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Tarja Knuutinen, Liisa Kunnas-Pusa, Kati Salo & Tuija Kirkinen

A PRE-ROMAN BURIAL SITE IN PUIJONSARVENNENÄ, KUOPIO, EASTERN FINLAND: PRELIMINARY RESULTS AND INTERPRETATIONS

Abstract

In 2019, a metal detector hobbyist found an iron spearhead, a knife, and some burnt bones from an ambiguous stone structure situated on the scenic cape of Puijonsarvennenä in Kuopio. Archaeological excavation and subsequent analyses of the find material confirmed that the site was a single cremation burial, which was radiocarbon dated to 410–355 calBC, in the Pre-Roman Iron Age. The find material included several fragments of bone artefacts and a small amount of asbestos-tempered ceramics. The burial and its finds seem to indicate that the deceased person engaged in hunting and possibly fur trading, setting Puijonsarvennenä into a continuum with similar burial sites known from interior and northern Finland from the Early Bronze Age to the Late Iron Age. Currently, Puijonsarvennenä is the only Iron Age burial site to have been excavated in the North Savo province.

Keywords: cremation burial, Early Metal Period, Iron Age, Pre-Roman Period, osteology, cairn

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INTRODUCTION

Puijonsarvennenä is a cape protruding into the Lake Kallavesi in the outskirts of the city of Kuopio, situated in the province of North Savo in Eastern Finland (Fig. 1). The Puijonsarvennenä cape is the northernmost point of Puijo, a recreational area and nature park visited for centuries by travellers, artists, and local people due to its beautiful scenery and nature. The cape is also mentioned in the lyrics of the well-known song "Kallavesj'".[1] Well-trodden trails in addition to metal detecting finds from the area indicate that camping and picnic activities have been carried out regularly at the cape. Although the point of the Puijonsarvennenä cape has been spared from construction work, summer cottages and villas have been built on the surrounding shores since the early 20th century. An engraving on a smooth waterfront rock surface resembling a coat of arms with the inscription “Sylvester 1904” acts as a memento of life at the villa closest to the cape.

Despite prevalent human activity at the cape for at least the last couple of centuries, a previously unknown prehistoric cairn existed there relatively undisturbed (Fig. 3). In the spring of 2019, a local metal detector hobbyist found an iron spearhead, a knife, and some fragments of burnt bone from a ground-level stone structure situated under the turf. He informed the Finnish Heritage Agency and Kuopio Museum. The site was considered a possible Iron Age burial after a piece of human skull was identified among the bones by osteologist Kati Salo. During negotiations with the National Heritage Agency and Kuopio Museum, it was decided that further research on the site would be incorporated into the present authors’ research project (Knuutinen & Kunnas-Pusa *forthcoming*; see also Kunnas-Pusa & Knuutinen 2020). The excavation of the cairn was conducted in 2020, with further analyses of the find material completed during 2021–2022.

The main aims of the excavation were to determine whether the structure was indeed an Iron Age grave, and whether any other prehistoric human activity could be detected at Puijonsarvennenä. The excavation and further analyses confirmed the existence of a burial, which also seemed to be an isolated phenomenon at the cape. According to radiocarbon-dating results from a fragment of bone, the burial was dated to the Pre-Roman Iron Age, 410–355 calBC. The early Iron Age as a transition period of cultural change can be observed in the find material: bone artefacts and asbestos-tempered ceramics represent old and enduring material traditions of interior Finland, while iron objects are new technology.

Besides Puijonsarvennenä, there are no other confirmed Iron Age burials known from the province of North Savo, though there has been a certain amount of speculation that some artefacts might originate from burial contexts. For example, an iron knife and a barbed spearhead were found in 1940 in Autiorinne, Joroinen (see Fig. 2 for the places mentioned in the text). However, the artefacts were found while digging a well at a depth of 2–3 metres, and the only indication of a burial were stones laid in a deliberate pattern.

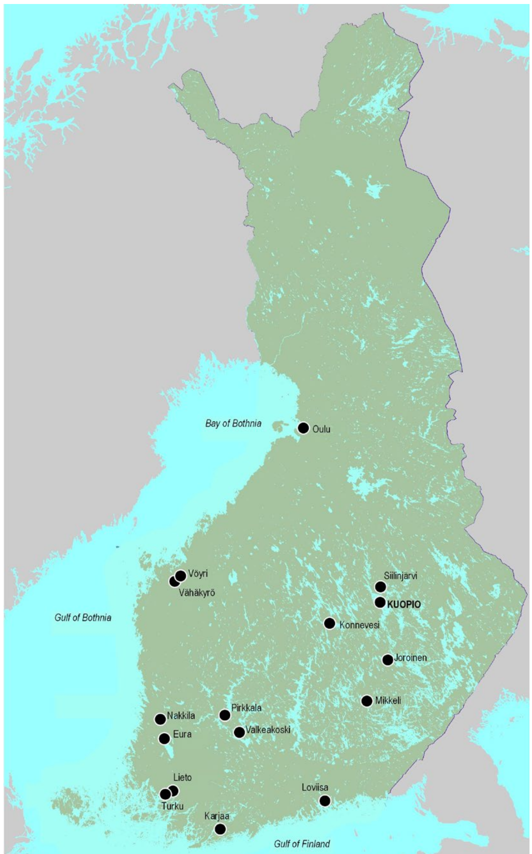

Figure 1. Location of Kuopio and other municipalities mentioned in the text. (Map: Tarja Knuutinen. Base map: National Land Survey of Finland 2022.)

The site was never archaeologically examined (Lehtosalo-Hilander 1988: 155; Ancient Relics Register).

As early as 1874, several artefacts, including a bracelet and a round brooch made of bronze, were found under a cairn near the Haminalahti mansion in Kuopio. Only the bronze artefacts found their way into museum collections, while other artefacts were lost. There are no mentions of any osteological material (Wegelius 1878: 123–4; Artefact Register: KM 1644–1648). Later, the location of the find could no longer be located, and the nearby structures turned out to be remains of a pre-modern stove or hearth (Meinander 1938). According to Pirkko-Liisa Lehtosalo-Hilander (1988: 162–3), molten glass, possibly from a bead, appears to be attached on

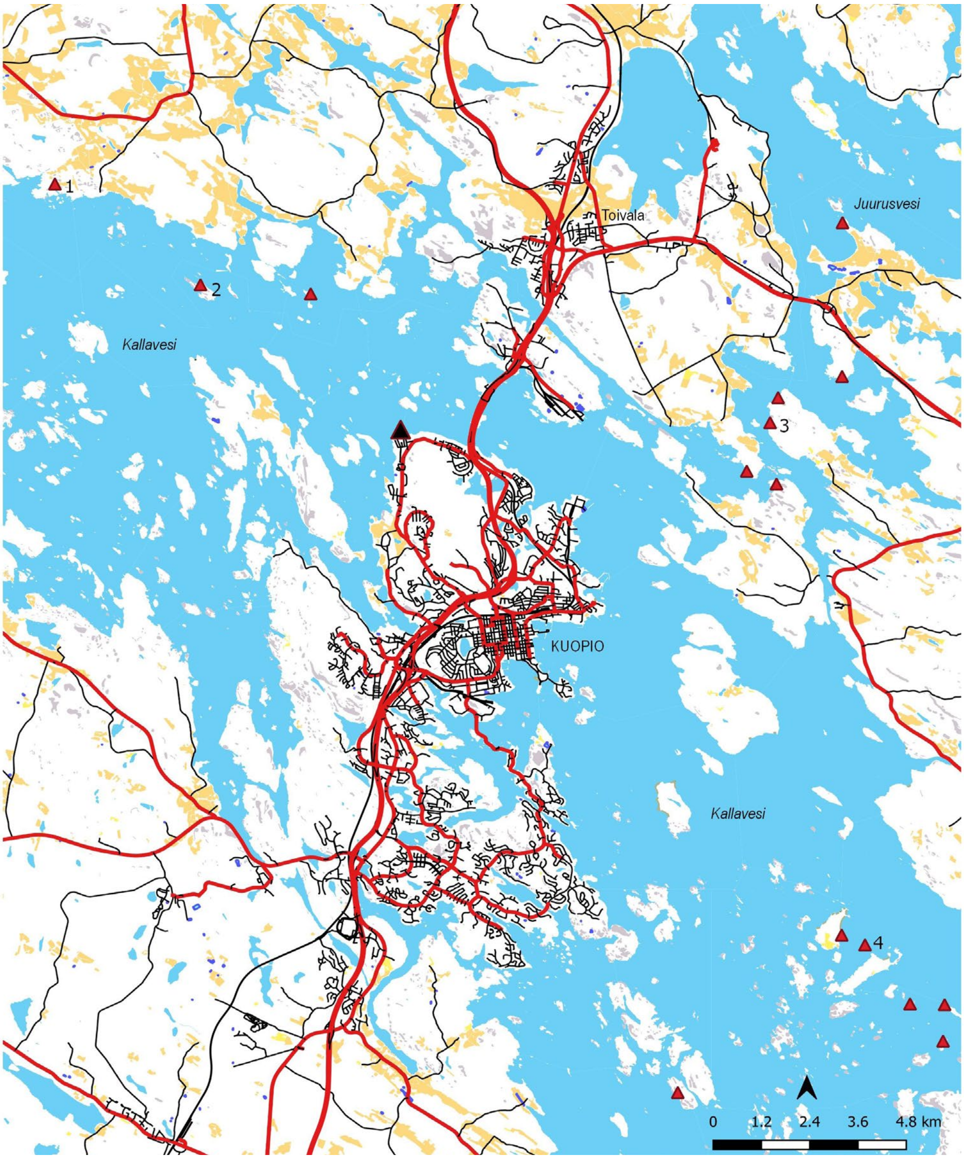

Figure 2 . Location of Puijonsarvennenä site (black triangle) and other Early Metal Age burial and settlement sites nearby (red triangles). Numbered sites mentioned in the text: 1. Saunalahti, 2. Honkasaari, 3. Kuusikkolahdenniemi, 4 . Luukonsaari. (Map: Tarja Knuutinen. Base map: National Land Survey of Finland 2022.)

one of the objects, possibly indicating that they originated from a Viking Age cremation burial.

Since these previous examples of possible Iron Age burials had evaded archaeological examination, the Puijonsarvennenä site and its excavation offered new insights into the past in North Savo. This article presents the preliminary results of the excavation and subsequent analyses of the find material, and aims to discuss the following questions: What new information does this site contribute to the current picture of the Pre-Roman Period of interior Finland when compared to some other excavated Iron Age burials of interior and northern Finland? What does the burial and its find material tell us about Early Iron Age North Savo?

Figure 2. Panoramic view of the site before excavation. (Photo: Tarja Knuutinen.)

PRE-ROMAN IRON-AGE IN NORTH SAVO

The Pre-Roman Period of the Finnish Iron Age refers to the first centuries of the Iron Age in c. 500 BCE–0, followed by the Early and Late Roman Period (0–200 CE and 200–400 CE, respectively). The term was used early on in Alfred Hackman's study of the Early Iron Age in 1905, where periodization is based on Oscar Montelius's earlier work (Hackman 1905: 4–5). Since the archaeological research conducted in early 20th-century Finland was mostly aimed at finding out the origins of ethnic Finns as a part of constructing national identity, the arrival of Finns to Finland and their colonization of the land was considered the most important event of the Iron Age (Salminen 2003; 2006; Fewster 2006; Immonen & Taavitsainen 2011; Marila 2018). Assumingly, the ancestors of Finns arrived during the Roman Period, which left the Pre-Roman Period as a less interesting prologue to the ethnically Finnish prehistory (Hackman 1905: 9–17).

The cultural change and the importance of the Roman Iron Age as a turning point in the Finnish past was even more emphasized in A. M. Tallgren's overview of Finnish prehistory in 1931. He described the Pre-Roman Iron Age as an intermission between the earlier, already perished Bronze Age culture and the event of Finns arriving to coastal areas of Finland in 200 CE. Even though Tallgren did not consider the area of Pre-Roman Period Finland to be totally devoid of population, he assumed there was a major disconnection in cultural traditions: only the "nomadic hunters and reindeer herders" of the interior and northern Finland continued their lifestyle unchanged (Tallgren 1931: 95–6, 121). Explicitly, he states: "Surely, the Pre-Roman Period was not of any interest in Finland. The following time period marks a crucial new phase: the beginning of sedentary peasant communities, the gradual fading of the hunter-fisher stage, and the eventual colonization of the whole land"[2] (Tallgren 1931: 98).

