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RESEARCH ARTICLE

Wiggle-match dating the fortification of Køge

Aoife Daly [a,b] and Karen Bork-Pedersen [c]

[a]Dendro.dk, Copenhagen, Denmark; [b]Saxo Institute, University of Copenhagen, Copenhagen, Denmark; [c]Cultural heritage, Museum Southeast Denmark, Vordingborg, Denmark

ABSTRACT

During archaeological fieldwork in the eastern part of the coastal city of Køge, situated on the east coast of the island of *Zealand* (Sjælland) in *Denmark*, remains of a rampart were found and, due to the lack of suitable material for dating via the more traditional dendrochronology, wiggle-match dating was conducted. This article aims at presenting the method used and discussing the result it provides for medieval and renaissance archaeology, in situations where there is an absence of dateable dendro-samples or for dating of non-oak samples.

Having unearthed the rampart remains, a major objective of the excavation became answering the question: Are the ramparts found those that were built during the short Swedish occupation of the town in 1658? And, could the C14 dating method provide us with a sufficient level of precision to answer this question? The results show that the ramparts found belonged to the medieval fortification of the town and have a long history of renewal and repair, allowing us to map the long life of the town despite the limitations of the small 'key-hole' style excavations. Applying this method more extensively on small-wood remains will perhaps help us to finally identify that elusive Swedish fortification.

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Wiggle-match dating; fortification; medieval; renaissance; Køge

Introduction

At the time of writing, a large-scale development project is taking place in the eastern part of the coastal city of Køge. The project is referred to as *Køge Kyst*, and it is a partnership between *The Municipality of Køge* and *Realdania By og Byg*, aiming to develop the central harbour area into a cluster of residential, cultural and commercial premises (http://koegekyst.dk/).

Prior to and during the many and vast building projects, the Museum Southeast Denmark (Museum Sydøstdanmark) has conducted a series of excavations in the area as required by Danish legislation (The Museum act no. 1505). Amongst the central finds were rampart remains that probably had several functions including legal and military boundary for the town in the medieval and renaissance period as well as serving as a dyke to prevent the low-lying town from being flooded. The locations of the excavations are dictated by the (projected) building works, and take the form, for the most part, of small trenches in classic urban rescue 'keyhole' archaeology. In other words, it is not possible to fully excavate the structures that are exposed; but rather, we must try to interpret the structures from these patchy discoveries.

Køge and its fortifications

Køge is situated on the northern bank of the stream Køge Å only a short distance from its mouth in the bay Køge Bugt (Figure 1). In the medieval period, the coastal town of Køge held an important strategic position amongst the cities in the eastern part of Zealand. The town was founded by the king by relocating the old village of Køge further up-stream probably sometime in 13th century and given the same privileges as Roskilde by King Erik Menved in AD 1288. Besides serving as a port for the export of grain, it probably also served as a counterweight to the towns of *Roskilde* and *Copenhagen* owned by the powerful bishop of Roskilde (Johansen 1986, p. 28).

The fortification of Køge is not mentioned in any preserved written sources until AD 1440

CONTACT Aoife Daly aoife.daly@hum.ku.dk Saxo Institute, University of Copenhagen, Karen Blixens vej 4, 2300 Copenhagen S, Denmark
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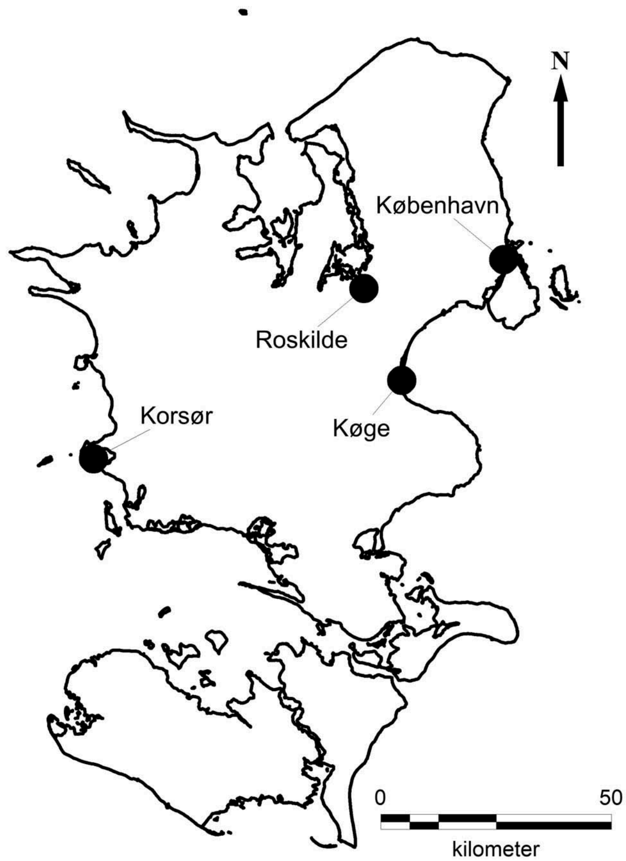

Figure 1. Map of the Island of Zealand showing the locations mentioned in the text (map: Karen Bork-Pedersen).

but must have been in place sometime prior to this mentioning (Johansen 1986, p. 35). The oldest fortification appears to have consisted of a small rampart with a palisade on top and a moat on the outside. The rampart and moat surrounded the eastern, western and northern parts of the town. To the south, the stream of Køge formed a natural boundary albeit without the fortification properties, giving the impression that the medieval fortification served more of a legal purpose rather than a military. From AD 1440 and onwards, the fortification is mentioned a number of times in different documents, often emphasising that the citizens are required to maintain the moat and fence/palisade, leaving the impression that these duties were perhaps sometimes neglected (Johansen 1986, pp. 33–35). However, such a requirement was not unusual for the citizens of a fortified town.

Upon the death of *King Frederic I* in AD 1533, a disagreement about his successor led to a civil war, known as *The Count's Feud*. Shortly after the King's death, the local nobility decided to demolish the ramparts, preventing the city to be used as a platform for attacking Copenhagen, some 45 km away. An attempt to rebuild and restore the rampart had been initiated by *Christopher, Count of Oldenburg,* during his short stay and occupation of the city in AD 1534 on behalf of *King Christian II*. In AD 1536, *King Christian III* faced no problems taking the city (Johansen 1986, p. 77).

By the end of the 16th century, written sources tell us that the fortification decayed; the ramparts were leased to the citizens for gardening and the moat turned into fishponds (Johansen 1986, p. 35, Frandsen and Nielsen 1976, p. 61–62).

The Swedish fortification?

