). The well was used to supply the inhabitants of Jelling with good drinking water. This shows that a perched water table that could feed the well with water must have been developed in the North Mound. In 1820, the well was filled up with soil material after an excavation into the centre of the mound.

In 2009, borings were made in the two mounds (Breuning-Madsen *et al.* 2012) in order to explain the development of the perched water tables. This study found that the genesis of the perched water table was very different than the perched water tables formed in the Bronze Age burial mounds, although the basic mound construction is rather similar. All mounds are built by grass or heathers sods placed with the vegetation surface downwards. First of all, it is not iron pans that generate the perched water tables in the huge burial mounds but changes in the hydraulic conditions between the bioturbation zone and the sods below. These changes cannot be ascribed to abrupt changes in the texture, as the two burial mounds are very uniform in that respect. It can be explained by biological activities in the soil layers above the muddy layer forming vertical cracks due to annual drying/rewetting processes and root burrows, while the muddy layer below has impeded the biological activity in the lower soil layers. The conditions that might have a huge impact on the formation of the perched water table due to abrupt changes in the hydraulic condition are: (i) precipitation surplus, (ii) the texture of the building material, (iii) the shape and size of the mound, and (iv) the root depth of the vegetation on the mound. (i) is important as a precipitation surplus will give time for the water to penetrate into the subsoil with low hydraulic conductivity. The texture (ii) is important, as a huge burial mound built of sand will not generate perched water tables due to the high hydraulic conductivity of pure sand. The size and shape (iii) seem to play an important role. The large dimensions, 8 to 10-m high and 60–70 m in diameter, in combination with the loamy texture may compact the two to three million sods leaving little space for the water to penetrate. The bioturbation loosens the upper 2 m and hereby develops the big differences in hydraulic conductivity between the bioturbation zone and the sods below. The shape of the mounds with a huge flat top and steep slopes may keep the water surplus in the mound for a longer period as it has to flow a long distance at a low gradient from the centre of the mound to the steep slopes. This might explain why the hydrological conditions in the Jelling mounds have not been described in other mounds in Denmark or other places in Northern Europe.

The description of the special hydrological condition developed in the Jelling raise the question: is it possible to find similar mounds in Denmark? An extensive literature survey showed that at Vennebjerg in Northern Jutland, a burial mound Klangshøj might have similar hydrological conditions as the Jelling mounds. In the *Museal berejsning*, in 1924, Klangshøj is described as 6-m high with a diameter of 45 m (http://www.kulturarv.dk/fundogfortidsminder/Lokalitet/15294/, [accessed 18 March 2016]). It is located on a ridge, it is partly demolished and the myth tells that there should have been a well in a small depression close to the top of the mound, and a spring called 'crutch-Karen's spring' (Danish: Krykke-Karens kilde) flowed in ancient times from the base of the mound towards the north. In 2001, the National Museum describes the mound as an prehistoric burial mount that might not be 6-m high as stipulated at the former inspections in 1949, 1938 and 1992 because the mound is built on a natural summit in the landscape (Breuning-Madsen *et al.* 2012).

If the myths are correct, the well and the spring from the base indicate that the hydrological conditions in Klangshøj are rather similar to the conditions in the two Jelling Mounds. Thus, the purpose of the study is clarifying the following questions:

i: Is the preservation condition of the organic matter in Klangshøj as optimal as in the Jelling mounds?
ii: Is Klangshøj a burial mound from the Bronze Age, Iron Age or Viking Age?
iii: Is the hydrological flow pattern in Klangshøj identical to the two Jelling mounds?
iv: Has the mound fed a spring running out of the mound at the base towards the north?
v: Has there been a well close to the top of the mound?

1.1. Location

Klangshøj is located at Vennebjerg, a small village in Vendsyssel, Northern Jutland about 6 km west of the town Hjørring, Figure 1. Vennebjerg is situated on a small hill formed for about 20,000 years ago during the late Weichselian Ice Age. Geologically it consists of a mixture of loamy till and sandy melt water deposits. About 15,000 years ago, the Yoldia Sea transgraded the lower part of Vendsyssel and the small hill was left as an island in the Yoldia Sea. Due to an uplift of the landscape which exceeded the raise of the sea level, there was a regression of the Sea, and Vennebjerg is today surrounded by the former sea bottom, the Yoldia sand and to a lesser degree Yoldia clay.

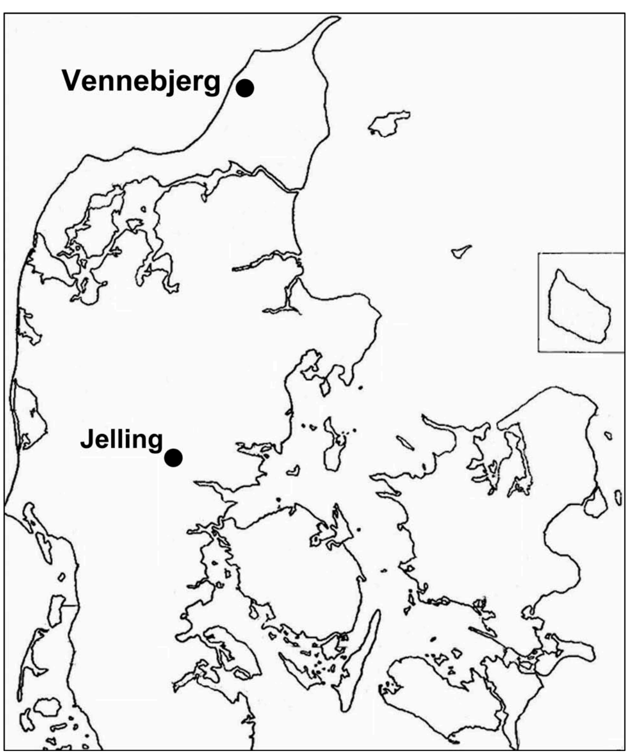

Figure 1. The location of Klangshøj at Vennebjerg and Jelling in Jutland.

The Klangshøj mound is located immediately west of Vennebjerg Church and it is reshaped several times due to human activity. The east side, facing the cemetery has been disturbed when building the church dike. The south side is relatively unaffected, although the long-time plowing at the base of the mound has steepened the south-facing slope. Excavation for the road may also have contributed to this. The west side is the most affected, as it was excavated about year 1900 to make a ground for common activities for the local community and different types of sport. The north side is the least affected, although a monument to a local teacher has been erected and a path to the top of the mound was made. Moreover, the majority of the mound was overgrown with trees and shrubs when investigated, which complicates the superficial analysis of the mound and potentially impair the preservation conditions in the mound due to deep root development.

2. Method

2.1. Field work

Field work was carried out in August and November 2013 in order to describe and map soil horizon sequences in the mound and for evaluation of the drainage conditions and preservation condition for plant remnants. In total, six deep borings were carried for detailed examination and several test borings were carried out for localisation of a former well and spring if they have existed. A seventh borehole (G) turned out to be outside the mound and is not further discussed. The six borings were placed in a north-south transect over the mound at a place with minimum human disturbance due to excavations of the mound towards west and south and the disturbance of the eastern part of the mound due to building of a stone wall fencing the church yard. Only the north-facing slope was not strongly modified by human activity. The test borings were carried out slatternly distributed at the top part of the north-facing slope in order to trace the well and at the foot slope in order to find the outlet of the former spring. All horizontal positions were measured with a Trimble R8 RTK dGPS (accuracy: horizontal = 8 mm, Trimble Navigation Ltd., Sunnyvale, CA, U.S.A.). Samples for soil physical and chemical analyses was collected from the six borings, and in order to trace the origin of the sods building up the mound, samples from the surrounding fields were collected. Furthermore, water was collected from the boreholes C and D in November in order to determine the chemistry of the soil water perched in the mound.