This interpretation of the Pre-Roman Period as an uninteresting intermittent phase in which "nothing was happening" in an almost deserted land was partly based on the small number of archaeological finds known at the time, but it also partly arose out of the need to archaeologically pinpoint the arrival of the Finns. New finds began to change this picture, but even more important was the overall change of focus away from ethnonationalistic interpretations of the past during the period between the 1960s and 1990s. Often considered a seminal work, C. F. Meinander's (1969) essay on the Pre-Roman Period provided evidence to assert the so-called continuation theory about prehistoric settlement, which argued that the area of Finland had been continuously inhabited since the retreat of the glaciers. Nowadays even more Pre-Roman than Bronze Age sites are known on the coastal areas. The situation of Northern and Eastern Finland is obviously different: for example, there are no results of pollen analyses that would confirm agriculture in interior Finland. There are, however, Pre-Roman finds and sites that suggest cultural connections between the interior and coastal regions (Raninen & Wessman 2015: 220–1, 224–5; Lavento 2015a: 164).

In archaeological tradition, North Savo during the Iron Age has often been described as virtually a wilderness, without permanent settlement, and frequented only by itinerant hunters and merchants (e.g., Rinne 1947: 1–2, 17–20; Kivikoski 1961: 260; Pohjakallio 1974b: 16; see also Jääskeläinen 2020). Although this description has often been used for the Late Iron Age, there are some issues related to the Early Iron Age. In interior Finland, the boundary between the Bronze Age and the early Iron Age is somewhat blurred, and the two are often merged under the term Early Metal Period, ending in the fourth century AD (Raninen & Wessman 2015; Lavento 2015a).

Only a few iron artefacts dated to the Pre-Roman Period are known from interior Finland, even though it seems that the practice of iron-working was adapted in Northern and Eastern Finland relatively early, ca. 300–200 BC. Then again, the oldest iron artefacts in Finland have been found in Savukoski, Lapland, namely two dagger-like swords originating from the Caucasus region and dated to 900–600 BCE (Lavento 1999; 2015a: 208–9; 2015b: 229; see also Hakamäki & Kuusela 2013 about Iron Age stray finds from northern Finland). Most of the Iron Age stray finds from North Savo are dated to the Late Iron Age (Lehtosalo-Hilander 1988; 155–7; Jääskeläinen 2020, Appendix 1; Ancient Relics Register).

As noted by Ville Hakamäki (2018), earlier research on the Iron Age of interior Finland has emphasized the traces of agriculture-based "peasant" communities associated with the Iron Age culture of the southern and western coastal regions of Finland, leading to the hunter-gatherer cultures of the inland regions being overlooked. Even though Hakamäki's observations relate to the Late Iron Age of Northern Ostrobothnia and Kainuu (neighbouring provinces of North Savo), there are many similarities in the interpretations of the Early Iron Age as well. Views such as Hakamäki's are entangled with notions of colonialism and "Finnish" or "Scandinavian" peasant culture expanding into the "wilderness" of nomad hunter-gatherers (Hakamäki 2018: 79–82; Saipio 2018: 47; Jääskeläinen 2020; see also Kirkinen 2012).

This interpretative model is often visible when prehistoric archaeological records are categorized according to the concept of two Iron Age Finlands: the indigenous population of interior Finland exhibiting a cultural continuation from the Stone Age versus the "new" population of agricultural, more organized people connected with the ancestors of the ethnic Finns. This approach is still prevalent in Lehtosalo-Hilander's (1988: 155, 162–70) speculations about fur hunters and traders from coastal Finland arriving to the wilderness of Savo and establishing outposts.

Critiques aimed at these interpretations of the Iron Age occupied early on by ethnic and cultural spheres have pointed out that some features related to interactions between social groups, and the internal diversity of cultural spheres, have been omitted. Burials and artefacts can represent many things about the identity of the deceased or the community, besides belonging to a certain cultural group (e.g., Pihlman 1992; 2004; Raninen 2005; see also Ikäheimo 2019: 37).

THE EXCAVATION IN 2020 AND OBSERVATIONS ON THE STRUCTURES

The excavation of the Puijonsarvennenä site was carried out in May 2020 (17–22 May 2020), predated by a survey of the site and its vicinity carried out in September 2019 (see the excavation report in Knuutinen & Kunnas-Pusa 2022 for a detailed description of the fieldwork).[3] Two metal detector hobbyists (one being the finder of the cairn) assisted in the fieldwork. In addition, several local people and history enthusiasts visited the site during the excavation, and it also drew some media attention (e.g., Hiltunen 2020; Nykänen 2020).

Apparently, the Puijonsarvennenä cape has been within the scope of some previous archaeological surveys (e.g., Pohjakallio 1974a; Jussila 2002), but the cairn had remained undiscovered. The cape of Puijonsarvennenä belonged to the grounds of Julkula vicarage until the 1930s, then to the city of Kuopio, and nowadays to a private landowner. There are some wooden villas on the western and southern sides of the cape. One large villa was situated close to the point, but it was destroyed in a fire and demolished during the first decade of the 21st century. Access to the point still goes through the yard of the demolished house, and some of its structural remains are visible on the southern side of the cape (for example, parts of the foundations and a concrete cellar vault).

Based on the observations made during the preliminary survey, as well as the results of a metal-detecting survey made at the same time, several areas holding potential archaeological interest were mapped out (Fig. 4). In addition to excavating the cairn, some test pits were dug on places where metal signals were detected the most. However, no other Iron Age finds were obtained, and the test pits only revealed the remains of fairly recent activity. The other stone structure detected nearby the burial cairn turned out to be the foundation of a modern outdoor cooking facility or some other light structure. In addition, a large number of modern nails was found.

The excavation of the cairn was carried out as a combination of stratigraphic excavation and removing layers of 5 cm. Clearly distinguishable stratigraphic contexts and features, like the burial, were excavated as a single context unit, but the layers of soil surrounding the burial and the test pits were dug out in layers of 5 or 10 cm. All the removed soil, when possible, was sieved. All of the soil from the context of the burial was collected to be sieved later in the laboratory, when the wet soil was dried. Without this method, it would never have been possible to retrieve such large number of burnt bone, and probably the smallest fragments of bone artefacts would not have been found at all.

The excavation area (measuring 3.5 x 4 m) was established around the find locations of the spearhead and the knife fragment, discovered in 2019. It encompassed the small, almost ground-level stone structure, which was almost invisible on the surface before the removal of the turf and topsoil. After the removal of the topsoil, the structure was revealed as an oblong-shaped cairn or stone setting built on the bedrock surface. The north-west end of the stone setting continued beyond the excavation area and remained unexcavated.

The stone setting was south-east–north-west-oriented and consisted of rocks and soil. In some parts, the soil was very sooty. As the excavation proceeded, two concentrations of rocks were observed at the setting, revealing an area between them containing less and smaller stones. The southern edge of the setting followed the rim of a shallow depression in the bedrock. Towards the bottom of the depression, the size of the stones grew smaller, and the amount of soil increased. At the bottom of the depression the soil became increasingly wet and sooty, possibly due to the enrichment caused by the water running along the bottom. No bones or artefacts were found in the stone setting or the soil in the depression.

The actual burial, approximately 0.6 x 0.8 m in size, was situated at the eastern end of the whole stone setting, on the highest point of the bedrock sloping gently towards the north and west. Surprisingly, the burial context was not covered with stones; the black and sooty soil with a large number of small fragments of burnt bone lay directly under the topsoil. Only the western and southern edges of the burial context were confined by somewhat larger stones, forming a possible structure. Consequently, it seems that the burial, comprised of cremated human remains and artefacts, had been laid on top of bare bedrock. The stone setting consisting of soil and rocks was not constructed on top of the burial as a traditional cairn but was instead gathered to fill the depression in the bedrock, running north-west from the burial (Fig. 5). It seems that this setting and the actual burial context could be connected to each other, although no archaeological finds related to the burial were found from the stone setting.

Some spare rocks also lay on the north-east side of the burial, but they had no straight contextual connection to the burial, as the soil including fragments of bone did not continue in this direction. Based on these few odd stones, it is possible that the burial was also originally covered by a stone setting or cairn, but became levelled out at some point. During the excavation, it was speculated whether the stones from the cairn could have been used to construct the nearby modern rectangular stone structure used as a fireplace or cooking facility. However, considering the fact that the burial was only found in 2019, it seems unlikely that there would have been a distinguishable cairn at the site. In addition, the existence of a clearly visible cairn would be unlikely given the nature of the burial practices of the Early Metal Period–Iron Age interior Finland (see below).

In some Early Iron Age burial sites there have been clear indications that cremations were also performed on the same spot (e.g., Vanhatalo

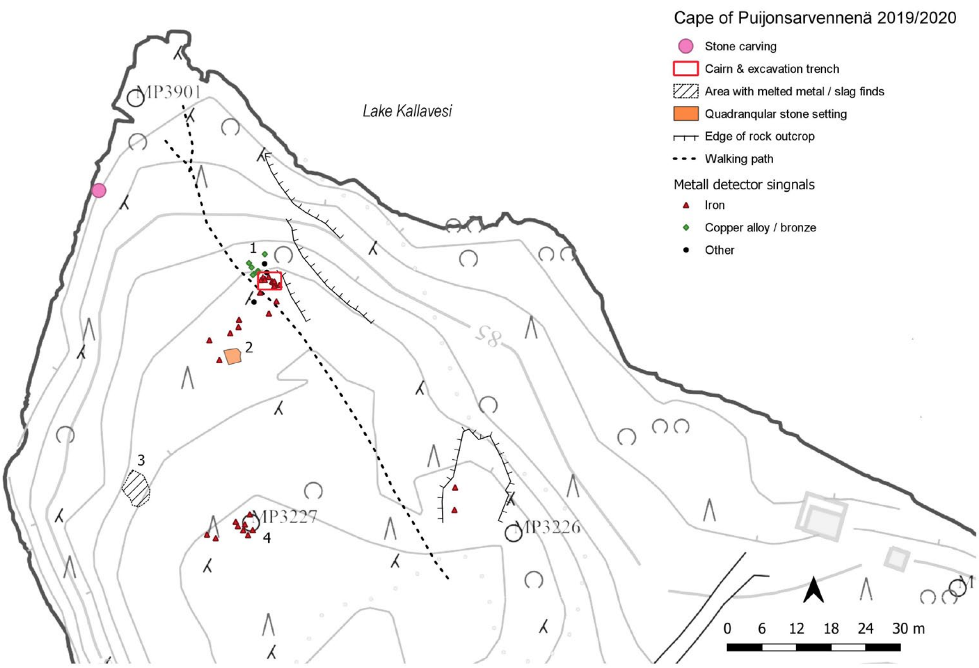

Figure 4. A map showing 1. Location of the burial and its vicinity showing metal detector signals indicating possible iron and metal alloy/bronze artefacts. 2. Rectangular stone structure and metal detecting signals situated approximately 20 m to southwest from the burial. 3. Area i ncluding a lot of metal detecting signals, situated approximately 30 m southwest from the rectangular structure. 4. Area with a lot of metal detecting signals, which was later confirmed to be an old fixed reference point for elevation. (Map: Tarja Knuutinen. Base map: City of Kuopio.)

Figure 5. The burial and related stone setting from S–SW . Burial is located on the eastern end of the stone setting, on the area not covered by stones. (Photo: Tarja Knuutinen.)

2005: 100–1). Some Iron Age burial sites from later periods with assumed funeral pyres have also been excavated, including Ylipää in Lieto, Moisio (Latokallio) in Mikkeli, Kokkomäki in Valkeakoski, Pörnullbacken in Vöyri, and Virusmäki in Turku, but with somewhat controversial interpretations (Wessman 2010: 51–2). In Puijonsarvennenä, there were certain features that could indicate the act of cremation. Based on the sooty soil and heat-cracked stones packed in the depression of the bedrock, the pyre could have been on the small rock terrace on the western and south-western sides of the excavated area. Since there were several metal detector signals from this area, referring to possible iron and bronze or copper alloy objects, the area was studied with a small auger to detect concentrations of soot or charcoal and a few small test pits were excavated. The results remained slim, as instead of a cultural layer or artefacts, only shells of a small-bore rifle were obtained. Further archaeological research on the site would be required to determine the existence of a funeral pyre.