In AD 1657, the Danish King Frederic III declared war upon Sweden. The signing of a peace treaty (in Roskilde) in February AD 1658, known today as '*The Treaty of Roskilde*' only brought a brief peace as, no sooner than August that same year, the treaty was broken by the Swedish *King Charles X* who went ashore in Korsør situated on the west coast on Zealand, advancing towards Copenhagen. During this advancement, the Swedes conquered and occupied Køge and subsequently set out to fortify the town (Johansen 1986, p. 78).

Their plans are well-known as we have the map of *Erik Jönsson Dahlberg* (1625–1703), a Swedish commoner made nobleman and holding many titles such as count, field marshal, soldier and engineer, depicting not only the town with the planned fortification AD 1659–1660 but also, importantly, showing the remains of the medieval moat (Figure 2).

The swedes only held the town until Charles X died 4 January 1660 after which peasants were deployed to destroy the rampart. Today, there are no visible remains of the Swedish occupation in Køge (Johansen 1986, p. 80).

How much of the fortification was actually built? According to an eyewitness, Axel Juul, the work was almost completed despite the short

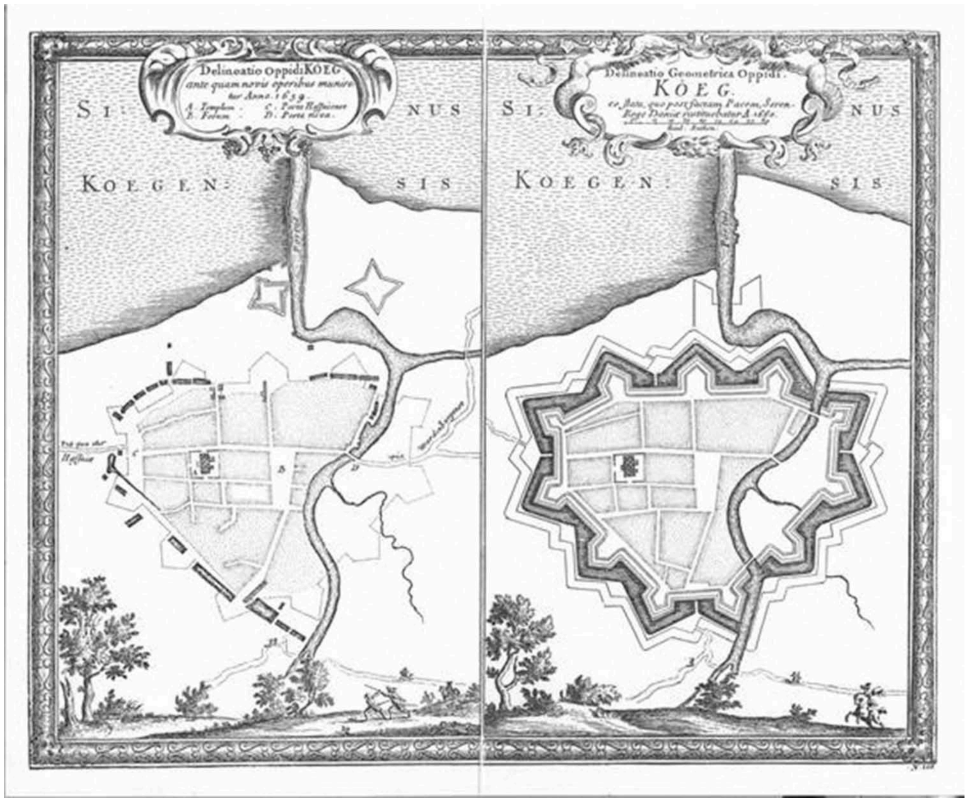

Figure 2. Map of Køge 1659–1660 by the Swedish field marshal Erik Dahlberg. To the left, the map shows Køge as it appeared when the swedes took the town; and to the right, the Swedish plans for fortifying the town (by permission, Køge Arkiverne).

duration of the Swedish occupation and he describes a fortification that fits very well with the design on Dahlbergs map as he writes that Køge is now '*regulær befæstet med sine courtiner og Volde og 11 Bolværker hvoraf Havnen og Indsejlingen synes smukt at kunne defenders; dog behøver Volden vel nogle steder at fortykkes og Brystværnene at forhøjes, og I Synderlighed Gravene omkring Fæstningen, hvilke ikke nær færdige er, at ville endelige fordybes fluks mere og jævnes, saa og Contrescarpen smukt at forfærdiges, saa synes det kunne vorde en fornem Fæstning*' (Frandsen and Nielsen 1973–1975, Nordentoft 1941). (Køge is now properly defended with its curtain wall and ramparts and 11 bulwarks of which the harbour and the seaward approach can be beautifully defended; though the fortification needs in some places to be strengthened and the ramparts raised, and in truth the moats around the fortification, which are nowhere near finished, should be promptly deepened and levelled, so that the escarpment is complete, then it could become a great fortress (authors' translation)) Apparently, the citizens of Roskilde, *Næstved, Ringsted* and *Store Heddinge* were commanded to take part in the construction of the fortification, and the buildings in the north-eastern part of the city were allegedly demolished and the materials used to build the fortification (Johansen 1985, p. 69) (Figure 1). In AD 1660, a map drawn by or under the command of the Swedish Commander Stahl (Jakob Staël von Holstein 1628–1679) shows the plan of the city and the fortification (Figure 3). In all likelihood, the Swedish fortification had a short life. On a later map by the Danish Oceanographer Jens Sørensen (1646–1723), only the bastions to the south are still visible, having apparently avoided demolition (Figure 4). Nothing is left visible today.

The archaeological surveys from the 1970s and up until today

In the 1970s, a series of archaeological excavations sought to confirm, or disprove, the fortification shown on the maps of Dahlberg by placing

Figure 3. Map of Køge from 1660, drawn or commissioned by the Swedish Jakob Stahl (by permission, Køge Arkiverne).