The borings were carried out using a hand-driven chamber auger for stony soils (Eijkelkamp, Giesbeek, NL). The auger consists of a hollow auger head (ø = 7 cm), an attachable handle and multiple 1-m extension rods. At each down-lead and uptake, a 10 to 15-cm long soil cylinder is extracted. All borings reached the yellowish brown subsoil below the mounds. The deepest boring of 3.5 m corresponded to about 25 down-leads and uptakes. The soil cylinders in the chamber were described according to a soil profile description system developed for Danish burial mounds (Breuning-Madsen and Holst 2003). Soil samples for chemical, physical and archaeobotanical analyses were collected from the six borings. A secondary boring to the surface of the low-conductivity layer was left open to determine the influx of water over a 3-day period. It was made close to boring C (Figure 3), which has the most well-preserved vegetation surfaces, and therefore supposedly the lowest vertical hydraulic conductivity. At the same location, a borehole was drilled in November 2013 and the water table was measured the next day.

2.2. Analyses

In the laboratory, the samples were air dried and sieved through a 2-mm mesh, and the soil chemical and physical analyses were carried out on the soil material finer than 2 mm. The following analyses were carried out on selected samples (double determination). The texture was determined by use of hydrometer method for silt and clay fraction and sieving of the sand fraction (Day 1965). Total carbon content was determined by dry combustion at 1250°C under oxygen addition (ELTRA 1995). Soil pH was determined potentiometrically in a suspension of soil and 0.01 M $CaCl_2$ at a soil–liquid ratio of 1:2.5.

About 100 cm^3 soil from the turf vegetation samples were used for the archaeobotanical analyses. The samples were wet sieved through a mesh size of maximum 0.3 mm to remove any fine sand and clay. The plant remains were then extracted from other materials and identified using a stereo microscope at 8x–100x magnification.

3. Results and discussion

3.1. Estimation of mound volumes

Figure 2(a) shows a digital elevation model of the current mound and the surroundings and Figure 2 (b) shows elevation profiles of an intact (NW) and an excavated part of the mound (SW). Table 1 show the average slopes of the mound sides, calculated as the elevation difference between the mound shoulder and the bottom of the respective side (N, E, S, W) divided by the horizontal distance between the shoulder and the foot slope.

Figure 3 show a transect through the mound with the location of the boreholes. It shows that the burial mound is built on top of a natural hill, which makes the mound look much bigger than it is. The natural hill raises about 4 m above the surrounding landscape; it is rather flat topped but slightly undulating. On top of it, a 3-m high mound was constructed. The mound has been reshaped several times by human activities. Excavations and/or plowing close to the hill foot has removed considerable parts of the south and west-facing sides, which results in steep slopes of 44% to the south and 56% to the west (see the difference between the NW and SW profiles in Figure 2(b)). The sides towards the north and the east have both an average slope of 34%. They appear less disturbed than the south and west slope, except for the construction of the church stone wall on the east side. Thus, the north-west side of the mound is the only side with a shape deemed comparable with the original mound. To calculate the volume of the current mound, a surface volume calculation was

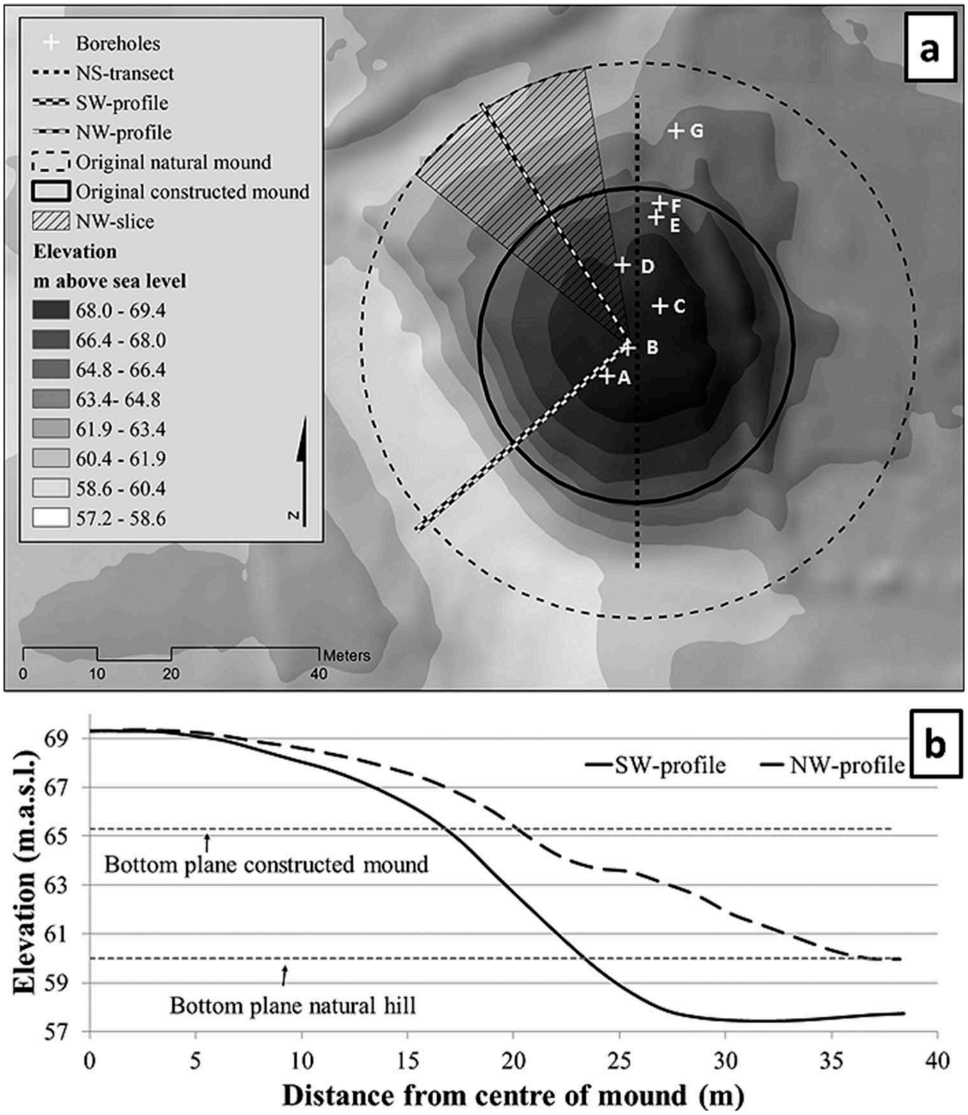

Figure 2. (a) DEM showing the Klangshøj mound and the locations of the borings, transects and profiles; (b) the north-west (intact) and south-west (excavated) profiles with the bottom planes of the natural hill and the constructed mound indicated as short dashed lines.

made in ArcGIS 10.2.2 (ESRI, Redlands, CA, U.S.A.) based on a high resolution LiDAR DEM (160x160-cm raster data, Danmarks Højdemodel, DHM-2007, Styrelsen for Dataforsyning og Effektivisering). To calculate the volume, it is necessary to define a bottom plane, although the mound construction site was not a plane plateau (see old surface in Figure 3). Based on the average (arithmetic) elevation of the old A-horizon below the mound known from the borings, the bottomplane for the constructed mound was set to 65.3 m.a.s.l. This yields an approximate current volume of the constructed mound of 2470 m^3 (Table 1). Assuming that all sides of the original mound had a similar shape as the north-west-facing side (Figure 2(b)), which appears to be the least disturbed part of the mound, a total volume of the original constructed mound would have been 2635 m^3 (Table 1). This suggests that ~165 m^3 (6%) of the original constructed mound was excavated, primarily on the south-west side (see profile in Figure 2(b)). If the same calculation is made for the natural hill underneath the constructed part, assuming this was also shaped like an imperfect truncated cone, the original hill volume is estimated to 14,260 m^3. As the shape of the natural hill underneath the constructed mound was not circular nor particularly flat topped, this is a rather rough estimate. It can be considered a conservative