DESCRIPTION OF FINDS AND OSTEOLOGICAL MATERIAL

Iron artefacts

The iron artefacts included a spearhead and a fragment of a knife (KM 41974:1–2; Fig. 6), found in 2019 while metal detecting, as well as finds obtained during the excavation: two small, rectangular objects resembling rivets or studs (KM 42642:1), two plate-like fragments (KM 42642:2–3), and one small drop-shaped piece of iron (KM 42642:4). All metal objects were X-rayed and some of them subsequently went through conservation (see the conservation report attached in Knuutinen & Kunnas-Pusa 2022). The conservation was conducted by Löytö Oy.

The spearhead is socketed, with a long shafting socket, resembling Type II b3 in Unto Salo's typology (Salo 1968: 131, Abb. 92). Such spearheads have been found, for example, from Malmsby Blombacka, Loviisa, in South-east Finland, where altogether eight spearheads, eight knobbed axes, one socketed axe, four sickles, and a scythe were found, all concealed in the same hoard. Based on the artefacts, the hoard has been dated to the end of the Pre-Roman Period and the Roman Period (Salmo 1953). A similar spearhead has also been found in a Roman Period cemetery in Penttala, Nakkila, in South-west Finland (Salo 1968: 130–41, T48–T49). Most of the known Pre-Roman spearheads from Finland resemble differently shaped types than the Puijonsarvennenä spearhead, usually with a longer blade in relation to the shaft socket. For example, the fragmented spearhead from Cairn 422 in Luistari cemetery in Eura, South-west Finland, belongs to a longer type (Lehtosalo-Hilander 1986; for a typology of Pre-Roman spearheads, see Salo 1968).

A few socketed spearheads (KM 1400: 482–488) are also included in the assemblage of artefacts from the Early Metal Period–Pre-Roman Iron Age burial ground in Anan'ino, Russia, deposited in the collections of the Finnish National Museum. J. R. Aspelin visited Anan'ino in the 1870s and brought these artefacts to Finland. They were mostly bought from the local people (see Salminen 2003: 53–7). The size and form of these socketed spearheads from Anan'ino vary considerably, and since the assemblage mostly originated from disturbed burial contexts, the variation is understandable. There have been some later attempts to date the artefacts typologically (Salminen 2003: 55). The so-called Anan'ino culture (c. 800–200 BC) is considered to have been an important transmitter of iron-working technology and iron artefacts in the areas of northern Russia and eastern and northern Fennoscandia (e.g., Raninen & Wessman 2015: 217–8).

According to Jonas Wikborg (2005b: 146), a single spear set in a Pre-Roman burial can be considered a symbolic token representing the equipment of a soldier, since in an actual battle situation a combatant would also need other weapons and a shield. If the person buried in Puijonsarvennenä had other such weaponry, they were not placed in the burial. However, the spearhead could also be related to hunting big game, or fur trading. Pirkko-Liisa Lehtosalo-Hilander (1988: 155–6) suggested that iron objects like arrowheads, knives, and axes, which are commonly unearthed as stray finds in interior Finland, would have been used as a payment for furs during the Early Iron Age, then being

Figure 6. Socketed spearhead (KM 41974:1) and a fragment of knife (KM 41974:2) found from Puijonsarvennenä in 2019. (Photos: Sari Poutanen / Löytö Oy.)

Figure 7. A knife from Anan'ino burial site (KM1400:526), brought for the collections of Finnish National Museum by J. R. Aspelin in 1870' s. (Photo: Finnish National Museum, open picture collection (Finna), CC BY 4.0 .)

substituted with coins from the Viking Age onwards.

Similar-looking iron knives have been used from the Iron Age until historical times, making them difficult to date (Lehtosalo-Hilander 1988: 155). However, iron knives have been found from Pre-Roman and Roman period contexts in Finland earlier, and e.g. Raninen and Wessman (2015: 218) mention them among the most usual iron objects from the era. Iron knives with a similar composition of a straight shaft set on the same line as the back of the knife have also been found in the Pre-Roman Period contexts in the Baltic region (Nylén 1979: 182; Arnberg 2007: 214, Fig. 103).

From Finnish inland areas, iron knives have been found from the aforementioned sites of Joroinen Autiorinne (KM 11267:1) and Konnevesi Siimarinsaari (KM 39149:6). Although the find context of Autiorinne has been somewhat unclear, the barbed iron spearhead (KM 11267:2), found seemingly in the same context, suggests an Iron Age origin (Lehtosalo-Hilander 1988: 155). The Siimarinsaari knife, resembling the knife from Puijonsarvennenä, was also found by a metal detectorist from a low cremation burial cairn together with other artefacts including an iron shaft-hole axe, bronze belt fittings and iron wedges (Ancient Relics Register). The site has not been further studied archaeologically, but based on the available information, it has some similar features as the Puijonsarvennenä burial.

There is also a knife (KM 1400:526) (Fig. 7) in the Finnish National Museum assemblage of objects from Anan'ino with a very close resemblance to the one from Puijonsarvennenä. In addition, the batch of artefacts from Anan'ino includes more than 30 different iron knives or their fragments (e.g., KM 1400: 523–555), showing that they were a rather common type of artefact during the Early Iron Age. The knife from Puijonsarvennenä could also have an eastern origin.

There was a piece missing from the socket of the Puijonsarvennenä spearhead. In addition, the point end was missing from both the spearhead and the knife. The two plate-like iron fragments (KM 42642: 2–3) found during the excavation were gauged to belong to the spearhead or the knife but could not be attached to the artefacts during the conservation. However, since they were obtained from the same context, they probably relate to the burial.

Both the spearhead and the knife had very uneven, bubbly, and corroded surfaces, which, according to conservator Anna Lehtinen, could have resulted from exposure to fire or high temperatures (Knuutinen & Kunnas-Pusa 2022, Appendix 5). Traces of fire were also observed on the inner surface of the socket. Microscopic analysis of the soil collected from the inside of the socket revealed small fragments of burnt bone and iron, but no wooden residue from the shaft of the spear. However, these observations indicate that the iron objects would have been on the funerary pyre with the deceased.

When excavated, the burial context seemed intact, but as there was no actual stone setting on top of the burial, the knife and the spearhead had been dug up immediately beneath the turf. Based on both the information gained from the finder of the site and the observations during the excavation, it would seem that the iron objects had been on top of the burial context. The extraction of the objects from the ground had not significantly disturbed the burial. Although the exact find location of the objects could not be pointed out during the excavation, their approximate location was on the southern edge of the burial context.

Ceramics

During the post-excavation phase, while detaching osseous material from the soil, a small number of asbestos-tempered ceramics were discovered amidst the soil collected from the centre part of the burial context. The sherds were in poor shape, very small, and fragmented, and possibly crumbled in fire. There was one slightly larger sherd, from the wall of a vessel, in which a pattern of stamped decoration could be observed (Fig. 8). In addition, one sherd possibly originated from the base of a vessel.

Due to the sherds being so small and crumbled, it is difficult to recognize the type of ceramics, but based on the asbestos temper, the appearance of the largest sherds, and the find context, they probably belong to the so-called Luukonsaari type, considered together with the Sirnihta type to be a subgroup of Säräisniemi 2 ceramic ware, dated ca. 1000 BC–400 AD) (Lavento 2015a: 194–7; see also Carpelan 1979). The sherds also bear some resemblance to earlier asbestos-tempered wares (for example Pöljä and Kierikki ware) used during the Stone Age and Early Metal Period. Most likely this is due to the difficulty of telling different asbestos-tempered wares apart from crumbled and worn sherds. Even with the Stone Age wares, there is a great deal of variation in decoration and the shape of the vessels, the use of asbestos and organic substances as temper being the common feature (Pesonen 2021: 34–6). While widespread in northern Fennoscandia, the tradition of asbestos-tempered ceramic wares is characteristic of the area of North Savo, beginning in the Stone Age in c. 3500 BC and lasting until the first centuries AD (Nordqvist & Mökkönen 2021).

Luukonsaari ware is known from several sites near Puijonsarvennenä (for example, the eponymous settlement site of Luukonsaari, see Fig. 2). The “Luukonsaari group” is one of the four cultural spheres C. F. Meinander proposed to have existed in the area of Finland during the Early Iron Age. He considered that the Luukonsaari group represented a continuous inhabitation of interior Finland through the Bronze and Iron Ages (Meinander 1969; Lehtosalo-Hilander 1988: 118–20; 143).

Human and animal bones in the burial

The osteological analysis of the Puijonsarvennenä bone material was conducted by PhD Kati Salo. The bone material consisted of 407.7 g of small fragments of burnt bone, with the total number of fragments being ca. 2,500. The fragments were first identified with the help of osteological

Figure 8. A sherd of asbestos-tempered ceramics showing stamped decoration (KM 42642:5). (Photo: Tarja Knuutinen.)

reference collections at the University of Helsinki (see list of all identified bone fragments in the osteological report, attached in Knuutinen & Kunnas-Pusa 2022). Due to the high number of very small bone fragments, only a part of the whole bone material could be identified to a species. Most of the identified bones were human: 249 fragments (73.4 g) were identified as human with certainty and 222 fragments (54.8 g) probably. The uncertain ones were fragments of long bones that could not be morphologically identified as human with certainty and could also belong to some other mammal. However, they were not as dense as animal bones tend to be and within the size range of human bones. One animal bone could be identified to a species, namely a fragment of right ulna from a mustelid (*Mustelidae* sp.). Based on its size, it most likely belonged to a pine marten (*Martes martes*), a European mink (*Mustela lutreola*), or a polecat (*Mustela putorius*).

Standard osteological methods (Buikstra & Ubelaker 1994) were applied to estimate sex as well as the age at time of death. In order to estimate the age, suture closure (Ruengdit et al. 2020), the width of the dental root canals (Kvaal et al. 1995), and the thickness of the cranial layers (Gejvall 1947) were observed. A cremation temperature estimation was based on visual observation of the colour of the bones (Walker et al. 2008). Most of the bones were white; thus, they were cremated at a high (above 800°C) temperature. The bone surfaces had a brownish tint due to the soil, and the fragile material could not be thoroughly cleaned before analysis.

The human bones are from an adult individual. The cranial sutures are open, but the diploë, or the internal layer of the cranium, is thick. The outer and inner tables are thin, as are the root canals. Therefore, the adult is likely to be a mature adult. One feminine trait could be observed in the orbital rim of the frontal bone (Fig. 9a). However, sex estimation is not very reliable when based on one trait alone, since many individuals carry both masculine and feminine traits in their skeleton. Woven bone formation was observed in one long bone fragment (Fig. 9b). Woven bone in adults is always pathological. It could be a sign of infection, trauma, or disease (see e.g., Salo 2016: 169–70).

Two human bones were selected for radiocarbon (AMS) dating, a fragment of skull (KM 24642:15, HELA-4884) and a fragment of long bone (KM 24642:25, HELA-4885). The dating of the samples was conducted by the University of Helsinki Laboratory of Chronology. Only the latter sample was successfully dated, resulting in a radiocarbon age of 2300±24 BP, and a

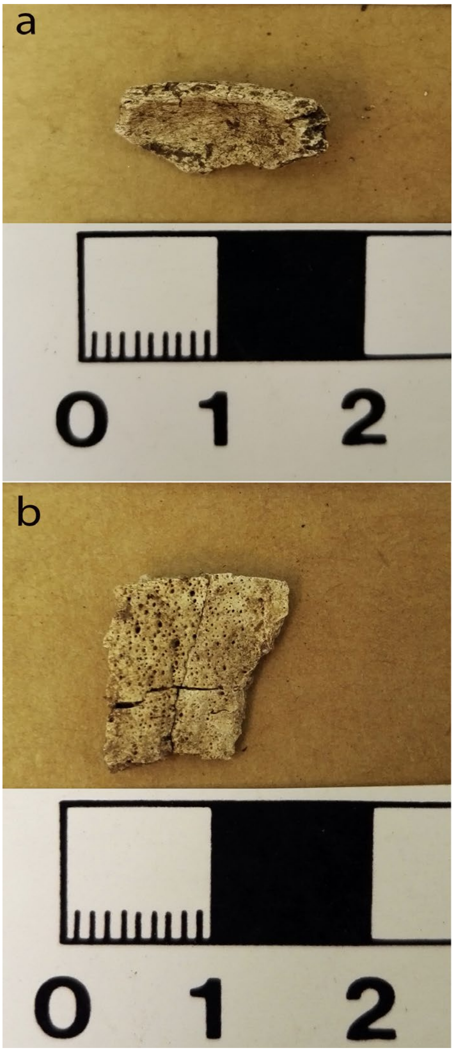

Figure 9. a) Sharp orbital rim on the frontal bone (KM 42642:16) b) Woven bone in a long bone fragment. (KM 42642: 15). (Photos: Kati Salo.)

calibrated date of 405–365 calBC (68.3% probability), 410–355 calBC (79.1% probability) and 285–230 calBC (16.3% probability)[4] (Fig. 10). Since there are some issues related to radiocarbon dating of burnt bone (e.g., Olsen et al. 2013), and only one of the samples could be dated, the authors will discuss further questions related to radiocarbon dating of cremation burials, including Puijonsarvennenä, in a separate study published later.