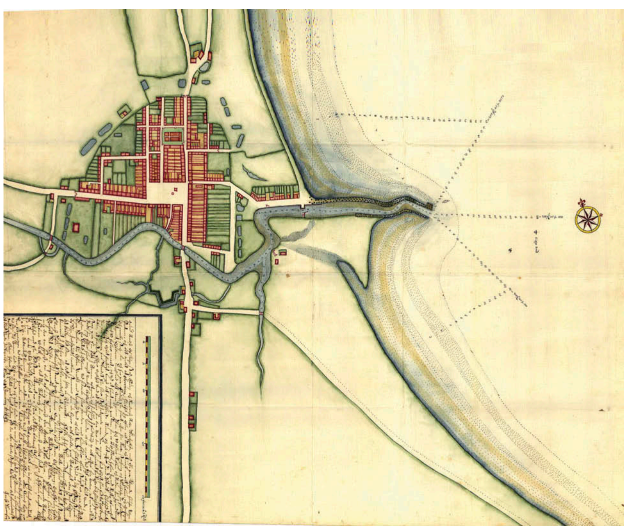

Figure 4. Map of Køge from 1693, drawn by Danish Oceanographer Jens Sørensen (by permission, Køge Arkiverne).

trenches according to the maps. The excavations took place in the western part of Køge in *Lovparken* and in the eastern part at the parking lot, *Bag Haverne*. Both excavations confirmed the existence of a rampart and a moat. Several construction phases were hypothesised, based on the different strata in the rampart, though lack of finds made it difficult to validate this interpretation. At Bag Haverne, C14 dating was conducted on a piece of wood (K-3162 380BP +- 50) found beneath peat tiles covering the rampart, dating the rampart to, to quote: '1475 e.Kr. Kal.' (Tauber 1979). These were in the early years of calibrating the radiocarbon timescale, and ranges were not quoted. However, using modern calibrating methods, this date re-calibrates to AD 1431–1645 (OxCal v4.2.4, accessed 18 April 2018 (Bronk Ramsey and Lee 2013) using IntCal13 (Reimer *et al.* 2013)). This is, unfortunately, a very wide calibrated age range when dealing with the historic period, leaving many questions unanswered.

Between 2012 and 2015, the Køge Kyst project has led to several archaeological surveys of which four have encountered remains of a fortification (Figure 5). *KNV80 Iver Huitfeldts Vej* was the first excavation, conducted in 2012–2013. The excavation took place in the north-eastern part of Køge, along the railway track and was conducted mainly as a watching brief in the trench alongside the construction of a large water pipe. West of this excavation, another, *KNV96 Jernbanegade*, took place in 2015, and in 2014 the parking lot *Bag Haverne* to the southeast of the town, was once again the centre of an archaeological excavation: *KNV123 Bag Haverne*, as the waterpipe from Iver Huitfeldts Vej continued here. In 2015, another excavation in connection with the construction of a new sewer pipe, *KNV306 Strædet* also provided evidence of a rampart and a moat (Figure 5). This article draws on the results of the excavation and dating analyses otherwise produced as unpublished reports (Bork-Pedersen 2015, Daly 2015a, Daly 2015b, Færch-Jensen 2017 & Rasmussen 1979).

The surveys in the 1970s were conducted as research excavations enabling the archaeologist to decide the size and location of the trench. The recent excavations, as mentioned earlier, took place alongside and prior to construction work, often resulting in a longitudinal trench within and/or along the rampart rather than across the rampart – the construction work dictated where to dig next.

The recent excavations, like the 1970s excavations, have uncovered the lower part of a sand-built rampart in several places and possibly a moat in at least one place. Nowhere do the remains of the rampart exceed 1.2 m in height but it might of course have been higher. The top sandy layers consisted of debris, probably from the destruction of the rampart and from erosion whilst exposed to wind and possible flooding. The rampart was built of multiple layers of sand with peat applied to keep the sand in place and subsequently held in

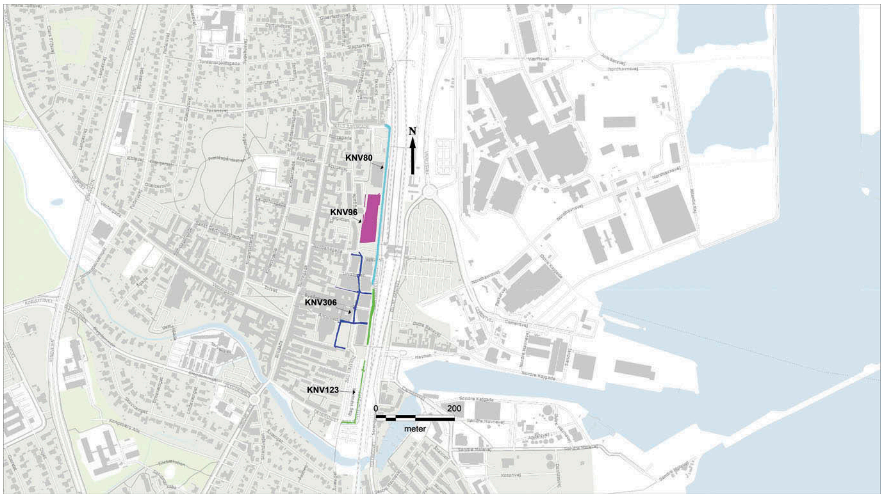

Figure 5. Map of the four surveys © TStyrelsen for Dataforsyning og Effektivisering (Map: Karen Bork-Pedersen).

Figure 6. Facing north, cross-section of the rampart found at KNV00080, with the wattle fence in front (photo: Karen Bork-Pedersen).

place by a wattle fence on the front side (Figure 6). In a few places, willow logs were laid out horizontally beneath the rampart; probably to stabilise the ground beneath the structure. The peat has been determined as heather-peat by Annine Moltsen from NOK, Natur og Kultur (Moltsen 2015). The provenance of the peat has not been determined but it is likely to derive from a bog nearby.

The most coherent structures of the fortification were found in the north-eastern part of Køge, whilst the finds in the south-eastern part are more dubious regarding whether they can be linked to the fortification. It should, however, be noted that the post-processing of the southern excavation is currently in the early stages. The processing of that excavation in combination with forthcoming archaeological work may shed further light on the construction of the fortification. At KNV80 Iver Huitfeldts Vej, the rampart was identified in two places, approximately 87 m apart; to the north over a course of 34 m and to the south over a course of 6 m. To the north, a wattle fence supporting the outer foot of the rampart (facing east), was found. Approximately, 20 m west of the wattle fence, a fence of more substantial posts facing the town (west) and supporting the inside foot of a rampart was found during the KNV96 Jernbanegade excavation. The trajectories of the two fences (Figure 7) are almost exactly parallel, which initially led to the assumption that these were contemporary but the datings suggests otherwise and we shall return to this later.