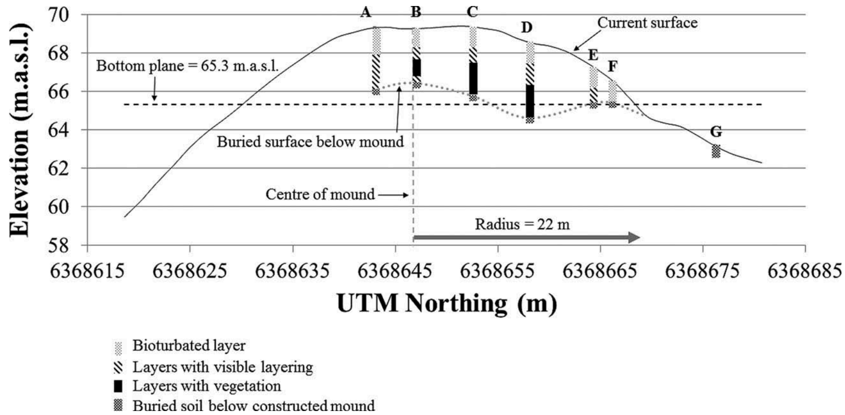

Figure 3. NS-transect with the location of the borings. Note the uneven, buried surface below the mound. The colours of the borings represent the approximate layering as described in the text.

Table 1. Data about the constructed mound and the natural hill underneath. Data about the natural mound are calculated as the difference between the entire mound and constructed mound. The excavated volumes are the difference between the estimated original volumes and the current volumes. Thus, natural erosion/deposition processes are considered negligible.

Side		Average slope[a]
North		34%
East		34%
South		44%
West		56%
Area ratio calculation	**Bottom plane elevation, m.a.s.l.**	**Area, m2 (2D)**
North-west (intact) 'slice' of mound[b]	60.0[c]	439
Entire mound[d]	60.0[c]	4536
Entire mound area:NW-slice area		*10.3*
Current mound volumes	**Bottom plane elevation, m.a.s.l.**	**Volume, m3**
Constructed mound	65.3[e]	2470
Natural hill[f]		11629
Entire hill	60.0	14099
Estimated original mound volumes	**Bottom plane elevation, m.a.s.l.**	**Volume, m3**
Constructed mound[g]	65.3	2635
Natural hill[f]		14260
Entire hill[g]	60.0	16895
Excavated volumes	**Volume, m^3**	**% of original**
Constructed mound	165	6
Natural hill	2631	18

a: (elevation of mound shoulder – elevation of footslope) /horizontal distance from shoulder to footslope
b: calculated with surface volume function in ArcGIS
c: average elevation of the surrounding landscape
d: area = $\pi \times r^2$, r = 38 m (measured in GIS towards NW)
e: position of bottom plane is the average elevation of the buried A-horizon underneath the constructed mound (difference between the borehole surface elevation and surface elevation of buried A-horizon in the boreholes)
f: difference between entire hill and constructed mound
g: [volume of NW-slice] × [Entire mound area:NW-slice area]

volume estimate, as the landscape to the east is higher than 60 m.a.s.l. (see Figure 2(a)), i.e. the original volume was likely bigger than what our truncated cone estimate suggests. Nonetheless, the landscape immediately west of the excavation has an elevation of about 58–60 m, which corresponds relatively well to what was used in the calculation. Therefore, the excavated volume is likely a reasonable estimate, although the volume fraction of the total is less reliable. The calculation suggests that the excavation removed about 2600 m^3 of the natural hill. This likely altered the preservation conditions in the mount as the distance from the surface to the sods with plant remnants became smaller. This caused a degradation of the vegetation remnants and lowered the organic C-contents, as oxygen entered the reduced layers close to the south-west shoulder.

3.2. Interpretation of the bore logs

Table 2 shows the bore logs from the six borings along a south-north tracee crossing the burial mound, Figure 3. All data is assessed in the field based on simple field tests and expert knowledge. A few descriptions have later been modified based on analytical data from the lab. Table 3 shows the pH and the carbon content in the sediments. The soil physical and chemical conditions change along the south-north tracee and hereby the preservation conditions in the mound. In the following, the preservation conditions in the mound are presented and discussed based on the six borings.

Boring A is located towards the south shoulder, i.e. close to the edge of the top plateau towards the south slope that has been steepened by ploughing at the base. The uppermost 130 cm consist of clayey sand with acid pH and 3.5% organic matter. The top 77 cm is classified as the bioturbation zone without sod structure. It is homogeneous and well-drained topsoil material that was moist and greyish brown at the sampling time. In the lower part, faint sod structures were noted and the layer can be considered as a transition horizon towards the more wet layers below, although the layer today must be considered well drained as mottles were not encountered. At

Table 2. Borelogs from the six borings in a south-north transect crossing Klangshøj, Vennebjerg. G is omitted, as it was outside the constructed mound. Texture) The texture is according to the Danish Soil classification system (Breuning-Madsen *et al*. 1992). Moisture) very wet = water logged; wet = wetter than field capacity; moist = field capacity until close to wilting point; dry = water content close to wilting point.

	Depthcm	Texture[a]	Horizon[b]	Layer[c]	Vegetation	Gley	Interpretation[d]	Colour	Moisture
A	0–77	cS	A	HO	0	0	BI	Greyish brown	Moist
	77–130	cS	A	SL	0	0	Sod	Dark greyish brown	Moist to very moist
	130–210	S,cS,C	A	SL/KL	Veg. layer (remnants)	(Gley)	Sod	Dark greyish brown	Very wet to wet
	210–325	S (C)	A/AC	KL/HE	0	0	Sod	Greyish brown	Moist to very moist
	325–357	S	C	HO	0	0	C	Yellowish brown	Moist
B	0–90	cS	A	HO	0	0	BI	Greyish brown	Dry
	90–150	S+cS	A/AC	SL	0	0/Gley	Sod	Greyish brown	Moist with depth very wet
	150–166	cS over C*	A	KL	0	Gley	Sod	Dark grey	Very wet
	166–195	sC+(S)	A	KL	Veg. layer	Anarobe	sod	Dark grey	Wet
	195–219	cS	A	KL	Veg. layer	Anarobe	Sod	Dark grey	Wet
	219–230	S	AC	KL	0	Anarobe	Sod	Dark grey	Very moist
	230–282	cS,sC,C	A	KL	0	Anarobe	Sod	Dark grey	Very moist with depth moist
	282–296	cS	A3C1	HE	0	Gley	A/C	Reddish brown	Moist
	296–305	S	C	HO	0	0	C	Light greyish brown	Moist
C	0–87	S	A	HO	0	0	BI	Greyish brown	Dry
	87–129	S	A	SL	0	0	BI	Greyish brown	Moist
	129–188	cS	A	KL	0	Gley	Sod	Dark grey	Very wet
	188–250	cS+C	A	KL	Veg. layer	Anaerobe	Sod	Dark grey	Very wet
	250–310	S+sC	A	KL	Veg. layer	Anaerobe	Sod	Dark grey	Wet
	310–349	S+cS	A	KL	Veg. layer	Anaerobe	Sod	Dark grey	Moist
	349–366	S	AE	HO	0	0	A	Dark grey	Moist
	366–378	S	E	HO	0	0	C	*Grey*	Moist
D	0–85	S+cS	A	HO	0	0	BI	Greyish brown	Dry
	85–100	S	A/C	HE	0	0	Disturbed sods?	Dark grey	Very moist
	100–134	S+sC	C	KL+SL	0	Anaerobe	Disturbed sods?	Dark grey	Very wet
	134–312	cS+sC+S	A	KL	Veg. layer	Anaerobe	Sod	Dark brownish grey	Very wet with depth wet
	312–381	cS+S	AC	KL	Veg. layer	Anaerobe	Sod	Dark grey	Wet
	381–388	cS	A	KL	0	0	A	Dark grey	Moist
	388–403	S	C	HO	0	0	C	Yellowish brown	Moist
E	0–88	S	A	HO	0	0	BI	Brownish grey	Dry
	88–138	S	A	SL	0	0	BI/Sod?	Greyish brown	Dry
	142–158	S	A	HO	0	Gley	BI/Sod?	Greyish brown	Moist
	171–178	S	C	HO	0	Gley	BI/Sod?	Yellowish brown	Moist
	178–184	S	A1C3	KL	0	Gley	A/C	Yellowish brown	Moist
	184–207	S	C	HO	0	Gley	C	Yellowish brown	Moist
F	0–89	S	A	HO	0	0	BI	Brownish grey	Dry
	89–106	S	AC	SL	0	0	A/C	Brownish grey	Dry
	106–121	S	C	HO	0	0	C	Greyish brown	Dry