Bone artefacts

A total of 21 fragments of bone artefacts were identified (Fig. 11). Some of the fragments could be pieced together so that it was possible to speculate on the nature and purpose of the objects they originated from. The best-preserved bone artefact is a needle or awl, 46.5 mm long and 1.5–2.55 mm in diameter, with only a small fragment missing (KM 42642:27) (Fig. 11a). Three fragments belonging to a bone arrowhead (KM 42642:30) were also identified. Both ends of the arrowhead with a rhomb-shaped cross-section are missing, but one of the remaining pieces has an interesting detail, a distinct curved cut indicating an effort to reshape the artefact by cutting a barb into it (Fig. 11b). Either the arrowhead was not finished by the time it was placed in the cremation with the deceased or it was broken and taken into reuse.

Six barbed arrowhead fragments (KM 41974: 4 and KM 42642: 29) (Fig. 11c) were also found amongst the bone material. Three of the fragments have distinctive barbs and one is possibly the base of a snapped barb. Two of the fragments could be fitted together, forming an approximately 2.5 cm long and 0.5 cm wide piece with a rounded rectangular cross-section and one barb. No tip or base fragments were identified from the collected bone material. As not all the pieces could be fitted together, and some of the fragments clearly have a different, triangular, or more flattened cross-section, it is possible that the deceased was cremated with more than one barbed arrowhead.

In addition, seven flat fragments of bone decorated with etched lines were recognized. Three of the fragments could be pieced together, forming a fragment of a plate-like piece decorated with incised ornamental feature consisting of three parallel lines. Two fragments had two incised decorative lines, and two only single line (KM42642:31; Fig. 11d).

Similar types of arrowheads with a rhomb-shaped cross-section have been found in the Viking Age Tursiannotko dwelling site in Pirkkala (Raninen 2013: 16) and the Kirstinmäki cairn burial site in Vähäkyrö (Kivikoski 1947, Tafel 37: 318). A very similar arrowhead was also found at the Lieto Kotokallio Bronze Age burial cairn (Edgren 1969; Ikäheimo et al. 2004).

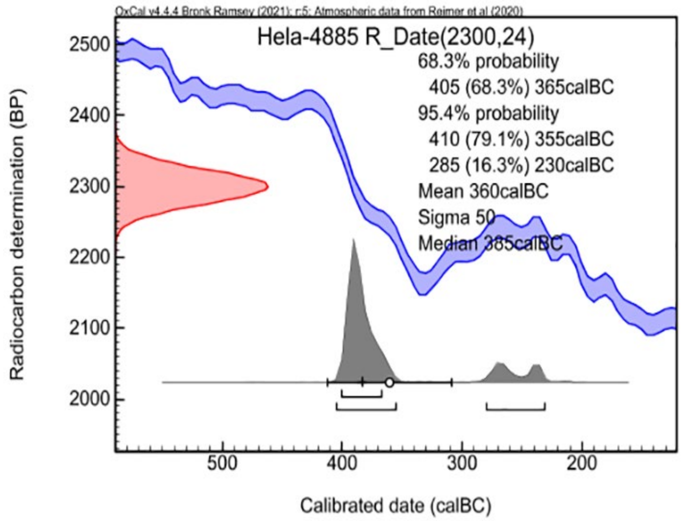

Figure 10. The dating results of the sample HELA-4885 (human long bone, KM 24642:25).

The arrowhead from Kotokallio is almost complete, with a total length of 55 mm, a greatest breadth of 10 mm, and a greatest thickness of 4 mm (Edgren 1969: 76–7, Abb. 2b.). The more fragmented arrowhead from Puijonsarvennenä, with both the tip and part of the butt missing, measures only slightly less, with a total length of 30.4 mm, a greatest width of 7.7 mm, and a greatest thickness of 4.3 mm.

A barbed bone arrowhead is known, for example, from the Välikangas burial site in Oulu, dated to the Roman period, ca. 150–500 CE (Mäkivuoti 1988; Ikäheimo et al. 2004). The Välikangas arrowhead (KM 24597:7) has a triangular cross-section and a slightly curved point, and the barb is located on the shoulder of the point. In addition, the point has been decorated with an incised longitudinal line (Ikäheimo et al. 2004). Very similar barbed points are also known from the St. Vikers Bronze Age cremation burial in Lärbo, Gotland (Rydh 1968; Ikäheimo et al. 2004), but also from the Migration period–Merovingian cremation burial of Karjaa Hönsåkerskullen (KM 11138:120; af Hällström 1939). In fact, barbed arrowheads in varying forms were used for hunting throughout the Stone Age from the Paleolithic onwards (e.g., Langley et al. 2016; Lozovskaja & Lozovski 2019). Small, barbed arrowheads were probably also used for shooting fish (Zhilin 2020). Luik (2006) has suggested that during the Late Bronze Age, barbed bone arrowheads were manufactured in Estonia as weapons of warfare as well.

Besides the Välikangas burials, the assembly of finds from the Bronze Age burial at Hangaskangas in Oulu also represents an interesting parallel with the Puijonsarvennenä burial site (Forss & Tuovinen 2001; Ikäheimo et al. 2004; see also Ikäheimo 2019). The finds from Hangaskangas included fragments of at least twelve bone arrowheads, fragments of osseous spearheads or harpoons, awl-like objects, and perforated and decorated pieces of thin plate made of horn. The latter were speculated to have been sewn onto the deceased person's clothes or other belongings like a hunting case or a quiver. Unfortunately, the decorated plate-like bone pieces from Puijonsarvennenä are too fragmentary to definitely identify their function. It is possible that the pieces originate from, for example, the handle or sheath of a knife, or a decorative feature of the outfit or accessories worn by the deceased, such as the decorative bone inlays of Hangaskangas. The fragments of awl-like objects from Hangaskangas and the needle or awl from Puijonsarvennenä could both be related to sewing or modifying pelts.

Due to Finland's acidic soil, bone artefacts are rarely preserved in the ground unless they are burnt. Therefore, cremation burials are a common context for finding them. In other areas of northern Fennoscandia, bone arrowheads and other objects are quite common in Early Metal Period–Iron Age contexts, and they have probably also been used in northern Finland more than is archaeologically visible (Ikäheimo et

Figure 11. Fragments of bone objects from Puijonsarvennenä: a) A bone needle or awl (KM 42642:27), b) Three fragments from an arrowhead (KM 42642:30) with a distinctive curved cut visible in the middle fragment, c) Fragments of barbed object(s) (KM 42642:29 , 41974:4), d) Flat fragments of bone decorated with etched lines (KM 42642:31). (Photos: Tarja Knuutinen.)

al. 2004). Most of the bone artefacts from later Iron Age contexts in Finland are combs, spoons, and spindle whorls (e.g., Kivikoski 1947; Raninen 2013), but artefacts like the ones from Puijonsarvennenä are more related to hunting and fishing. Based on Kati Salo's preliminary observations, bone artefacts seem to be more common in Early Metal Period and Iron Age cremation burials in Northern Finland, especially when the fact that fewer burials have been excavated there than in southern and western Finland is taken into consideration. For example, in a large and richly furnished Roman Iron Age burial ground in Kärsämäki, Turku, Southwestern Finland, there have been no bone points in the graves, leading to speculations that only iron weapons have been considered important, or magical, enough to be laid in burials (Raninen 2005: 53–5; see also Wikborg 2005b: 150–2).

Hairs

The microarchaeological analysis was conducted by PhD Tuija Kirkinen. The studied material consisted of two soil samples (sample 1, 224 g and sample 2, 319 g) taken from the burial and three small samples taken from under the iron rivets (KM 42642:1) and inside the spearhead socket (KM 41974:1). The samples were prepared by sieving the soil in a 0.125 mm sieve to remove the smallest particles. The washed material was floated and centrifuged and the extracted material was studied by a transmitting light microscope and documented by photographing. The detected animal hairs were studied by a scanning electronic microscope at Aalto University Nanomicroscopy Center. The hairs were identified by their morphology following Teerink (2003) and Tóth (2017), and by

Table 1. Results of the fibre analysis.

Sample id: Fibre id	Species idenfication	Diagnostic features	Identification references
K1	Unidentified mammal (Mammalian) / small rodent e.g. Clethrionomys glareolus	Underhair, medulla amorphous, scale structure elongate petal. Width 12.6 µm, length 0.5 cm.	
K2	Unidentified mammal (Mammalian)	Underhair, medulla uniserial regular, scale structure coronal mosaic. Width 17.4 µm, length 0.7 cm.	
K3	Ursus arctos	Guard hair, brown pigmentation. Medulla tubular, hollowed out, medullary index 0.25. Scale structure figureless waved/sketched. Width 65.2 µm, length 1.4 cm.	Tóth 2017, 182-183
K4	Mustelidae (Mustela erminea / nivalis)	Guard hair, white. Medulla multiserial chambered, medullary index 0.84. Scale structure rhomboidal near the root section and mosaic irregular on the shaft. Width 65.4 µm, length 0.7 cm.	Teerink 2003, 188-191

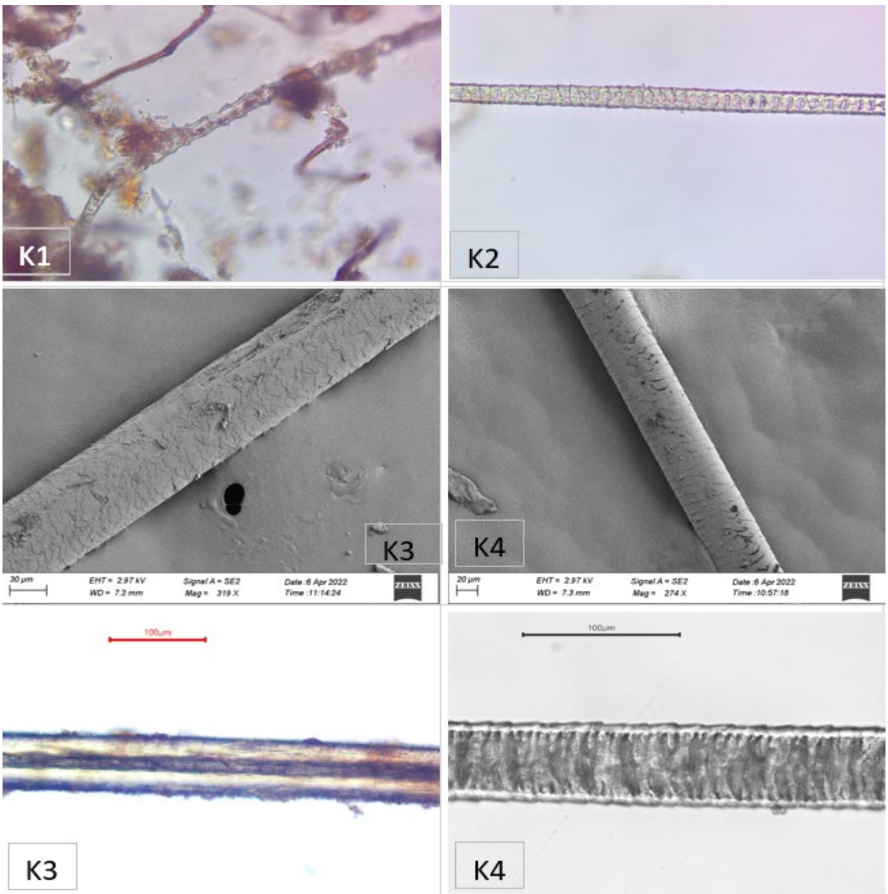

Figure 12. Hairs detected in microscopic analysis, fibre ID K1-K4 (see Table 1). (Photos: Tuija Kirkinen.)

comparing the hairs with a reference collection of Fennoscandian species.