Lack of material for conventional dating

Very few artefacts were retrieved from the rampart; most of them came from the upper layers, themselves questionable as to whether they were indeed functional parts of the rampart or disturbed/demolition layers/debris. Within the certain construction layers, the finds were scarce, and the few artefacts only provided a wide date range. Taking into consideration the massive relocation of deposits, the artefacts retrieved are considered discarded and redeposited material, contributing only a *terminus post quem* for the deposit(s). However, two ceramic sherds are attributed to a primary deposit: a handle from

Figure 7. Map of KNV80 and KNV96 © Styrelsen for Dataforsyning og Effektivisering (map: Jeppe Færch-Jensen).

a redware tripod, and a sherd from a green-glazed plate, X6 (Figure 8). The latter was retrieved from between the peat tiles beneath the small yew posts in the wattle fence and was most likely deposited during the construction of the peat coating. This was the only artefact directly linked to the construction of the rampart. The sherd was from an earthenware plate or dish made of very bright clay with a grass-green glaze on both sides covering a slip-coating on the inside and with a suspension hole. Presented with the sherd, Dr. Jette Linaa has suggested that it may have been manufactured in Poland or Niedersachsen no earlier than AD 1650 (Linaa pers comm).

One oak post, (L233/P17), within or at the outer foot of the rampart, was dendrochronologically dated to after AD 1523. Since written sources suggest that the timber from the buildings demolished in the eastern part of the city were used for the construction of the fortification, the date of this post possesses an inherent conflict as it could just as well originate from earlier buildings in the area (Nordentoft 1941).

The horizontally placed willow log used as a stabiliser beneath the rampart was not suitable for dendrochronological dating and as this log contained only 14 rings, it was not ideal for attempting wiggle-match dating either. A few

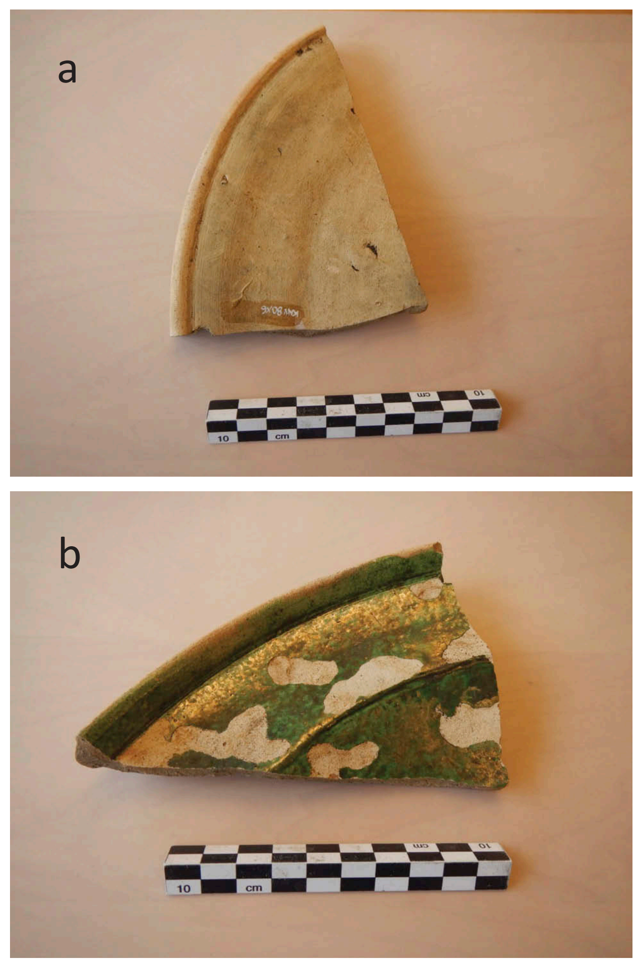

Figure 8. The green-glazed sherd, X6, found between the peat tiles (photos: Karen Bork-Pedersen).

other successful dendrochronological dates were produced for timbers that could not be linked to the fortification, even though some may derive from it. The objective was primarily to establish which activities in the area belonged to modern disturbances, and which were of archaeological interest. The dendrochronological results showed activities in the proximity of the fortification from the second half of the 15th century and well into the second half of the 16th century. These finds from KNV80 Iver Huitfeldts Vej includes a - 20 × 20 cm square oak post (L220/P18) from a row of five (AD 1461–1476), a post (L161) (winter AD 1537–38), and a barrel (A1/P4), made of beech, (after AD 1564) (Daly 2014b)).

The wiggle-match dating

Owing to the lack of sources for dendrochronological dating, an alternative to the more common dating practices in Danish archaeology was attempted. Several of the small posts contained, despite their size, as many as 70 tree-rings, and whilst having too few for a reliable dendrochronological dating and being of a genus that is not widely subject of dendrochronological analysis, their potential for dating the structure would be essential to the interpretation of the find. One post from each of the three excavations, KNV80, KNV96 and KNV123, were, therefore, selected for wiggle-match dating. The selected posts did not fall into the category of recycled timber and all had the bark edge preserved. (The full list of C14 samples is given in Table 1.)

The technique of wiggle-match C14-dating of tree-ring series is described and carried out widely (e.g. Bronk Ramsey *et al.* 2001; Galimberti *et al.* 2004, Lorentzen *et al.* 2014, Daly 2014a). The method involves extracting sub-samples from single tree-rings in a timber at known intervals along the tree's growth. When the exact time span between the resulting series of C14 dates is known, calibration of the group of C14 results is carried out together, taking the known exact distance (i.e. the number of tree-rings) between the separate sub-samples into account. For two posts, six sub-samples were extracted at various intervals (Figure 9). As the tree-rings were very narrow in both cases, wide rather than narrow rings along the tree-growth were selected in order to attain enough material for Accelerator mass spectrometry (AMS) dating, whilst at the same time avoiding contaminating the sample with material from adjacent rings. From the third sample, only two sub-samples were taken for analysis: from the innermost and outermost rings. The rings were very clear on the samples, and all sub-sampling was done under a stereo microscope, so there was no doubt as to how many rings were present between sub-samples.

As with the calibration of single sample C14 dating, the width of the calibrated dating range depends on where on the calibration curve the dating falls. Some parts of the curve are steep, allowing a narrow calibrated dating range. But if the dating falls at places where the calibration curve is flatter, a wide calibrated dating range is the result. Taking samples at known intervals along the tree-rings of a wooden post, for wiggle match dating, (using the D Sequence function of OxCal (Bronk Ramsey et al. 2001)), attempts to reduce the effect of the fluctuations in the calibration curve, producing a narrower dating range for the post and, thus, for when it was felled to be used in the structure.

To the south, at the parking lot Bag Haverne, a small post (L1258/P28) was wiggle-match dated. The post was initially linked to a feature interpreted as belonging to the front of the rampart, but further analysis and post-processing needs to be done in order to confirm or reject this. Nevertheless, we have chosen to include the result for this post in this article because with the appearance of yew post fences in different locations it was important to see if these were from the same construction activity. This yew post contained 78 tree-rings and six sub-samples were taken at intervals along the tree's growth, from outer to inner tree-rings. The outermost sub-sample was taken from a ring two rings under the bark edge. Calibration of this sample alone gave a dating range AD 1436–1478 (95.4% probability). The modelled (wiggle-matched) dating for this tree-ring is a little narrower, at AD 1450–1461 (again 95.4% probability) and if we add the two rings to bark the formation of the last ring before this post was felled, can be placed at c. AD 1452–1463 ((95.4% probability) (Figure 10).