a: S = fine sand; cS = clayey fine sand; sC = sandy clay; C = clay
b: A = topsoil material; C = subsoil material
c: HO = homogenic; HE = heterogenic; SL = faint layered; KL = distinct layered
d: BI = bioturbation layer; mound sod; A = (buried) topsoil; C = subsoil

Table 3. Texture (FK), carbon content (%w) and pH ($CaCl_2$) in the bioturbation zone, turfs and the soil below the mound, respectively.

Site	Layer	Depthcm	Carbon %	pH[a] ($CaCl_2$)
A	Bioturbation	20–95	2.0	4.1
A	Sods with vegetation (remnants)	130–210	1.3	4.7
A	C horizon below mound	347–357	0.6	4.1
B	Bioturbation	30–107	1.6	4.1
B	Sods with vegetation	166–219	3.1	4.9
B	Ap/C below mound	282–296	0.8	4.8
C	Bioturbation	18–117	1.5	4.2
C	Sods without vegetation	154–169	0.9	4.6
C	Sods with vegetation	271–310	3.6	4.7
C	A-horizon below mound	349–362	2.7	5.6
C	C-horizon below mound	368–378	0.3	5.5
D	Bioturbation	20–115	1.8	4.1
D	Sods with vegetation	144–262	3.0	4.5
D	Sods with vegetation	262–350	2.6	5.0
D	C-horizon below mound	395–403	0.5	5.9
E	A-horizon	16–142	1.3	4.2
E	C-horizon	171–207	0.5	4.3
F	A-horizon	53–70	1.0	4.5
F	C-horizon	110–121	0.3	4.4

a: Very acid <4.0; acid 4.0–4.9; slightly acid 5.0–5.9; neutral 6.0–7.9

130 to 210-cm depth, a wet to very wet dark greyish brown soil layer with only few mottles had developed. It consists of a mix of faint and distinct sods, of which some had a vegetation layer at various degrees of decomposition. The sod are made op of topsoil material and the texture varies from sand to clay. It is acid and has about 2.2% organic matter, which is low compared with similar layers in the other borings (Table 2). Below the wet soil layer from 210–325 cm the soil material was moist, the vegetation layer on top of the sods were decomposed, part of the soil material did not have sod structure but were heterogenic. Most of the soil material was topsoil (A-material), but a minor part was yellowish subsoil (C-material). The texture varied from sand to clay, it was acid and lower in organic matter than the layer above. Below 325 cm, it was exclusively yellowish brown subsoil showing the thickness of the mound material was 325 cm at this site. The buried C-horizon was acid with about 1% organic matter.

Boring B is located close to the middle of the small plateau on top of the mound. In order to avoid the disturbed soil around the flagpole in the mound centre, the boring was made ~1.5 m away from it. The top 90 cm is classified as the bioturbation zone without any sod structures. It consists of homogeneous greyish brown, well-drained clayey sandy soil material (A) that was dry at the sampling time. It was acid and contained about 2.8% organic matter. From 90–150 cm, faint sod structures are dominating, the top part is well-drained fine sand or clayey sand, but with depth, the abundance of redoximorphic mottles increased, which indicate periodical waterlogging of the sediments. This is also evident from in the moisture content increasing from moist to very wet with depth. Underneath, a thin 16-cm transitions zone is found between the relatively well-drained top part and a very wet layer below. It consists of clayey sand over clay. It has pronounced gley features and distinct sod structures, but no plant remnants are observed on the sod surfaces. From 166 cm and half a metre below, undecomposed plant remnants are observed on the sod surfaces. The layer is dark grey without mottles (anaerobic) and built of topsoil material. The sediments had a texture of mainly sandy clay or clayey sand, acid pH and contained about 5.3% organic matter. A sandy sod layer made of topsoil and subsoil material was observed underneath (219–230 cm). This layer is dark grey and anaerobic but without vegetation layers, indicating periodically aerobic conditions, and it is also relatively dry compared to the layers above and below. From 230 cm depth to the base of the mound at 282 cm, the mound material consists of anaerobic distinct sods made up of dark grey sandy to clayey topsoil material. There were no remnants of the original vegetation on the sod surfaces and it became drier with depth (from very moist to moist). The soil below the mound is a heterogenic mix of topsoil and subsoil with gley features. It consists of reddish brown clayey sand, is acid and contains about 1.4% organic matter. The gley can be seen as the transition from the anaerobic mound material to the well-drained subsoil below that consists of homogeneous light greyish brown sand.

Boring C is located at the top plateau on the north shoulder. The top 87 cm is bioturbated without sod structures. It is homogeneous sandy topsoil material, greyish brown when dry; it is acid and contains about 2.6% organic matter. Below this layer, a transition zone towards the distinct sod-layer is found (87–129 cm). It consists of moist, homogeneous, greyish brown sand that showed increasing tendency to faint sod structures with depth. The uppermost layer with distinct sods consists of gleyey (mottles), clayey sand without

Figure 4. Picture of greenish plant remnants on top of a sod used for building the mound.

vegetation layers on top of the sods, indicating periods with aerobic conditions where decay of the plant remnants has taken place. This is also reflected in the low organic matter content of 1.5%. The layers from 188 cm to the bottom of the burial mound (349 cm below the surface) showed distinct sods with vegetation layers, some of which were greenish in colour (Figure 4). They are all dark grey topsoil material with persistent anaerobic conditions in the top of the layer. The layer becomes dryer with depth, with moisture conditions changing from very wet in the top part to moist at the bottom of the constructed mound. This coincides with changes in texture from clay at the top to sand at the bottom. The layer is acid with 6% organic matter, which is the highest content found in the mound. The soil below the mound comprises a dark grey A-horizon above a grey subsoil. They are only slightly acid with an organic matter content of 4.6% in the A-horizon and 0.5% in the subsoil below (C-horizon).