As a result, four mammalian hairs were recovered in sample 1, two of which were identified as brown bear (*Ursus arctos*) and Mustelid coarse hairs. The Mustelid hair was white in colour, so it is most likely from the winter coat of a stoat (*Mustela erminea*) or weasel (*Mustela nivalis*). Two hairs were fine hairs, probably from small rodents such as a bank vole (*Myodes glareolus*). Their excellent preservation speaks for their recent origin. In the other soil samples, no animal hairs were detected (Table 1; Fig. 12).

COMPARISONS AND DISCUSSION

In the coastal areas of Finland, the Pre-Roman and Early Roman Periods brought forth changes in the burial traditions: instead of singular cairns, there began to be fields of cairns. New stone structures like rectangular settings and dry-stacked pavings emerged. Red sandstone slabs are a distinctive feature in Pre-Roman and Early Roman burials in Ostrobothnia, as are cooking pits in the vicinity of cairns. Besides cremation, inhumation burial was also practised (about the Pre-Roman–Roman Period burial practices, see e.g., Edgren 1992; 1999; Forsén & Moisanen 1993; Wikborg 1996; Raninen 2005; Kuusela et al. 2010; Soikkeli-Jalonen & Oksanen 2015).

However, several burials considered as Pre-Roman do not include any finds: either objects were not placed with the deceased, or they were made of materials that have been destroyed by fire or have decomposed. Tahkokangas in Oulu, for example, is considered a Pre-Roman burial site with several stone structures, even though there are no finds. The burials are implicated by the nature of the structures, while the dating is based on shoreline displacement chronology (Kuusela 2011; Väänänen 2012).

When Puijonsarvennenä is examined in the context of Pre-Roman burial practices, it seems that some features of the burial resemble Lapp cairns, but also "discrete" Late Iron Age burials, which are both typical for the interior and northern parts of Finland (Kuusela et al. 2016; see also Moilanen & Raninen 2022). According to Ville Hakamäki (2018: 94), there is a continuum of these similar burial practices throughout the Early Metal Period and Iron Age in interior Finland, with common features being cremation (with only some of the burnt bones placed in the burial), stone settings and low cairns usually quite unnoticeable above the ground. Besides interior and northern Finland, there is also a similar tradition of "hunting-ground graves" in northern Scandinavia.

The burial of Puijonsarvennenä seems to fit into this tradition. Even though there are no other known Iron Age burials in North Savo, there are more than twenty Early Metal Period cairn sites around the Kuopio region. Most of them have not been excavated. Even the excavated ones have yielded barely any finds. For example, a cairn in Honkasaari, Kuopio had already been dismantled before excavation, so besides the mention of an outlining paved structure, there is very little information available (Pohjakallio 1978b; Lehtosalo-Hilander 1988: 131).

The Siilinjärvi Saunalahti cairn had fragments of flint arrow heads, but no remains of cremated bone, even though some traces of fire were observed. Several human-made small pits, or "cups", were found from the bedrock surface underneath and around the cairn (Pohjakallio 1978c). At least in the area of Finland, the Saunalahti cairn is apparently still the only known Lapp cairn situated on top of such cups, although during the Late Iron Age cup-marked stones are often situated near burial grounds and even in cairns (Lehtosalo-Hilander 1988: 131). They are connected to sacrificial practices, and therefore the Saunalahti cairn has also been considered a sacrificial cairn (Lavento 2015a: 169; for sacrificial cairns and the problems of categorization, see e.g., Muhonen 2009).

The cairn site of Kuusikkolahdenniemi in Kuopio is dated to the Bronze Age based on its finds, namely Luukonsaari ware ceramics and two bronze objects (Pohjakallio 1978a: 23; Salo 1984; Meinander 1985; Lehtosalo-Hilander 1988: 130; Soikkeli-Jalonen 2021). During the authors' research project, a bone from Kuusikkolahdenniemi was also sent to be radiocarbon dated; the results of this will be published later in a separate study about the site (for the most recent osteological analysis of Kuusikkolahdenniemi, see Salo 2021).

Until the discovery of Puijonsarvennenä, this tradition of burial customs in interior Finland seemed to come to a halt in North Savo at the beginning of the Iron Age. Even though

Puijonsarvennenä is dated to the very early Iron Age, there could also be similar sites from the later periods, since they are known from the neighbouring areas of North Savo. For example, the site of Konnevesi Majakangas in Central Finland, dated to the Late Roman or Migration Period, the Siimarinsaari site, also in Konnevesi, and one burial in the Early Roman–Migration Period cemetery in Välikangas, Oulu, bear some resemblance to Puijonsarvennenä.

Majakangas was originally found during metal detecting in 1998 and excavated in 2003 (Ukkonen 2003; Vanhatalo 2005). Several iron artefacts were found from the burial including a spearhead, an arrowhead, a seax or dagger, a knife, and an axe as well as a bronze ring and fragments of bronze. In addition, the finds included several fragments of arrowheads made of bone, which resemble those from Puijonsarvennenä. Like Puijonsarvennenä, the burial was not visible before the removal of the topsoil, and there was no distinct stone setting placed on top of the burial.

According to Vanhatalo (2005: 97, 99), the bone arrows could have been used for hunting birds or animals for fur, and the knife would have been suitable for handling animal pelts. The connection of the burial with fur hunting is further supported by the osteological material of the site, which differs from Puijonsarvennenä by being more numerous and by including more animal bones identified to a species. Most remarkably, the burial seemed to have included a dog and a pine marten (Martes martes) pelt. The only bones identified as being from a pine marten were from the skull, the lower parts of the legs and from the tail, interpreted as originating from a pelt with the skull, paws, and tail left intact (Ukkonen 2003).

Also, in Puijonsarvennenä, a fragment of bone belonging to an animal of the family Mustelidae, possibly a pine marten, was identified. In addition, a hair belonging to an animal of the Mustelidae family was detected in the soil from the burial context. There was also a bear hair, which could indicate a bear pelt, even though no osteological remains of a bear were identified. The third phalanges of a bear paw, i.e., the remains of claws, have commonly been found in Iron Age cremation cemeteries under level ground in Finland and in burials in northern Europe in general, indicating the cremating of bear pelts in the pyre (e.g., Kirkinen 2017, with references; see also Wikborg 2005a: 171; 2005b: 141–4).

Välikangas includes nine inhumation burials, in addition to three cremations, and only in one cremation burial were there bone artefacts (two combs and at least five arrowheads). The cremation burial seemed to be a double burial of two women (at least one woman was confirmed in the osteological analysis), with an iron knife and asbestos-tempered ceramics as grave goods (Mäkivuoti 1987; 1988; 1996; Ikäheimo et al. 2004). There has been some speculation about bone arrowheads often being found especially in women's graves during the Migration Period (Ikäheimo et al. 2004). Since the sex of the person buried in Puijonsarvennenä could not be confirmed in osteological analysis, there is insufficient data to contribute to this discussion. However, issues related to different identities, and their relation to the livelihoods and agency of the people in their local communities will most likely be addressed in future archaeological research of Early Metal Period–Iron Age interior Finland.

As Janne Ikäheimo (2019: 37) has remarked, archaeological interpretation should be more about what happened in the local community, and what did they do with the things they had, rather than focusing on the mobility and origins of objects. Most probably, the iron objects in the Puijonsarvennenä burial were obtained through trade or exchange, since the dating of the site predates known ironworking sites in the vicinity. Precise proof cannot be provided if it was furs that were traded, but a lot of evidence seem to indicate that. Hunting for furs is evidenced by the bones and hair of a Mustelid animal, bone arrowheads suitable for hunting, and a knife which could be used for skinning and working on pelts. Possibly the iron spearhead was a token received in trading pelts, or was somehow an important personal object, and was therefore included in the burial.

While the archaeological material does not provide a great deal of information about the identity of the person buried in Puijonsarvennenä, that individual's death clearly meant something for the surrounding community, since someone took the time to cremate the body, perform the burial with (presumably) the usual rites, and construct the stone structures in a stunningly beautiful place on a cape visible from one of the most important waterways in the Kuopio area.

CONCLUSIONS

Archaeological excavations confirmed that the site of Puijonsarvennenä was a single cremation burial, with objects, set inside a stone structure, but not actually covered by stones, situated immediately under the turf. Based on the results of osteological analysis, radiocarbon dating, analysis of the finds, and microscopic analysis of the soil samples, as well as observations made during the excavation about the features of the structure, it can be concluded that the deceased person was most likely a member of a local hunter-gatherer population who engaged in hunting and possibly in trading furs.

The burial structure represents a tradition typical of the Early Metal Period–Iron Age population of interior and northern Finland. Similar low cairns and stone structures with cremation as the preferred burial ritual are known from a large area, from the Bronze Age until the Late Iron Age. The presence of asbestos-tempered ceramics also connects the burial to the local cultural traditions of interior Finland.

Since the cairn was totally undetectable in the landscape before the excavation, it is likely that it would not have been found, or excavated, without the coincidence of the metal detector hobbyist and the authors' survey project happening to be in Kuopio at the same time. Archaeological sites like Puijonsarvennenä are hard to find while surveying, nor are they necessarily noticed during construction work or forestry performed with heavy machinery. It is likely that there are more burials resembling Puijonsarvennenä that are still undiscovered, as well as similar sites already destroyed by the increasing building activities on the shores of Kallavesi.

In addition, there are several instances of stray finds from the areas of interior and northern Finland that could have belonged to a burial context, but the finding spot has never been archaeologically examined. If anything, the Puijonsarvennenä burial site is a reminder that a lot of undiscovered archaeological potential regarding the Early Iron Age exists in North Savo and the whole interior part of Finland.

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REFERENCES

Archival sources

Ancient Relics Register (Muinaisjäännösrekisteri), Finnish Heritage Agency. Available at <https://www.kyppi.fi/palveluikkuna/mjreki/>

Artefact Register (Muinaiskalupäiväkirja), Finnish Heritage Agency. Available at <https://www.kyppi.fi/palveluikkuna/kmloyto/>

Unpublished sources

Forss, A. & Tuovinen, O. 2001. Oulu Hangaskangas – varhaispronssikaudelle ajoittuvan hautauksen kaivaus 1998. Excavation report, Archaeology, University of Oulu.

af Hällström, O. 1939. Redogörelse för undersökningen av ett järnåldersröse på Hönsåkerskullen (Alsätra lägenhet) i

Kroggård by av Karis köping. Research report, Finnish Heritage Agency, Helsinki.
Jääskeläinen, E. 2020. Koskematonta korpeako? Uusia lähtökohtia Savon myöhäisrautakautisen paikallisasutuksen tulkintaan. M. A. Thesis, Archaeology, University of Oulu.
Jussila, T. 2002. Kuopion ympäristön: Siilinjärven Kehvo, Vuorela, Toivala, Kuopio Ranta- Toivala, NW- saaristo, muinaisjäännösinventointi 2002. Survey report, Finnish Heritage Agency, Helsinki.
Knuutinen, T. & Kunnas-Pusa, L. 2022. Kuopio Puijonsarvennenä, tarkkuusinventointi ja kaivaus, syyskuu 2019 – toukokuu 2020. Excavation report, Finnish Heritage Agency, Helsinki.
Knuutinen, T. & Kunnas-Pusa, L. forthcoming. Inventointiraportti, Iisalmi – Siilinjärvi – Kuopio. Survey report.
Kuusela, J.-M. 2011. Oulu Tahkokangas. Rautakautisen röykkiökohteen kartoitus ja lähialueiden koekaivaus syksyllä 2010. Excavation report, Archaeology, University of Oulu.
Mäkivuoti, M. 1987. Kaivauskertomus. Oulu, Kaakkuri, Välikangas 1987. Research report, Museum of Northern Ostrobothnia, Oulu.
Mäkivuoti, M. 1988. Oulu, Kaakkuri, Välikangas. Rautakautinen röykkiötutkimus 4.7.–5.8.1988. Research report, Museum of Northern Ostrobothnia, Oulu.
Mäkivuoti, M. 1996. Oulun Kaakkurin Välikankaan rautakautinen kalmisto. Lic. Phil. Thesis, Department of History, University of Oulu.
Meinander, C. F. 1938. Kuopio Haminanlahti, maakummun koekaivaus 1938. Excavation report, Finnish Heritage Agency, Helsinki.
Pohjakallio, L. 1974a. Kuopion inventointi 1974. Survey report, Finnish Heritage Agency, Helsinki.
Pohjakallio, L. 1978b. Kuopio Honkasaari. Kiviröykkiön kaivaus. Excavation report, Finnish Heritage Agency, Helsinki.
Salo, K. 2021. Osteologinen tutkimusraportti. Kuopio Kuusikkolahdenniemi KHMESIE 6154. Research report, Finnish Heritage Agency, Helsinki.
Ukkonen, P. 2003. Konnevesi Majakangas (KM 34052). Luuanalyysi 30.1.2003. Research report, Finnish Heritage Agency, Helsinki.