Table 1. The table lists all C14 dated samples including the laboratory numbers and the original, uncalibrated results.

Site name	Submitter Number	Genus & no. of rings	Sample size (mg)	Comments	Beta Analytic no.	Pretreatment	δ13C (‰)	Conventional radiocarbon age	2 sigma calibration
Bag Haverne	KNV00123 P28.6	*Taxus baccata*, yew, 78 rings, bark	20	Rings 5&6	409251	Acid/alkali/acid/ cellulose extraction	−21.4	641 ± 19 BP	Cal AD 1288 to 1319 and CAL AD 1351 to 1390
	KNV00123 P28.5		c. 50	Ring 20	409252	Acid/alkali/acid/ cellulose extraction	−22.0	569 ± 19 BP	Cal AD 1317 to 1353 and Cal AD 1390 to 1413
	KNV00123 P28.4		c. 50	Ring 33	409253	Acid/alkali/acid/ cellulose extraction	−21.4	497 ± 18 BP	Cal AD 1413 to 1439
	KNV00123 P28.3		26.8	Ring 47	409254	Acid/alkali/acid/ cellulose extraction	−20.1	490 ± 18 BP	Cal AD 1415 to 1441
	KNV00123 P28.2		13.1	Ring 64	409255	Acid/alkali/acid/ cellulose extraction	−20.4	457 ± 18 BP	Cal AD 1429 to 1449
	KNV00123 P28.1		14.6	Ring 76. Two rings to bark	409256	Acid/alkali/acid/ cellulose extraction	−19.5	424 ± 18 BP	Cal AD 1440 to 1466
Ivar Huitfeldtsvej	KNV00080 P11.6	*Taxus baccata*, yew, 49 rings, bark	17.6	Rings 1&2	409257	Acid/alkali/acid/ cellulose extraction	−21.8	313 ± 18 BP	Cal AD 1500 to 1503 and Cal AD 1513 to 1601 and Cal AD 1616 to 1644
	KNV00080 P11.5		23.2	Ring 14	409258	Acid/alkali/acid/ cellulose extraction	−19.6	330 ± 18 BP	Cal AD 1486 to 1641
	KNV00080 P11.4		c. 50	Ring 23	409259	Acid/alkali/acid/ cellulose extraction	−20.1	306 ± 18 BP	Cal AD 1517 to 1594 and Cal AD 1618 to 1646
	KNV00080 P11.3		c. 50	Ring 33	409260	Acid/alkali/acid/ cellulose extraction	−21.7	356 ± 18 BP	Cal AD 1462 to 1525 and Cal AD 1556 to 1632
	KNV00080 P11.2		c. 50	Ring 43	409261	Acid/alkali/acid/ cellulose extraction	−20.3	336 ± 18 BP	Cal AD 1480 to 1640
	KNV00080 P11.1		c. 50	Ring 49 just under the bark	409262	Acid/alkali/acid/ cellulose extraction	−19.8	304 ± 18 BP	Cal AD 1518 to 1593 and Cal AD 1618 to 1646
Jernbanegade	KNV00096 P7	*Fagus sp*., beech, c. 40 rings, bark	225.5	Ring under bark	423358	Acid/alkali/acid/ cellulose extraction	−22.6	506 ± 24 BP	Cal AD 1407 to 1440
	KNV00096 P1	*Alnus sp*., alder, 18 rings, bark	288.6	Ring under bark	423359	Acid/alkali/acid/ cellulose extraction	−25.7	529 ± 24 BP	Cal AD 1331 to 1337 and Cal AD 1398 to 1433
	KNV00096 P3B	*Fagus sp*., beech, 55 rings, bark	263.2	Outermost ring	423360	Acid/alkali/acid/ cellulose extraction	−25.5	596 ± 24 BP	Cal AD 1299 to 1369 and Cal AD 1380 to 1409
	KNV00096 P3A		225.6	Innermost rings	423361	Acid/alkali/acid/ cellulose extraction	−28.6	666 ± 24 BP	Cal AD 1280 to 1312 and Cal AD 1359 to 1387

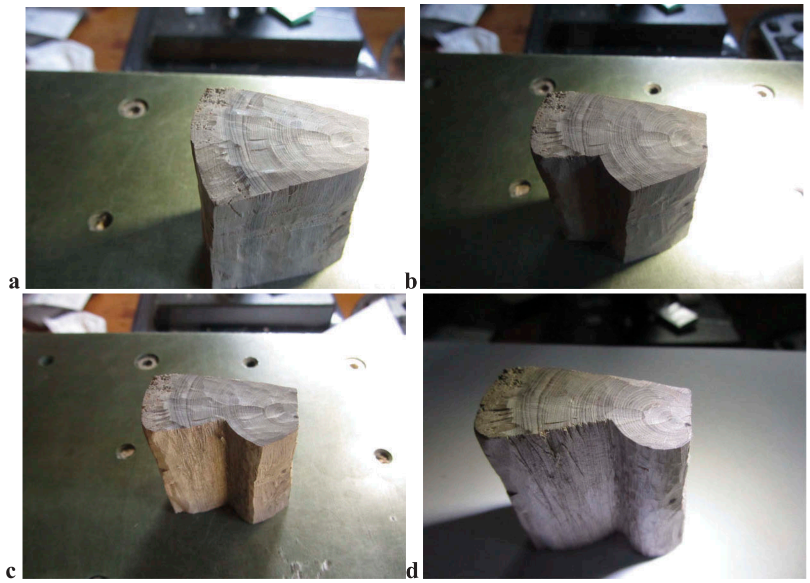

Figure 9. Sampling for the wiggle-match analysis. Sub-samples from single tree-rings along the tree's growth are sampled. The exact distance (number of tree-rings) between each sub-sample is recorded. (Photos: Aoife Daly).