Boring D is located at the top part of the north slope with a gradient of approximately 10°. This location is where a former well should have existed, according to the local community custom. The bioturbation zone is 85-cm thick greyish brown topsoil, the pH is acid and the organic matter content is about 3.1%. The texture is homogeneous sand or clayey sand. Below, a 15-cm thick heterogeneous, dark grey layer is found, which is a mix of A and C material. The sand in this layer is very moist and might be disturbed sods from a previous excavation, which is also thought to be the case for the layer below. This layer consists of very wet, anaerobic C-material that is a mixture of sand and clay and faint and distinct sods without vegetation layers. From 143 cm to the bottom of the mound at the depth of 381 cm, the mound consists of distinct sods with well-preserved vegetation layers, clearly indicating anaerobic conditions. It comprises a mixture of textures from sandy clay to pure sand; it is mainly topsoil material mixed with some subsoil material in the lower part of the mound that is less wet compared to the top part. The colour is primarily dark grey, although the upper part in some places is brownish grey. The top layer is acid with 5.2% organic matter but with depth it turns into being slightly acid and show a decrease in organic matter content to about 4.5%. Below the mound, a 7-cm thick clayey sandy A-horizon is overlying yellowish brown, sandy subsoil. They are slightly acid, and the subsoil contains 0.9% organic matter.

Boring E is located on the middle part of the north-facing slope with a gradient of approximately 15°. The uppermost 138 cm is brownish grey to greyish brown well-drained sand, with acid pH and 2.2% organic matter. It consists of a homogeneous bioturbation zone upon a similar horizon with faint layering. These may be sod remnants indicating that the layer might be a part of the mound. From 142 cm to the depth of the boring (207 cm below the surface) the soil layers are gleyey, indicating increased wetness and reducing conditions in parts of the year, probably during winter when the precipitation surplus is largest. The layering shifts between greyish brown A and yellowish brown C material, which might represent slope processes where precipitations surplus has washed down upslope soil material, before the mound was constructed. The layers are acid with an organic matter content of 0.9%.

Boring F is located close to the base of the mound and has sandy texture. It has a 100-cm thick brownish grey A-horizon above a greyish brown subsoil. The A horizon consists of mull and there are no signs of sods. Nonetheless, it might be a part of the constructed mound where the sods have been bioturbated. The soil is well drained as there are no gley features, which is typical for a soil with this texture. The layers are acid and the A-horizon contains

Table 4. The results from the archaeobotanical analyses of samples from Klangshøj. The figures are number of observations. Bold numbers marked with an asterisk represents the number of charred plant remains. 100 cm^3 soil samples were analysed.

Species	Popular name (fossil type)	Boring D Depth (cm)370–381	Boring D Depth (cm)180–190	Boring B Depth (cm)170–181
Calluna vulgaris	Heather (twig-fragments)	≈600	≈800, **10***	≈500, **5***
Calluna vulgaris	Heather (flowers)	≈200	≈100, **10***	12, **6***
Calluna vulgaris	Heather (seeds)	≈100	≈200, **5***	9
Dianthus deltoides	Maiden pink (seeds)	1		
Carex pilulifera	Pill sedge (seeds)		2	3
Carex sp.	Sedges (seeds)	6	2	
Cerastium fontanum	Common mouse-ear (seeds)	3		
Epilobium sp.	Willowherb (seeds)		**1***	
Plantago lanceolata	Ribwort Plantain (seeds)			**1***
Poaceae	Grass family (seeds)			1
Potentilla erecta	Tormentil (seeds)	1	7	26
Viola canina	Heath Dog-violet (seeds)		1	8
Viola canina	Heath Dog-violet (capsules)			2
Bryophyta	Mosses (stems and leaves)	≈1000	≈1000	4

about 1.7% organic matter while the subsoil contains about 0.5%.

3.3. Preservation conditions in the mound

Comparing the preservation conditions in the six borings it can be concluded that very good conservation conditions have persisted in the deeper part of the mound on the northern shoulder. Generally, a bioturbation layer slightly less than 1-m deep is underlain by a transition zone towards wet layers with continuously anaerobic conditions. In this transition zone gley (mottles) is abundant, indicating seasonal wetting/drying cycles leading to alternating anaerobic and aerobic conditions. During winter time with precipitation surplus, a perched groundwater table in these layers must be expected, while they will be dry or moist during summer time. Underneath, layers saturated by water throughout most of the year are found. These are greyish or blueish in colour without reddish brown iron-oxide nodules and mottles. The moisture level gradually decreases from *very wet* at the top to *wet* at the bottom. The same pattern was observed in the Jelling mounds (Breuning-Madsen *et al.* 2013), and it can be explained by relatively rapid drainage through the bioturbation layer, and to some degree through the transition layer below. Roots, worms and soil structuring forms vertical macropore systems bypassing the normal percolation through the soil matrix. In the anaerobic layer below, such pores have not developed, i.e. the permeability is low enough to periodically sustain a perched water table. This creates anoxic conditions, allowing the sods to be preserved with undecomposed vegetation layers on some of the surfaces. Hence, brownish and occasionally greenish remnants of mainly heather and mosses are found in these layers (Table 4).

Human activities have altered the preservation conditions in Klangshøj, which is reflected in the very thin anaerobic layers of boring A and B (80 cm and 53 cm, respectively). In boring A, this is primarily due to the steepening of the south slope due to plowing, which leads to a lower permanent groundwater table in the southern part of the mound. The result is that the vegetation on the sod is oxidized and decomposed. The excavation along the west side of the mound might have lead to oxygen penetration even into the central part of the mound. This is the likely explanation why boring B only contained about half a metre of sods with vegetation remnants, although it is close to the centre of the mound. Boring C is the less disturbed boring. Here, we find about 1.6 m of anaerobic sods with well-preserved and occasionally greenish vegetation covers. Even during the sampling in August (absolute minimum groundwater level) the soil was very wet, although no perched groundwater was detected after 3 days. Within 24 h in November, however, enough water had gathered in the borehole to form a perched groundwater. The thickest anaerobic soil layer with plant remnants was found in boring D on the top part of the north slope (~2.5 m). The profile appears disturbed, probably by human activity. For example, below the bioturbation layer a heterogeneous mixture of top and subsoil materials are found. The preservation conditions in boring E and F are poor, as they are mainly aerobic, although gley is common in the deeper layers of boring E (see further discussion about hydrology in section 3.5).

3.4. Archaeobotanical analyses

Due to the very good preservation conditions in parts of the mound, it is possible to determine the flora in the vicinity of the mound at the time of construction. Two archaeobotanical analyses were made on well-preserved samples from boring D and one on a sample from boring B. The results from the analyses are seen in Table 4. The macrofossil analysis shows that the sods were cut in areas where the vegetation was dominated by heather and mosses and other plants typically growing in heathlands. As the sampling was done with an auger with a diameter of 7 cm, each sample only represented a turf surface of *c*. 38 cm^2. An individual sample can therefore be dominated by a single plant which by chance happened to be in this particular surface area. Therefore, the large variation between the samples is expected. The results of the macrofossil analyses is very similar to the results from the analyses of samples from the Jelling mounds (Henriksen *et al.* in press), except the lower number of represented plant species. This is probably due to the drier, sandy soils at Vennebjerg. Also similar to the findings from Jelling, there were charred plant remains in the samples from Klangshøj, shoving that the heathland had been managed by occasional burning of the heather.

The extraordinary preservation conditions in the borings on the top plateau made it possible to collect a vegetation sample for ^{14}C age determination. A heather twig collected from boring C (370–381 cm) was dated to 1060 ± 30 BP (uncal) (Cal CE 897–925 and 943–1024). The calibrated dating is also shown in Figure 5. Thus, Klangshøj at Vennebjerg was constructed in the Viking Age, most probable slightly later than the two Royal Viking mounds at Jelling, although there is a little probability that it is temporary with these.