Literature

Arnberg, A. 2007. *Där människor, handling och tid möts: en studie av det förromerska landskapet på Gotland*. Stockholm: Stockholms universitet, Institutionen för arkeologi och antikens kultur.
Buikstra, J. E. & Ubelaker, D. H. 1994. *Standards for data collection from human skeletal remains.* Arkansas archaeological survey research series no. 44.
Carpelan, C. 1979. Om asbestkeramikens historia i Fennoscandien. *Finskt Museum* 1979: 5–25.
Edgren, T. 1969. Kotokallio in Lieto. Ein Grabfund aus der älteren Bronzezeit im Dorf Vanhalinna. *Suomen Museo* 1969: 74–84.
Edgren, T. 1992. Lavansaaren Suursuonmäen röykkiöhaudat. *Suomen Museo* 1992: 5–20.
Edgren, T. 1999. Alkavan rautakauden kulttuurikuva Länsi-Suomessa. In P. Fogelberg (ed.) *Pohjan poluilla. Suomalaisten juuret nykytutkimuksen mukaan*: 311–33. Ekenäs: Ekenäs Tryckeri Ab.
Fewster, D. 2006. *Visions of Past Glory: Nationalism and the Construction of Early Finnish History.* Helsinki: SKS.
Forsén, B. & Moisanen, J. 1993. Svartån och bebyggelsen runt denna. *Finskt Museum* 1993: 26–49.
Gejvall, N. G. 1947. Bestämning av ben från forntida gravar. Fornvännen 1947: 39–47.
Hackman, A. 1905. *Die Ältere Eisenzeit in Finnland 1. Die Funde aus den fünf ersten Jahrhunderten n. Chr*. Helsingfors: Finnische Altertumsgesellschaft.
Hakamäki, V. 2018. *Seeing behind Stray Finds: Understanding the Late Iron Age Settlement of Northern Ostrobothnia and Kainuu,* Finland. Oulu: University of Oulu.
Hakamäki, V. & Kuusela, J.-M. 2013. Examining the topography and social context of Metal Age artefact finds in Northern Finland. *Fennoscandia Archaeologica* XXX: 91–102.
Hiltunen, J. 2020. Piippaus, joka vei yli tuhannen vuoden taakse. *Savon Sanomat,* 20 May 2020.
Ikäheimo, J. 2019. Taruja herran tikarista – Oulun Hangaskankaan polttohaudan metallilöydöistä. *Muinaistutkija* 4/2019: 30–41.

Ikäheimo, J., Joona, J.-P. & Hietala, M. 2004. Wretchedly poor, but amazingly practical: Archaeological and experimental evidence on the bone arrowheads of the Fenni. *Acta Borealia* 21(1): 3–20. DOI: 10.1080/08003830410001840

Immonen, V. & Taavitsainen, J.-P. 2011. Oscillating between national and international: The case of Finnish archaeology. In L. R. Lozny (ed.) *Comparative Archaeologies: A Sociological View of the Science of the Past*: 137–77. New York: Springer.

Juntunen, R. 2015. Pakolaisjuristi Aaro Jalkanen: Koti-ikävä synnytti Kallaves' -laulun. *Lakimiesuutiset* 19.10.2015. https://lakimiesuutiset.fi/pakolaisjuristi-aaro-jalkanen-koti-ikava-synnytti-kallasves-laulun/. Read 2 March 2022.

Kirkinen, T. 2012. Myyttinen erämaan esihistoria: arkeologian erämaakäsitykset ekokriittisestä näkökulmasta. In T. Kallinen, A. Nygren & T. Tammisto (eds.) *Ympäristö ja kulttuuri:* 131–56. Helsinki: University of Helsinki.

Kirkinen, T. 2017. "Burning pelts" — brown bear skins in the Iron Age and Early Medieval (1–1300 AD) burials in south-eastern Fennoscandia. *Estonian Journal of Archaeology* 21(1): 3–29.

Kivikoski, E. 1947. *Suomen rautakauden kuvasto* 1. Porvoo: WSOY.

Kivikoski, E. 1961. *Suomen esihistoria. Suomen historia* I. Porvoo: WSOY.

Kunnas-Pusa, L. & Knuutinen, T. 2020. "Kyllä tuon sais jo polttaa kun on tuommonen rähjänä." – Kulttuuriperinnön rakentumisen ja tutkimuksen kerrostumia Pohjois-Savossa. *Suomen Museo – Finskt Museum* 2020: 110–25.

Kuusela, J.-M., Nurmi, R. & Hakamäki, V. 2016. Co-existence and colonisation: Reassessing the settlement history. *Norwegian Archaeological Review* 49(2): 177–203. DOI: 10.1080/00293652.2016.1260048.

Kuusela, J.-M., Vaneeckhout, S. & Okkonen, J. 2010. Places of importance and social communication: Studying the Pre-Roman cairn field of Viirikallio in Laihia, Finland. *Estonian Journal of Archaeology* 14(1): 22–39.

Kvaal, S. I., Kolltveit, K. M., Thomsen, I. O. & Solheim, T. 1995. Age estimation of adults from dental radiographs. *Forensic Science International* 74(3): 175–85.

Langley, M. C., Pétillon, J.-M. & Christensen, M. 2016. Diversity and evolution of osseous hunting equipment during the Magdalenian (21,000–14,000 BP). In M. Langley (ed.) Osseous Projectile Weaponry: Towards *an Understanding of Pleistocene Cultural Variability:* 143–58. Vertebrate Paleobiology and Paleoanthropology. Dordrecht: Springer. DOI: 10.1007/978-94-024-0899-7_10.

Lavento, M. 1999. An iron furnace from the Early Metal Period at Kitulansuo in Ristiina, in the southern part of the Lake Saimaa water system. *Fennoscandia Archaeologica* XVI: 75–80.

Lavento, M. 2015a. Pronssi- ja varhaismetallikausi. In G. Haggrén, P. Halinen, M. Lavento, S. Raninen & A. Wessman (eds.) *Muinaisuutemme jäljet. Suomen esi- ja varhaishistoria kivikaudelta keskiajalle*: 125–211. Helsinki: Gaudeamus.

Lavento, M. 2015b. Sisämaan asutus ja kulttuuri varhaismetallikauden lopulla (500 eaa.–300 jaa.). In G. Haggrén, P. Halinen, M. Lavento, S. Raninen & A. Wessman (eds.) *Muinaisuutemme jäljet. Suomen esi- ja varhaishistoria kivikaudelta keskiajalle*: 228–230. Helsinki: Gaudeamus.

Lehtosalo-Hilander, P.-L. 1986. Luistarin röykkiöhauta – kivi-, pronssi-, rautakautinen mysteeri. *Studia praehistorica Fennica C. F. Meinander septuagenario dedicata.* Iskos 6: 53–66. Helsinki: Finnish Antiquarian Society.

Lehtosalo-Hilander, P.-L. 1988. Esihistorian vuosituhannet Savon alueella. In P.-L. Lehtosalo-Hilander & K. Pirinen (eds.) *Savon historia 1. Esihistorian vuosituhannet ja keskiaika*: 11–264. Kuopio: Kustannuskiila.

Lozovskaja, O. & Lozovski, V. 2019. Bone and antler projectile points from the Meso-Neolithic site Zamostje 2, Moscow region, Russia. In D. Groß, H. Lübke, J. Meadows & D. Jantzen (eds.) *Working at the Sharp End: From Bone and Antler to Early Mesolithic Life in Northern Europe*: 341–66. Kiel/Hamburg: Wachholtz Verlag.

Luik, H. 2006. For hunting or for warfare? Bone arrowheads from the Late Bronze Age fortified settlements in Eastern Baltic. *Estonian Journal of Archaeology* 10(2): 132–49.

Marila, M. 2018. Finnish reactions to new archaeology. *Fennoscandia Archaeologica* XXXV: 19–47.

Meinander, C. F. 1969. Dåvits. En essä om förromersk järnålder. *Finskt Museum* 1969: 27–69.
Meinander, C. F. 1985. Akozino, Achmylovo och Mälaryxorna. *Finskt Museum* 1985: 15–34.
Moilanen, U. & Raninen, S. 2022. Merovingiaikainen polttohauta Kihniön Pyhäniemessä. *Muinaistutkija* 2/2022: 24–31.
Muhonen, T. 2009. Something old, something new: Excursions into Finnish sacrificial cairns. *Temenos – Nordic Journal of Comparative Religion* 44(2): 293–346.
Nordqvist, K. & Mökkönen, T. 2021. Pöljä ware: Properties, dating and regional variation. *Fennoscandia Archaeologica* XXXVIII: 29–58.
Nykänen, H. 2020. Harrastaja teki merkittävän löydön Kuopiossa: tutkimuksissa varmistuu, onko kyse Pohjois-Savon ensimmäisestä rautakauden haudasta. *Yle Uutiset* 23 May 2020. <https://yle.fi/uutiset/3-11364704>. Read 4 February 2022.
Nylén, E. 1979. Goterna, Gotland och Gutasagan. In W. Falck, E. Nylén, K. Nylén, K. Schönbeck & K. Svahnström (eds.) *Arkeologi på Gotland. Gotlandica* 14. Visby: B. Press.
Okkonen, J. 2003. J*ättiläisen hautoja ja hirveitä kiviröykkiöitä – Pohjanmaan muinaisten kivirakennelmien arkeologiaa.* Oulu: University of Oulu.
Olsen, J., Heinemeier, J., Hornstrup, K. M., Bennike, P. & Thrane, H. 2013. 'Old wood' effect in radiocarbon dating of prehistoric cremated bones? *Journal of Archaeological Science* 40(1): 30–4.
Pesonen, P. 2021. *Continuity and Discontinuity in Early, Middle and Late Neolithic Pottery Types of Eastern Fennoscandia. Reflections from Bayesian Chronologies.* Helsinki: University of Helsinki.
Pihlman, S. 1992. Problems of ethnicity relating to the Migration and Early Merovingian Periods in Finland. In V. Lang & J. Selirand (eds.) *Cultural Heritage of the Finno-Ugrians and Slavs. Papers presented by the participants in the Soviet-Finnish archaeological symposium* 10–16 May 1990 in Tallinn: 41 – 61. Tallinn: Varrak.
Pihlman, S. 2004. Väestöräjähdys historiallisen ajan taitteessa? Voisiko aineistoja tulkita toisinkin? *ABOA. Turun maakuntamuseon vuosikirja* 66–67/2002–2003: 47–98.
Pohjakallio, L. 1974b. *Pohjois-Savon esihistoriallisten kohteiden arkistoinventointi.* Kuopio: Pohjois-Savon seutukaavaliitto.
Pohjakallio, L. 1978a. Kuopion muinaisuus esihistoriallisten löytöjen valossa. *Aarni* 17: 7–33.
Pohjakallio, L. 1978c. Siilinjärven autiorannan lapinraunio ja sen alainen kuppikallio. *Aarni* 17: 103–17.
Raninen, S. 2005. Tuskan teatteri Turun Kärsämäessä. Ajatuksia ja sitaatteja roomalaisesta rautakaudesta. 1. osa: Maarian Kärsämäki ja Itämeren maailma. *Muinaistutkija* 4/2005: 40–71.
Raninen, S. 2013. Arkeologinen kaivaus Pirkkalan Tursiannotkon rautakautisella asuinpaikalla. *Pirkan maan alta* 13: 8–19.
Raninen, S. & Wessman, A. 2015. Rautakausi. In G. Haggrén, P. Halinen, M Lavento, S. Raninen & A. Wessman (eds.) *Muinaisuutemme jäljet. Suomen esi- ja varhaishistoria kivikaudelta keskiajalle*: 215–365. Helsinki: Gaudeamus.
Rinne, J. 1947. Esihistoria muinaislöytöjen valossa. In M. Ruuth, L. Harmaja, I. Salomies, K. Teräsvuori & H. Waris (eds.) *Savon historia, 1 osa. Esihistoria ja keskiaika*: 1–38. Kuopio.
Ruengdit, S., Case, D. T. & Mahakkanukrauh, P. 2020. Cranial suture closure as an age indicator: A review. *Forensic Science International* 307: 110–1.
Rydh, S. 1968. Ett gotländskt fynd av benpilspetsar från bronsåldern. *Fornvännen* 3/1968: 153–65.
Saipio, J. 2015. Bronze Age cairns in the Finnish lake district: Cultural contacts, creative translations and local traditions. In P. Suchowska-Ducke, S. Scott Reiter & H. Vandkilde (eds) *Forging Identities. The Mobility of Culture in Bronze Age Europe. Report from a Marie Curie Project 2009–2012 with Concluding Conference at Aarhus University, Moesgaard 2012,* Vol. 2: 123–31. Oxford: British Archaeological Reports.
Saipio, J. 2018. Ritualisation of landscape in the Finnish Lake District during the Early Metal Period: The Forms and landscape settings of Early Metal Period burial cairns. In P. Kouki & T. Kirkinen (eds.) *Landscapes of the Past*