The fence, holding the outer face of the rampart in place in the north-eastern part of the city (KNV80) was made of small yew posts. The post containing the most tree-rings (L120/P11) was selected for wiggle-match dating and six sub-samples were extracted, again taking wider rings along the tree's growth from outer to inner ring. The first sub-sample was taken from the last formed ring on the post, just under the bark. Calibration of this sample alone results in a calibrated dating range of AD 1515–1647 (95.4% probability). The dating of the formation of this tree-ring using the modelled (wiggle-matched) calibration falls at c. AD 1561–1636 (95.4% probability) (Figure 11). In spite of the fact that the series of C14 dates for this post fall at a flat part of the calibration curve, the dating range is still narrower than if the outer ring had been dated alone. This dates the fence 14–89 years earlier than the aforementioned sherd found between the two peat tiles held in place by the posts and, thus, the result poses more questions. Either the date of the sherd has to be pulled back a couple of decades or the turf represents a repair or renewal of the rampart, perhaps during the Swedish occupation, reusing the yew posts.

Northwest of KNV80, the shallow remains of a suspected rampart covered with peat, were found at KNV96. A fence, to which a least 107 posts belonged, kept the inner side of the rampart in place. The posts were larger than those in the front of the rampart at KNV80, and of different wood species such as oak, beech, and alder. Two sub-samples from a beech sample (L230/P3) from this structure were taken; one from the innermost four rings and the other from the outermost ring just under the bark. There are precisely 50 rings between each sub-sample. If only the sub-sample from the outermost ring had been C14 dated the resulting calibration of this would give a range Cal AD 1299 to 1369 and Cal AD 1380 to 1409 (2 sigma). However, when the C14 results of the two sub-samples are calibrated together taking the distance of 50 years between them into account, the resulting calibration of the dates is AD 1326–1407 (95.4% probability).

Regular C14 AMS was performed on two other posts, from the same fence (L225/P1 and L173/P7) with fewer growth rings. The C14 samples from these were each taken from the outermost ring just under the bark. The results of the two regular AMS datings were AD 1331–1337 and AD 1398–1433 for L225/P1 and AD 1407–1440 for L173/P7 (see Table 1).

Unfortunately, the dating of this structure falls at a place in the calibration curve (IntCal13, Reimer *et al.* 2013), which exhibits a marked bend, producing a very wide calibrated dating

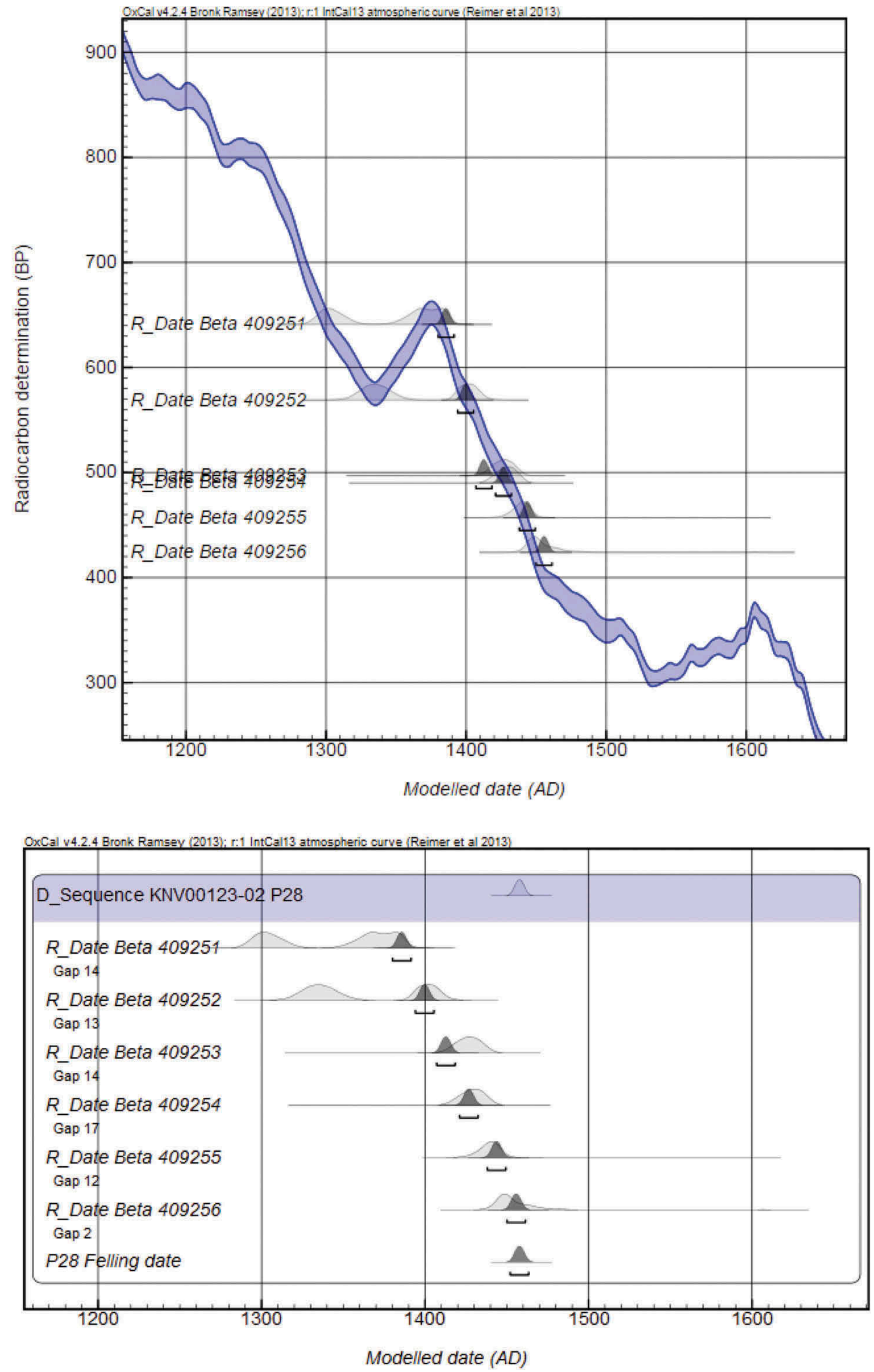

Figure 10. Bag Haverne, Køge. The diagram shows the calibration (Bronk Ramsey 2009; Reimer *et al.* 2013) of the C14-results for the six sub-samples from L1258/P28 (light grey), and the narrower calibration when the actual temporal distance between the sub-samples is accounted for (dark grey). The estimated felling date for the tree that the post was made from is placed at c. 1452–1463 (95% probability).

range. Perhaps, the combined evidence of the wiggle-match dating and the calibrated date for L173/P7 at AD 1407–1440 might allow us to suggest that if the structure is built from wood felled at the same time, then this felling took place in the early decades of the 15th century.