Although Klangshøj is much smaller (less than half the height and diameter) and is sandier than the Jelling mounds, there are similarities between the two monuments. The mounds have the same shape with a plateau at the top decreasing the possibility for rapid run-off, and they are built using sods probably collected from agricultural set-aside covered by heather vegetation. Furthermore, it seems like Klangshøj is constructed so the clayey sods act like impermeable layers forming the wet layer below the bioturbation zone, as was also the case in the Jelling mounds. The anaerobic conditions in the mound make it possible to estimate the carbon content in the Viking Age soils around Klangshøj and to compare it to similar studies in Denmark (Breuning-Madsen *et al.* 2013). Table 5 shows that the carbon concentration is highest in the well-preserved sods from the Jelling mounds built of loamy material, while the sandy mounds from the Bronze Age showed the lowest carbon concentration. Klangshøj has an intermediate value, which corresponds to the varying textures of the sods ranging from sand to clay. Breuning-Madsen *et al.* (2013) explained the difference in carbon concentration between the Jelling Mounds and the sandy Bronze Age mound to the difference in drainage conditions of the parent material. The loamy soils at Jelling led to imperfect drainage of the soils in the vicinity of the

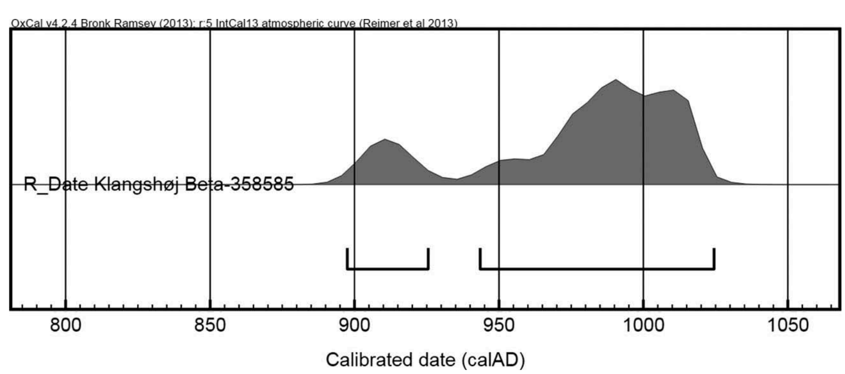

Figure 5. AMS radiocarbon date of plant remnants from Klangshøj calibrated with OxCal v4.2.3 (Bronk Ramsey 2013) and IntCal13 (Reimer *et al*. 2013).

Table 5. The carbon concentration in sandy and loamy burial mounds with anaerobic cores.

Type of mound	Texture[a]	Time	Carbon %
Skelhøj, Lejrskov, Hüsby	S	Bronze Age	1.57 (3)
Klangshøj	S,cS,sC,C	Viking Age	3.05 (8)
Jelling	C	Viking Age	3.74 (29)

a: see Table 2 for abbrivations.

construction site, which inhibit the decomposition of the organic matter, at least during parts of the year. On the contrary, the soils at the Bronze Age construction sites were excessively drained due to the coarse parent material. Following this logic, the intermediate texture of the soils at Vennebjerg would lead to intermediate drainage conditions, which should be reflected in an organic matter content of the sods in Klangshøj in between the sods from the loamy and the sandy mounds. As shown in Table 5, this is the case, i.e. the present study leans support to the hypothesis that the organic matter content of prehistoric soils was primarily determined by the texture of the parent material.

3.5. The hydrology in Klangshøj

The investigation of the presence of a standing groundwater at location C showed that a shallow groundwater was formed after 3 days in August and after 1 day in November. The presence of a perched water table is also demonstrated in Table 2 where some of the soil layers were very wet in August. Thus, it is clearly demonstrated that a perched groundwater has developed below the plateau on the top of Klangshøj. It has no direct connection to the topographic groundwater, which is located several metres below the mound. Although the perched water table might not be permanent, the soils in parts of the mound will still be very wet and anaerobic, for the 1000-year old vegetation to remain greenish and undecomposed. Even a short aerobic period would have resulted in degradation of the chlorophyll in the heather leaves, which would have caused the plant remains turn brown. In periods with precipitation surplus, the water will feed the perched water table that will raise and create a runoff as shown in Figure 6. The vast majority of the runoff will be internal, which creates the gleyey soil layers just above the sod layers with undecomposed vegetation or in the top of the latter. Surface run-off will only happen on the slopes. The percolating water on the plateau will run in all direction following the contour of the layer with vegetation covered sods. When the sod layer disappears, as seen at the outskirts of the mound along the north slope (boring E), the water percolates vertically downwards due to gravity until it meets the primary groundwater. The extensive gley features in the subsoil of boring E is thought to be a consequence of substantial amounts of percolating water running off the edge of the well-preserved sod layer. That internal drainage dominates is further supported by boring F that is well drained without any gley features. Thus, according to the observations in the current study, it seems highly unlikely that water has ever been running out of the mound forming a spring, as the local legend suggests. Neither an inspection at the foot of the mound (boring G) showed signs of wetness or water running out of the mound. In that respect, the hydrology in Klangshøj is the same as found in

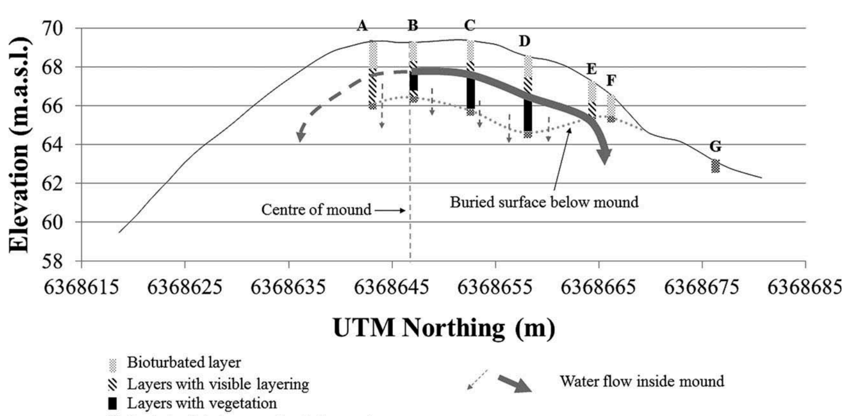

Figure 6. The perched groundwater flow in Klangshøj. The thickness and structure of the arrows indicate the relative magnitudes of the flow.

the two Jelling mounds where all the percolating water is drained internally. The cuts into the mound on the south and west slopes of Klangshøj have changed the hydrology around boring A and maybe also boring B, lowering the perched groundwater table. As mentioned previously, this is reflected in the partly decomposed or missing vegetation on sod surfaces, and the significantly lower carbon content compared to well-preserved sods in other borings (e.g. boring C and D).

The legend about the well that previously existed on Klangshøj is similar to the one on the North Mound in Jelling. The latter existed for centuries, and gave high-quality drinking water to the locals. Calculations have estimated that the well could provide about 50–100 m^3 water from the perched water table, which was only fed by precipitation. As the genesis of this well has been investigated thoroughly (Breuning-Madsen *et al.* 2012), it serves as a good basis for the assessment of whether Klangshøj was ever able to sustain a well. The well on the Jelling mound can be explained by a combination of an intrusion into the mound from the top and the existence of a waterlogged soil horizon at shallow depth. As indicated earlier, Klangshøj fulfils the latter preconditions, as the transition layer between the layers with well-preserved sods the layers above is very wet and semi-viscous (muddy). However, if a well was to be created, a deep intrusion into the centre top-plateau would have to be made to allow water and mud from the water-saturated layer to flow into the intrusion. The mud would settle at the bottom of the intrusion leaving a water phase at the top. The mud should be removed from time to time and a depression will develop around the intrusion as the result of cavitation due to the gradual outflow of material from the waterlogged muddy horizon into the intrusion. Considering the diameter of the plateau is about 12 m, the water inflow will come from the about the 3-m radius around the intrusion, the rest will drain internally towards to edges of the mound, as described above. The 3-m radius gives about 30 m^2 from where the precipitation surplus will run into the well. Anticipate a precipitation surplus of 400 mm per year which is representative for the study area today, the amount of water flowing into the well would be about 12 m^3, which is an amount of little practical significance. According to the legend, however, the well was not located in the middle of the top-plateau but on the north slope close to boring D. As the internal run-off of the precipitation surplus would be almost evenly distributed in all directions, only a very little amount of water will feed a well placed on the slope, i.e. far less than 12 m^3. Furthermore, considering the gradient at the suggested well site a substantial downslope outflow of water would be expected, making the extractable amount even smaller. Thus, the amount of water that could have been collected from the well at the site suggested by the legend would have been negligible and of no practical use. Despite the indication of an intrusion in boring D to a minimum depth of about 135 cm, there is no evidence to suggest the presence of a permanent well on Klangshøj.