and Future: Current Finnish Research in Landscape Archaeology. MASF 6: 45–68. Helsinki: The Archaeological Society of Finland.

Salminen, T. 2003. *Suomen tieteelliset voittomaat. Venäjä ja Siperia suomalaisessa arkeologiassa 1870–1935*. SMYA 110. Helsinki: The Finnish Antiquarian Society.

Salminen, T. 2006. Searching for the Finnish roots – archaeological cultures and ethnic groups in the works of Aspelin and Tallgren. In V.-P. Herva (ed.) *People, Material Culture and Environment in the North. Proceedings of the 22nd Nordic Archaeological Conference*, University of Oulu, 18–23 August 2004: 26–32. Oulu: University of Oulu.

Salmo, H. 1953. En handelsdepå från romersk tid från Pernå. *Finskt Museum* 1953.

Salo, K. 2016. *Health in Southern Finland: Bioarchaeological Analysis of 555 Skeletons Excavated from Nine Cemeteries (11th–19th Century AD)*. Helsinki: University of Helsinki.

Salo, U. 1968. *Die frührömische Zeit in Finnland.* SMYA 67. Helsinki: The Finnish Antiquarian Society.

Salo, U. 1984. On the Weaponry of the Early Roman Period in Finland and neighbouring areas. *Iskos* 4: 83–92. Helsinki: The Finnish Antiquarian Society.

Soikkeli-Jalonen, A. 2021. Bronze Age bronze objects in Finland – An update. *Fennoscandia Archaeologica* XXXVIII: 73–110.

Soikkeli-Jalonen, A. & Oksanen, E. 2015. Hautaustavat esiroomalaisella rautakaudella (500 eaa. – 0). *Kalmistopiiri* 18 November 2015. <https://kalmistopiiri.fi/2015/11/18/hautaustavat-esiroomalaisella-rautakaudella-500-eaa-0/>. Read 23 May 2022.

Tallgren, A. M. 1931. Suomen historia 1. Suomen muinaisuus. Helsinki: WSOY.

Teerink, B. J. 2003. *Hair of West-European Mammals: Atlas and Identification Key.* Cambridge: Cambridge University Press.

Tóth, M. 2017. *Hair and Fur Atlas of Central European Mammals.* Nagykovácsi, Hungary: Pars Ltd.

Väänänen, J. 2012. Tahkokankaan värikkäät latomukset – Uuden tutkimusmenetelmän esittely ja ensimmäiset tutkimustulokset. In S. Niinimäki, A.-K. Salmi, J.-M. Kuusela & J. Okkonen (eds.) *Stones, Bones & Thoughts. Festschrift in Honour of Milton Núñez*: 76–87. Oulu: Milton Núñezin juhlakirjan toimituskunta.

Vanhatalo, S. 2005. Konneveden Majakankaan rautakautinen polttohauta. *Kentältä poimittua. Kirjoitelmia arkeologian alalta* 6: 96–102. Helsinki: Museovirasto.

Walker, P. L., Miller, K. W. P. & Richman, R. 2008. Time, temperature, and oxygen availability: An experimental study on the effects of environmental conditions on the color and organic content of cremated bone. In C. W. Schmidt & S. A. Symes (eds) *The Analysis of Burned Human Remains*: 129–36. London: Elsevier.

Wegelius, H. E. 1878. Muinaisjäännöksiä Kuopion kihlakunnassa. *SMYA* III: 109–43.

Wessman, A. 2010. *Death, Destruction and Commemoration. Tracing Ritual Activities in Finnish Late Iron Age Cemeteries (AD 550–1150)*. Iskos 18. Helsinki: The Finnish Antiquarian Society.

Wikborg, J. 1996. Skelettgravarna på Bastubacken. Skelettgravskicket i Mälardalen under romersk järnålder. *TOR* 28: 105–52.

Wikborg, J. 2005a. En krigares grav. Förromersk begravning i Holmsmalma. In L. Karlenby (ed.) T*idens resenärer. Arkeologiska händelser längs vägen mellan Köping och Kolsva:* 169–84. Stockholm: Riksantikvarieämbetet.

Wikborg, J. 2005b. Bärsärkar och magiskt järn. Om föremålen i de förromerska gravarna vid Holmsmalma. In L. Karlenby (ed.) *Tidens resenärer. Arkeologiska händelser längs vägen mellan Köping och Kolsva*: 141–52. Stockholm: Riksantikvarieämbetet.

Zhilin, M. G. 2019. Early Mesolithic barbed bone points in the Volga–Oka interfluve. In D. Groß, H. Lübke, J. Meadows & D. Jantzen (eds.) *Working at the Sharp End: From Bone and Antler to Early Mesolithic Life in Northern Europe*: 319–39. Kiel/Hamburg: Wachholtz Verlag.

NOTES

[1] The lyrics of the song "Kallavesj'" were written in the local North Savo dialect by diplomat and lawyer Aaro Jalkanen (1875–1960) in 1916. The words were set to the melody of an Estonian song composed by Johannes Kappel (Juntunen 2015).

[2] "*Näyttää varmalta, ettei esiroomalainen rautakausi ole ollut Suomessa mitenkään merkittävä. Sen jälkeinen aika merkitsee ratkaisevasti uutta: kiinteän talonpoikaisväestön alkua, metsästäjä-kalastaja-asteen vähittäistä häviämistä ja maan lopullista kolonisaatiota.*" Translated by L. Kunnas-Pusa.

[3] The mapping and measuring were done with University of Helsinki GPS equipment (measuring accuracy of < 5 cm, coordinate system ETRS GK27, and elevation system N2000).

[4] The dating report is included in the research report of the excavation (Knuutinen & Kunnas-Pusa 2022).

[5] A Lapp cairn is a term used in Finnish archaeology to designate Early Metal Period–Iron Age cairns situated in the interior and northern part of Finland. In comparison to the "real" Bronze Age cairns of coastal Finland, the Lapp cairns are often considered to be smaller and more ambiguous. The term has been used from the 18th century onwards. Since it seems to connect the cairns with the Sámi, previously referred to as Lapps (now considered derogatory), the discussion about the ethnicity of the builders of these structures, as well as the conceptualization and categorization of them has a long and winding history (see e.g., Okkonen 2003: 44–50; Saipio 2015; 2018).

Hanna-Leena Puolakka & Jari-Matti Kuusela

BURIAL PRACTICES IN NORTHERN SWEDEN, NORTHERN FINLAND AND THE WHITE SEA COAST BETWEEN THE 9TH AND 16TH CENTURIES AD: ADAPTATION OF PRACTICES IN A DECENTRALISED NETWORK

Abstract

This paper presents an overview of known burials and burial practises in the region comprising of present-day Northern Finland, Sweden, the Murmansk oblast and the White Sea coast in Northwest Russia during the study period, the Late Iron Age and Middle Ages (ca. 800–1600 AD). Burial sites offer a unique perspective on examining social structures and social change, as they are focused on the present of the community while still being rooted in tradition. We discuss how these burials represent the multicultural environment and the fluidity of adaptation of cultural features in the north, as well as the distinct similarities between the communities. We will also examine how the decentralised network, that the northern Fennoscandian communities formed, caused and maintained this multicultural environment during the Late Iron Age and the Middle Ages.

Keywords: Burials, Late Iron Age, Middle Ages, Northern Fennoscandia, adaptation, decentralised network

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INTRODUCTION

In this paper, we present an overview of the known burial practices in the region comprising present-day Northern Finland, Sweden, Murmansk oblast and the White Sea coast in Northwest Russia (Fig. 1; we will henceforward refer to this region with the term Northern Fennoscandia) between the 9th and 16th centuries AD. We discuss how they represent the culturally variable environment of the North and the fluidity of the adaptation of practices, on the one hand, and at the same time certain similarities between the communities, on the other hand. We will also examine how the decentralised network, which the Northern Fennoscandian communities formed, caused and maintained this variable environment during the Late Iron Age and the Middle Ages.

The Late Iron Age and Middle Ages of Northern Fennoscandia (Fig. 1) – i.e., the period between the 9th and 16th centuries AD following the periodisation used in the present paper (see below) – have until recently been in many ways a problematic period to study mostly due to the scarce and fairly poorly understood archaeological record. In the past, scholarly studies have relied on a retrospective method where the situation of the Late Iron

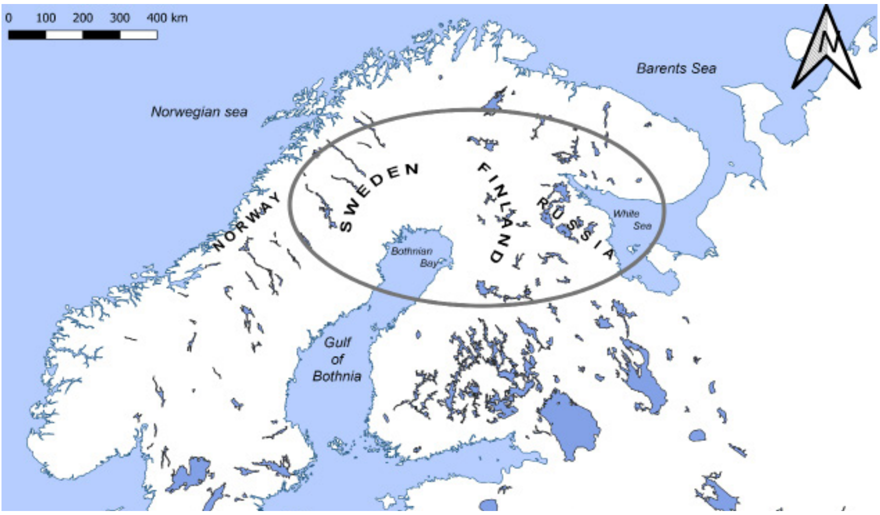

Figure 1. Study region.

Age and early medieval period has been reconstructed based on the few earliest literary sources, later 16th century sources and onomastic studies, and then applying archaeological – primary artefactual – evidence to the narrative (e.g., Vahtola 1980; Huurre 1983: 414–9; Julku 1986). To simplify this, all these enquiries have followed a general pattern of interpretation where Northern Fennoscandia has been utilised as a usufruct by people from the regions of Southern Finland, Sweden or Karelia now in Northwest Russia. Finally, the coastal regions – specifically the Bothnian Bay coast – were colonised by these southern communities, whereas the inland dwellers were either gradually pushed back or otherwise exploited by these southern colonists. Characteristic for these studies is the inherently passive role and the lack of agency ascribed to local northern communities.