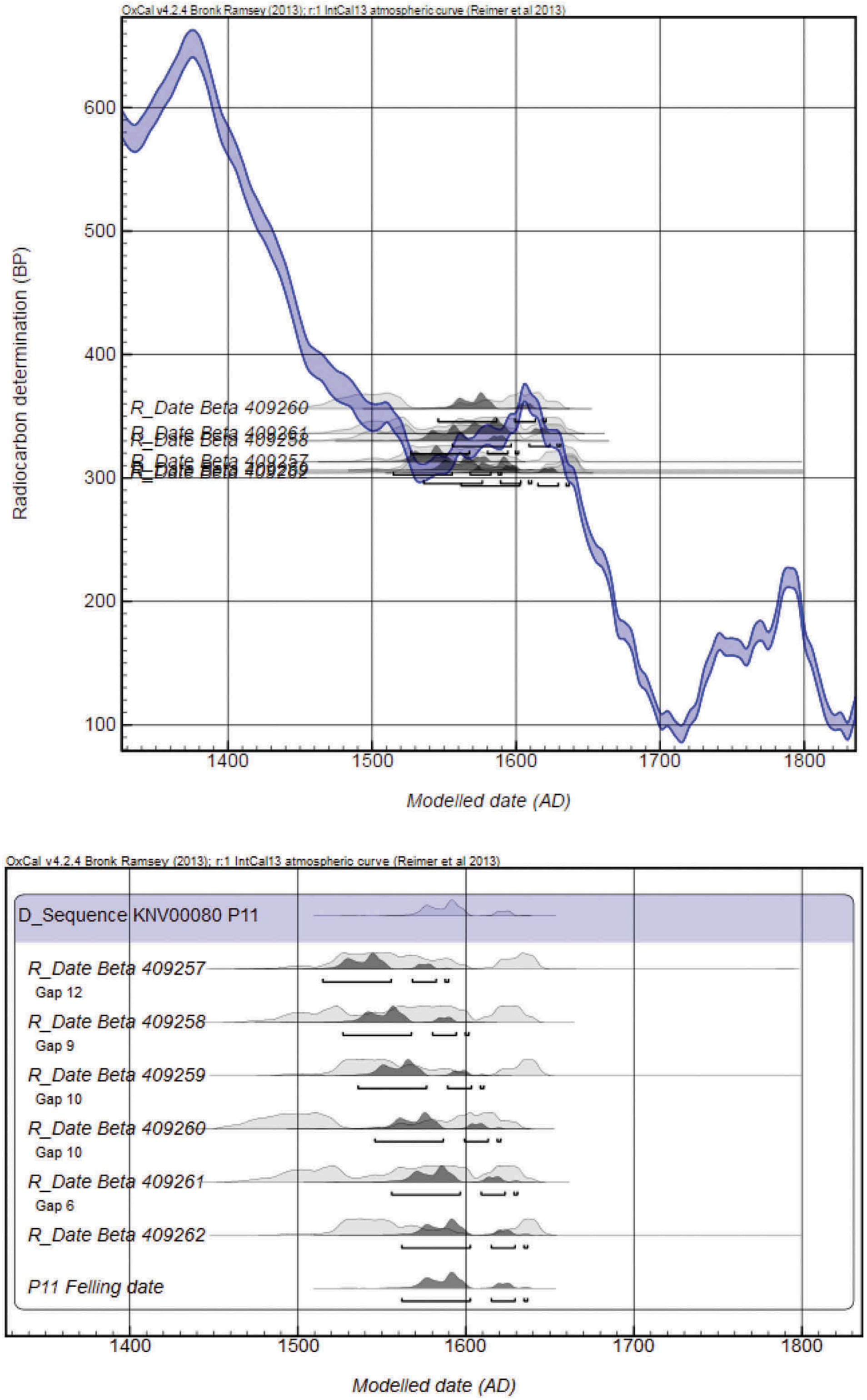

Figure 11. Ivar Huitfeldtsvej, Køge. The diagram shows the calibration (Bronk Ramsey 2009; Reimer *et al*. 2013) of the C14-results for the six sub-samples from L120/P11 (light grey), and the narrower calibration when the actual temporal distance between the sub-samples is accounted for (dark grey). The estimated felling date for the tree that the post was made from is placed at c. 1561–1636 (95% probability).

Discussion/conclusion

As can be seen in Figure 12, where the dating evidence from the material is summarised, a long series of building events in Køge are identified from these recent excavations. While the dendrochronological analysis produced a range of precise dates for the felling of trees for various uses, most of the timbers found suitable for dendrochronological analysis were found in disturbed contexts, or in contexts not associated with the establishment of defensive town ramparts. Additionally, the probability (backed by written sources) that large timbers were derived from reuse was high.

A number of fencing structures made from smaller timber posts in firm contexts associated with rampart building are most likely made from wood felled for that purpose, and these could probably be harvested locally. Even though they were not suitable for dendrochronological analysis, they presented us with the possibility of scientific dating of these construction phases. As previously mentioned, the trajectories of the two fences found to the east and west of today's Ivar Huitfeldts Vej, respectively, were thought to represent the inside and the outside of the same rampart (Figure 4). The C14 wiggle-match results suggest that these two parallel lines of posts are more than a century, perhaps as much as two-and -a-half centuries apart. While we still do not know what structural remains lay between these two fence lines, we can surmise that the evidence indicates that the layout of the ramparts continued to follow the same alignment from the c. 15th to 17th centuries.

The use of the wiggle-match dating method in this case has primarily provided dating where none of the usual methods could be applied successfully. The dating of the structures spans as much as 300 years, even when looking only at the material from the two northern excavations, and suggest a very organic process of numerous repairs or/and variations of the fortification rather than discrete, successive fortifications surrounding the town.