4. Conclusion

Klangshøj on Vennebjerg is a flat-topped burial mound similar to the Royal Jelling mounds, although significantly smaller. It is built of sods mainly harvested from heathland, probably located in the vicinity of the mound. The sods are of different grain sizes, mainly fine sand or loamy sand but layers of sandy clay and clay were present in all borings at the top plateau. The preservation conditions were excellent in three of the six borings, and undecomposed plant remnants, occasionally greenish, were observed in three of the borings. A ^{14}C-dating showed that the mound was built in the Viking Age. The hydrology in Klangshøj is the same as in the Jelling mounds, with a permeable bioturbation zone covering almost impermeable, distinct sod layers. This form a perched groundwater table in the transition zone, which keeps the distinct sod layer below anaerobic, i.e. the preservation conditions extremely favourable. The perched water table drains internally as in the Jelling mounds, and there are no current nor fossil (e.g. gley) evidence to suggest a spring was ever present at the foot slope, as the local legend suggests. Moreover, it seems very unlikely that a well, similar to the one on the Jelling mound, has existed on the top of the north-facing slope, as another legend tells. The intrusion (boring D) is rather shallow only to a depth of about 135 cm and the amount of water the well would have been able to collect is negligible, even if it would have been created in the centre of the top-plateau.

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DANISH JOURNAL OF ARCHAEOLOGY, 2016
VOL. 5, NOS. 1–2, 86–88
http://dx.doi.org/10.1080/21662282.2016.1202658

DISCUSSION ARTICLE

Comments on Maria Panum Baastrup's Invitation systems and identification in Late Iron Age southern Scandinavia

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ABSTRACT
The article provides some basic facts and updates on the gold foil figures and also questions certain aspects of Baastrups interpretation. Attention is drawn to the importance of the complex iconographic content ofthe gold foils.

KEYWORDS
Gold foil figures; amulets; die (patrix); central place; iconography

As a so-called 'expert' on the narrow topic of gold foil figures (guldgubber), it is always stimulating to come across novel interpretations – in this case the possible use of these small and fragile objects as tokens of invitation and/or identification. Baastrup's article reminds us how difficult it can be to imagine a time when a relatively small number of people would recognise the 'chieftain' or the 'king', if they saw him, and – no less important – how the chieftain or king could distinguish friend from foe. My comments include some basic correction or expansion on facts, but should first and foremost be viewed as further 'food for thought' and reminders of some aspects that have a bearing on the interpretation.

Baastrup correctly points to the extreme fragility of many of the gold foil figures which makes a use as 'coinage' highly unlikely. However, it should be added that a few foils (both male and female figures) have been mounted (strengthened) with a backing of thicker gold or bronze sheet with a loop attached. Distinct traces of wear along the edges confirm their occasional use as pendants. This could point to a function as 'identification' tokens or 'signs of honour' worn for all to see or maybe as amulets.

A large number of foils particularly from Sorte Muld had been 'spent'(?) and subsequently deliberately folded and even hammered (for melting/re-use?) – a fact that does not necessarily contradict Baastrup's hypothesis. As she also points out – a token of this kind could very easily change hands without the person who issued the 'invitation' being aware – let alone in control – of this. If the gold foils, on the other hand, had been used in the same way as later 'pilgrim's badges', I suspect that the spatial distribution would have been different (less concentrated on central sites).

Baastrup touches on the production, and although I agree that the manufacture of a small detailed die (patrix) by the *cire perdue*-technique requires skill, many dies are best described as amateurish in quality and could have been produced by any reasonably able bronze caster. The map of die-links (Figure 1) suggests that 'sharing' (i.e. transport) of the most detailed and popular dies appears to have taken place between allied chieftains (central places), for example, between Sorte Muld and Uppåkra.

At Sorte Muld alone there are 440 different dies (out of a Scandinavian total of *c.* 750). Most dies are represented by only one or two gold foils while occasional figures are known in more than 100 die-identical copies. Nearly 100 pieces with a wide distribution within southern Scandinavia have been fashioned individually – most of them crudely cut out or scratched on a thicker gold sheet (Figure 2(a)). These were very likely 'home-made' – and as such do not fit into a use as 'officially issued' tokens of identification or invitation.

A small correction (p. 9) may be relevant for Baastrup's discussion, as the latest count shows

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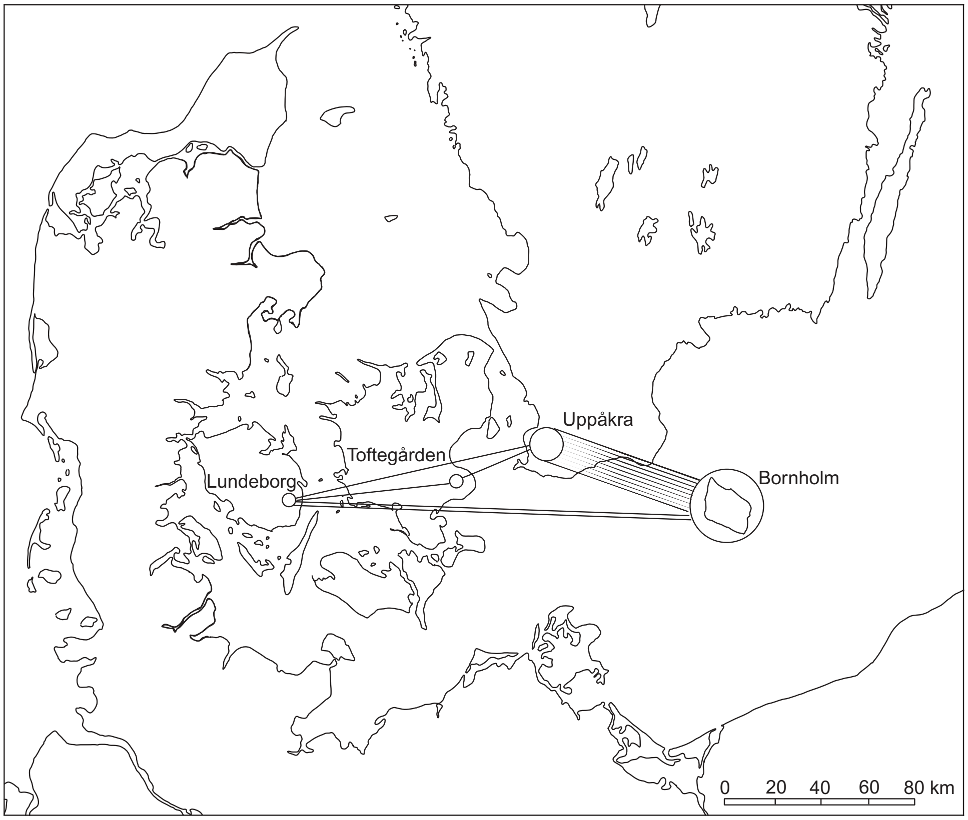

Figure 1. Die-links in southern Scandinavia. Drawing: M. Watt.