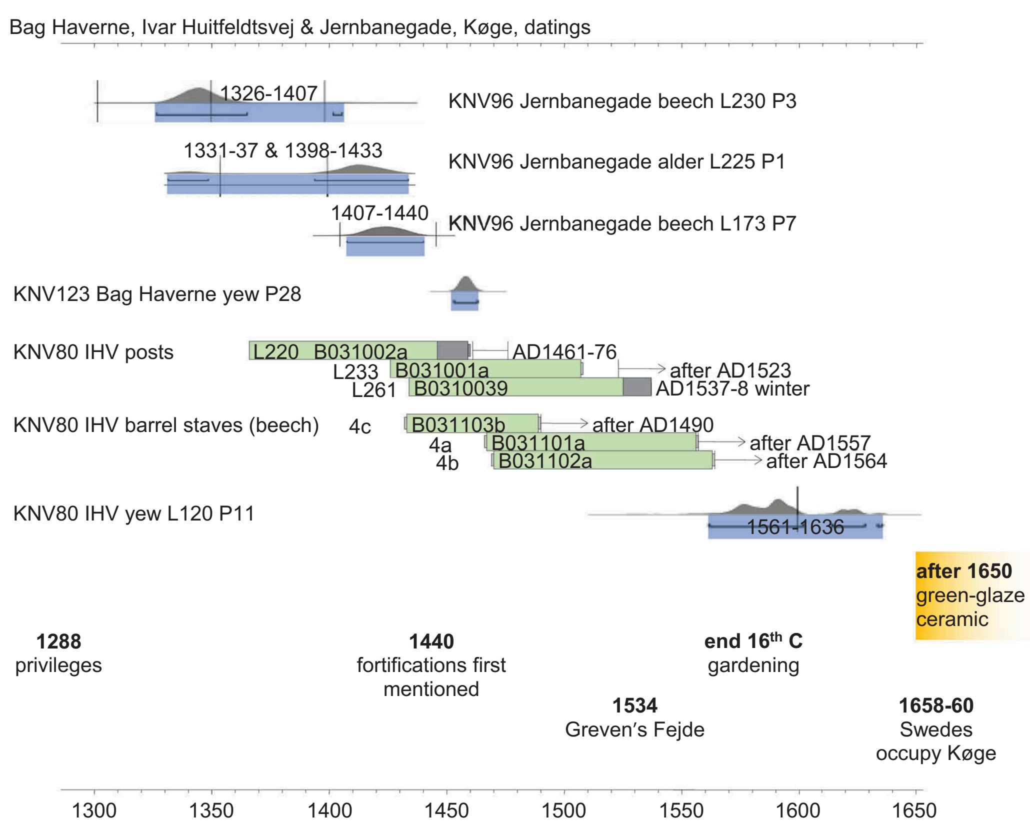

Figure 12. Timeline for Køge. The diagram summarises the chronology of the scientific dating of the wood remains from the three sites, placed with the dating of the ceramic sherd and the main historic events mentioned in the text. The dating ranges for the C14 calibration are marked in blue, the dendrochronological dating of other timber from IHV are highlighted in green and the dating of the ceramic is in yellow (diagram: Aoife Daly).

Perhaps unexpectedly, none of the current finds can be attributed to the fortification built in AD 1658. Even though the design by the Swedish occupiers in AD 1658 with its bastions differed in layout from the medieval fortification, the materials used for the construction and the location may not have changed significantly, being built within a short timeframe by an occupying power using local workers. This underlines the importance of exact dating rather than relying solely on typological or stylistic grounds or indeed written or iconographic/cartographic sources.

Furthermore, it is dubious to use ‘dating by association’ where only random scattered parts of the supposed construction have been excavated. The dating results show us that this would have been an erroneous approach. In addition, the lack of solid timber constructions of non-recycled wood and the lack of suitable artefacts for typological dating necessitated the use of alternative dating methods. All in all, the present project has demonstrated that the wiggle-match dating method is effective. It has provided us with the first elements of a chronology of construction, repair and, maybe even, demolition phases of the fortification of Køge, which will be of great value in future projects.

The initial assumption that the remains of fortifications that were found might be those built during the Swedish occupation of Køge in 1658 meant that conventional C14 dating method for the structures might not deliver the desired precision. Though still lacking the precision to date – and thus identify – exact, singular events such as the 1658 fortification, wiggle-match dating allows us to see the complexity of the phases of building and maintenance of the town defences through maybe as much as at least three centuries. The written evidence, as mentioned earlier, for ramparts at Køge before 1440 is confirmed and parts of it located, and furthermore it is now also shown that in the late 16th or early 17th century these defences were reinforced. This could imply that the requirement for the citizens to maintain the fortification, mentioned in the written sources, at least to some degree was executed. As additional structures are discovered in future excavations, they may provide additional snapshots from the construction, usage and decay and, thus, the method can help us understand the organic process and life of a long-lived structure.

Even though excavation cuttings have in many places crossed the purported position of the ramparts (Figure 13), the physical evidence for the fabled Swedish fortification has, however, still not been produced.

The use of the wiggle-match method for dating wood is a costly exercise. Applying the method here has allowed us to gain extensive insight into its advantages and limitations. As we wished to

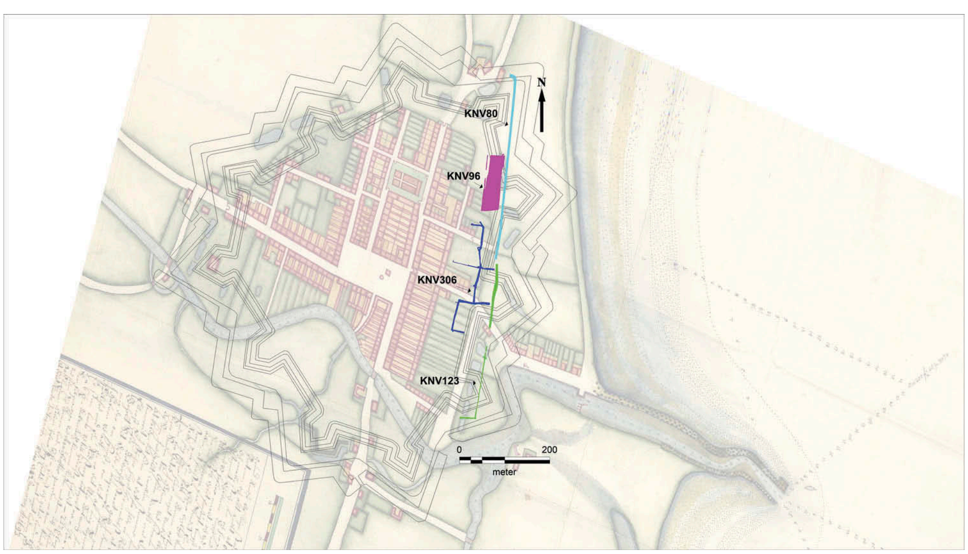

Figure 13. The planned Swedish fortification by Dahlberg is superimposed (to its best fit) on the 1693 map of Køge by Jens Sørensen, with the locations of the four excavations. Jens Sørensens Map by permission Køge Arkiverne. Digitzation of Dahlbergs map by Jeppe Færch-Jensen.

use the method to identify a very specific historical building event, the expense was justified. However, as the results of the analysis show, the wood constructions analysed are several centuries apart. This could have been discovered using fewer than six sub-samples for two of the posts. Strategies for adapting the choice of samples, the number of sub-samples per wooden component and the interval between sub-samples, to optimise the dating precision while minimising costs can now be developed for future excavations.

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No potential conflict of interest was reported by the authors.

ORCID

Aoife Daly http://orcid.org/0000-0002-4389-3238

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