Figure 2. (a) Crudely cut-out gold foil figure (with added neck ring) from Sorte Muld, Bornholm; (b) lower half of a die (*patrix*) with secondary use as a weight from Neble, Sjælland; (c) gold foil with scratched female figure (Bornholm with no further provenance); (d) stamped foil with the same motif as c. Photo: Nationalmuseet, Copenhagen (a), Bornholms Museum (d). Drawings: M: Watt.

that 10 dies (out of a total of 20) are found in places where gold foil figures have also been recorded. Of these three dies are from the Sorte Muld area. One of the dies from the Neble-area incidentally has had a secondary use as a weight (Figure 2(b)). To find the often worn and corroded dies, we are first and foremost dependent on skilled and knowledgeable detectorists.

Baastrup barely touches on the iconographic content of the gold foils. Some dies are very detailed with an apparent 'message' meant to be understood by the initiated with a clear link to Late Antique iconography;

on others the motif is barely recognisable (Watt 2015a, 2015b). A small number of single figures (mostly from one locality) are naked and some of them sexually loaded(?) (Figure 2(c,d)). The naked figures seem particularly difficult to place within Baastrup's theory, unless they were invitations to a sexual orgy (no sarcasm intended). How do the figure-foils with two persons (man–woman pairs) fit the picture, with their dissimilar iconographic content and different spatial distribution from the single-figure foils? What about the animals? Several animal-foils depict a boar. Do they perhaps represent the 'consecrated (i.e. sacrificial) boar' mentioned in the Frankish (Merovingian) law texts, *Lex Salica* (II, 17)?

Disentangling the iconographic diversity and possible symbolism of the gold foil figures is complex and touches on themes ranging from the dress code of Late Antiquity and Early Christian iconography and from legal to 'pagan' gesture language etc. – all fascinating but well beyond the scope of a short discussion.

It is now nearly 300 years since the first scientific study of gold foil figures appeared (von Melle 1725), and it is amazing how these tiny images can still provoke new ideas.

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DANISH JOURNAL OF ARCHAEOLOGY, 2016
VOL. 5, NOS. 1–2, 89–90
http://dx.doi.org/10.1080/21662282.2016.1240286

DISCUSSION ARTICLE

Comments on Maria Panum Baastrup's: invitation systems and identification in Late Iron Age southern Scandinavia? The gold foil figures from a new perspective

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ABSTRACT
This commentary points out the importance of looking at apparently well-known archaeological material from new angles and highlights Maria Panum Baastrup's work of putting gold foil figures into a functional context as an inspiring example.

ARTICLE HISTORY
Received 29 August 2016
Accepted 21 September 2016

KEYWORDS
Gold foil figures; invitation systems; identification

Archaeology is not an exact science. But archaeology can clarify contexts and develop arguments where context is interpreted on the basis of empirical data and theory. And that is exactly what Maria Panum Baastrup does in her article, 'Invitation systems and identification in Late Iron Age southern Scandinavia? The gold foil figures from a new perspective.'

Gold foil figures, small and mostly rectangular plates or figurines of very thin sheets of gold, have been studied for several years and are an abundant source material with more than two thousand examples alone from the area around Sorte Muld on Bornholm (Watt 1999, p. 134). The research has been firmly grounded in empirical data while theories have been primarily driven by iconographical studies (such as Ratke 2010, Mannering 2012, Hedeager 2015). But it is as if the interpretation of the gold foil figures' both microscopic and complex imagery has, in several respects, overshadowed the interpretation of the function of the object. Therefore, the major strength of Baastrup's article is the new perspective, which she brings. Function is placed ahead of motif thereby making her reflections an inspiration not only for when working with gold foil figures, but also for any work involving antiquity's many other objects, which have a specific form, but also a form whose function we do not recognize and whose use, therefore, we cannot clearly contextualize (Lyngstrøm 2006, p. 56f). Once the perspective changes, the contexts of the source material can also be expanded.

Gold foil figures are almost exclusively found at late Iron Age assembly sites – not in the graves, not on ordinary farms and not around the countryside. Their function must, therefore, have had a clear relation to the assembly site and to the actions, which took place therein. But gold foil figures are tiny, weighing about 0.1 g and are too delicate to withstand regular handling. Moreover, in a society in which the higher echelons had massive gold rings weighing several hundred grams, the precious metal value of the gold foil figures cannot have been high in an economic sense. And neither were they jewellery. Only a very small portion of them are reinforced with a plate and eyelet and only few are worn around the edges (Watt 1999, p. 140 & Abb. 12,9d). On the face of it, gold foil figures do not seem to have had a practical function and, therefore, their archaeology has been to perceive them as small offerings – somewhat like lit candles in front of icons and statues of saints in today's churches.

But Baastrup, who has previously achieved significant results through her work on network analysis based on imported finds of the Viking Age (Baastrup 2009), has shifted the focus from the motifs of the gold foil figures to their function, and she argues convincingly that this was a primarily social function within intellectual network of the late Iron Age. She draws this idea from examples such as the terracotta tokens that served as invitations or entry tickets for rituals and celebrations in the Temple of Bel in Palmyria, Syria (Baastrup 2016, Fig. 3a-b). An analogy that is not based on it being a tradition that has spread but rather

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on an assumption that the need for identification and control of access is universal and that that is crucial in relation to forming an understanding of the activities, which occurred at those late Iron Age assembly sites, where spatial organization through architecture and fences clearly shows that concepts such as control and regulation were emphasized.

Following Baastrup's argument, the production and subsequent distribution of gold foil figures are key, because as a potential form of 'bearer-identity' control also becomes a keyword. The interpretation presupposes a supervised production and distribution, because once you possess a gold foil figure, it gives access to the innermost social circles of the assembly sites. If we assume that the required amount gold was more or less easily accessible to the elite workshops, then it is the die which is of significance. It is that and the use of that, which was to be supervised as long as its motif was valid. When the gathering was held, the motif may have lost validity, and perhaps it is this non-validity that we are seeing in the bent or cut gold foil figures of the assembly sites (Ratke 2010, Fig. 25).

The fact that gold foil figures are different in relation to how their motifs are constructed and how their gold plates are cut in relation to the motif must be brought in here. For even if there are large groups of relatively similar and apparently systematically produced gold foil figures, there are also several, which have a different motif and one of a more sketchy quality (Watt 1999, Abb 12,8 & 9b, Baastrup 2016, Fig. 6). Here the artist has not applied a die, but has incised the motif or cut it out. His knowledge may have been greater than his ability. For although the artist – unlike us – may have known the function of the object he was making, in principle, he has not been able to produce an infinite number of identical identification tags. Maybe he is imitating the phenomenon from the possibilities available to him. Baastrup also points out, quite correctly, that not all gold foil figures necessarily have to have had the same function.

The production of gold foil figures required access to and control of material, tools, and skills. The use of gold foil figures required a knowledge and acceptance of the underlying mechanisms. Baastrup makes it clear that knowledge was known in the intellectual network within the late Iron Age. And it is that network, which she helps us to see the contours of the relationship between the era's most powerful women and men. Maybe they did not speak the same language or know each other's faces when they met and identified themselves at Sorte Muld, Toftegård, Uppåkra, and Lundeborg. Therefore, the gold foil figures were essential.

Baastrup's ideas are an inspiring contribution to the very important discussion of the intellectual network of the late Iron Age. And as she herself – with the title's question mark – stresses: the results of her argument are neither true nor false. But she makes convincingly clear that in the late Iron Age's environments means to identify and legitimize themselves in certain contexts where necessary. Thus, the science of archaeology has gained a brand new tool for its toolbox for when we try to put the gold foil figures into a functional context in the future.

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