In recent years, focused archaeological research has resulted in a need to revise conceptions regarding the period (see e.g., Kuusela 2015; 2018; 2020a; 2020b; Bergman & Edlund 2016; Hakamäki 2016; 2018; Kuusela et al. 2016; 2018; 2020; Ikäheimo et al. 2017; Bergman 2018; Bergman & Ramqvist 2018; Murashkin & Kolpakov 2019; Nurmi et al. 2020; Puolakka 2020). Specifically, the view of the Late Iron Age and Medieval North as a usufruct of southern agricultural communities with little significant cultural input from local communities has been severely criticised (e.g., Kuusela 2015; 2020b; Bergman & Edlund 2016; Kuusela et al. 2016; 2018; Hakamäki 2016; 2018; Ikäheimo et al. 2017; Puolakka 2020). As the local character of the northern communities has become evident, so has the observation that, although they clearly differ from the southern communities, they also exhibit considerable local variation indicating that the northern communities did not form a homogeneous group (Kuusela 2020b). This is most evident in the burial forms in use in Northern Fennoscandia during the study period.

For this reason, we will also eschew the – what may be called a traditional – way of examining the North, meaning a comparison of the "cultural spheres", often condensed into what in essence is a binary opposition between a farming society and a hunting society. To start with, there is scant evidence of a farming society present in the study area during much of the examined period (see Nurmi et al. 2020 for a detailed examination), but more importantly, we do not feel that this perspective is fruitful in the examination of the northern prehistoric and medieval communities precisely because these northern groups do not form a unified and homogeneous "culture group". Instead, we will examine the archaeological evidence without predetermined premises of what cultural groups they should represent. In our view, this opens the most fruitful avenue of examination fully appreciating the variation evident in the North during the study period and shifts the focus of examination to the northern groups themselves and not to the external factors outside their purview.

Chronological notes

This paper is mostly concerned with the time period between the 9th and 16th centuries in the territories of present-day Finland, Sweden, and Northwest Russia presenting terminological challenges in regard to chronology. The definition of the Viking Age is fairly uniform with the period beginning at the onset of the 9th century and lasting until the early 11th (e.g., Helle 2003). In Sweden, the 11th century marks the beginning of the Middle Ages (Helle 2003). In Northwest Russia, the Middle Ages are considered to begin at the end of 10th century and last until the late 16th century (Martin 1995; Karpov 2003).

In Southwest Finland, the Viking Age is followed by the Crusade Period lasting from the early 11th century until the mid-12th century after which the Early Middle Ages are conventionally set to begin (e.g., Haggrén 2015: 369–70). In Southeast Finland, the Crusade Period lasted until the early 14th century after which the Middle Ages began (Haggrén 2015: 370–5). In Northern Finland, the chronology is far more indistinct, and some scholars maintain that the very Northernmost regions did not have a medieval period at all but rather existed in a state of prehistory until the early modern period (Haggrén 2015: 370). However, at least the coastal regions of the Bothnian Bay area can be said to enter a medieval period by the 14th century from which time the earliest literary sources regarding ecclesiastical organisations in the area are known (Lavery 2006: 25–8).

As no unified chronological terminology conforming to the conventions of the study region as a whole exists, for reasons of convenience of presentation, we have chosen to follow the periodisation used for Southeast Finland, since the same conditions mostly apply in Northern Scandinavia. Thus, we will use the term Viking Age when referring to the period between the 9th and early 11th century, the Crusade Period when referring to the period between the early 11th century and 14th century, the Late Iron Age when referring to the whole period between the 9th and 14th century and, finally, the Middle Ages when referring to the time between the early 14th and 16th century. We acknowledge this as a shorthand but it is a necessary one for a fluid representation.

NORTHERN FENNOSCANDIAN COMMUNITIES IN THE LATE IRON AGE

If looking from the centres of Europe, Northern Fennoscandia is in a peripheral and difficult to reach region. Nevertheless, due to the general intensification of trade and contacts in Europe beginning at the onset of the Viking Age in the 9th century, Northern Fennoscandia saw an increase in activity at the same time, which is archaeologically visible in the increasing number of sites and finds originating from the West, South and East during the period (e.g., Kuusela 2013a: 76–88; 2014). The interest in the North for Europe was due to the northern wildlife and its commercial value – fish increased in importance in Europe during the 9th century (e.g., Wallerström 1983: 33–44; 1995: 129; Martin 1986; 1995: 134–40; Makarov 1991: 73–8; Sawyer & Sawyer 1993: 158–9; Barrett et al. 2011; Star et al. 2017; Barrett 2018; Kuusela et al. 2020) and furs were also valued. In addition, reindeer meat, pelts and antlers have been northern trade commodities (e.g., Pilø et al. 2018; Salmi & Heino 2019; Kuusela et al. 2020). This increase in trade naturally caused an increase in the contacts between different areas. This in turn increased the influx of new ideas and practices which can be seen in the burials of the region.

BURIAL PRACTICES BETWEEN THE 9TH AND 16TH CENTURIES

Burials in the study region (Fig. 2) are divided into two basic types: cremations and inhumations. Most of the cremations have been found in the Finnish side of the study region with only three cremations in the period and region covered in this paper which are currently known to be outside of Finland – two in Sweden and one possible case in the Kola Peninsula in Russia. Although appearing on the Swedish side more frequently prior to the 9th century, cremations appear to be rare post-9th century (Hedman 2003: 93–4). Inhumations, in turn, have mostly been found on the Western – i.e., Swedish – side, but they do appear on the Eastern side of the Bothnian Bay as well as on the coast of the White Sea. In addition to these two, a third form of sorts are burial sites where both burial practices appear, and currently three such cases are known – Kyrkudden on the Swedish side of the Tornionjoki river as well as Valmarinniemi and Suutarinniemi on the Bothnian Bay coast, all being coeval with each other (Fig. 2).

In the following, we will briefly examine the burials based on their various features when applicable. These include structural features, body placement, cremated bone distribution and grave goods. Due to the highly variable nature of the material, the following may appear as a fairly confusing treatise and the reader is strongly encouraged to refer to Appendix 1 for a collated overview.

Structural features

The structural features of the burials vary considerably, and no clear pattern can be found. As we can see in Appendix 1, both cremations and inhumations occasionally include structures made out of stones or timber.

A relatively common but varied form of inhumation burial is a singular burial incorporating a stone structure of some form and these appear to have been common in the inland regions throughout the study period (see Schanche 2000; Hansen & Olsen 2014: 107–14). One such example is the Tärna 195:1 burial (Storuman, Västerbotten, Sweden) documented by the Swedish ethnologist Ernst Manker (1961: 156–60) in 1950 when he conducted a small investigation of the site but it was properly excavated and radiocarbon dated in 2001 (Heinerud 2002). This burial is an inhumation where the deceased – together with grave goods – was laid in a cist constructed into a shallow bedrock hollow on the ground. Instead of soil, flat stone slabs were used to cover the body (Manker 1961: 157; Heinerud 2002: 7–8). Radiocarbon dating (Appendix 2) offers a wide margin placing the burial to between the 14th and early 17th centuries. The Skäran (officially Nysätra 240:1, located in Skellefteå, Västerbotten, Sweden) inhumation cemetery in turn consists of burial cairns or stone settings, where the deceased have been laid on top of the ground surface and covered with a burial cairn, with at least one burial also including a cist (Larsson & Rathje 2001; Rathje 2003).

1 = Anzersky Island (12th-14th century)
2 = Arjeplog 301:1 (14th-16th century)
3 = Arjeplog 3135 (9th-11th century)
4 = Arvidsjaur 2140:1 (9th-11th century)
5 = Byske 67:2 (9th-11th century)
6 = Godejaure (15th-17th century)
7 = Gutuberget nära Forsbäck (14th-16th century)
8 = Heinisaari (8th-10th century)
9 = Hiukka (11th-14th century)
10 = Ii Illinsaari Suutarinniemi (11th-14th century)
11 = Iin Hamina (15th-16th century)
12 = Iso Märäntö (11th-12th century)
13 = Jokkmokk 24:1 (11th-14th century)
14 = Jukkasjärvi 533:1 (11th-14th century)
15 = Kivisaari (11th-12th century)
16 = Kuzomen 1 (11th-12th century)
17 = Kuzomen 2 (12th-13th century)
18 = Kyrkudden (10th-17th century
19 = Skellefteå stad 179:1 (10th-11th century)
20 = Skäran (10th-15th century)
21 = Sotatalval 3 (9th-10th century)
22 = Tärna 195:1 (14th-16th century)
23 = Valmarinniemi (11th-15th century)
24 = Vanha kirkko (15th-17th century)
25 =Viinivaaran itäpää (9th-10th century)
26 = Vilhelmina 1:1 (7th-11th century)
27 = Överluleå 436:1 (11th-14th century)

Figure 2. The examined burials in the study region.

Some stone structure burials were made in natural boulder fields, such as the singular inhumation on Anzersky island (Martynov 2010) and the Viinivaara Itäpää cremation burial, in which the natural boulder field had been modified by building a low, but perceptible, stone setting on the site of the burial, becoming visible only after de-turfing (Hakamäki et al. 2013: 5). The Anzersky burial within the boulder field for its part seems to have been a preferred choice, since a nearby sandy beach could have been used instead like in the Kuzomen inhumation burials discussed later.

The Skellefteå stad 179:1 (Skellefteå, Västerbotten, Sweden) cremation cemetery consists of three low and difficult to perceive stone settings built on top of bedrock niches on a rocky hill (Östlund 1996). The burials were deposited below ground level in a concentration typically measuring a few dozen centimetres in diameter. Radiocarbon dating to the Viking Age implies contemporaneity with Arvidsjaur 2140:1 and several of the Finnish burials (Appendix 2).

The dating range of the burials using stone structures is wide, as most appear to belong to the Middle Ages – i.e., between the 14th and 16th centuries – a few cases are older. The Finnish part of the study region currently lacks known burials using stone structures. While it is possible this reflects a research lacuna rather than an actual phenomenon, this distinction is nevertheless notable. In 2021, a stone structure, which might be a burial, was inspected (Kuusela 2021) in Savukoski (Lapland, Finland) but the function and dating of the feature remains unknown at this time.

Timber burial structures are a rarer feature compared to stone structure burials, and they are found only within cemeteries of the study region: Kyrkudden, Kuzomen II and Vanha Kirkko. All these cemeteries date to the Crusade Period or after. In Kyrkudden (officially Hietaniemi 83:1 and 326:2, in Övertorneå, Norrbotten, Sweden), inhumations have been placed on the ground surface or in timber burial chambers and covered with a burial cairn (Wallerström 1995). Two out of the four cremations in Kyrkudden have been buried individually in chambers as described hereinabove, while two have been incorporated into inhumations. Only one of the cremations contained grave goods (Wallerström 1995: 155, 158). In Kuzomen II (on the bank of Varzuga river on Kola peninsula, Russia), the inhumations were made in shallow graves containing timber burial structures (Ovsyannikov & Ryabinin 1989). The Vanha kirkko cemetery in Hailuoto, Finland diverges from the others in that it incorporates timber structures containing several inhumations (Paavola 1991: 24–31). In some cases, it is possible that wooden structures have not survived, which might be the case in Kuzomen I. This cemetery was found mostly destroyed with the burials and grave goods scattered along the sandy beach where the site was located. No signs of grave structures were recorded on the site. The grave goods and dating were similar to Kuzomen II with object typology as well as a coin dating the site to the Crusade Period, more specifically the 12th–13th centuries (Ovsyannikov & Ryabinin 1989; Gurina 1997).

Sotataival "ochre graves"

Perhaps the most curious case among the burials is the possible red ochre inhumation burials that seemingly date to the Late Iron Age. In 2021, a group of metal detectorists came upon a group of Late Iron Age artefacts 70 m South of the Sotataival 3 cremation in Savukoski (Lapland, Finland). A rescue excavation on the site later the same year revealed features that are somewhat reminiscent of red ochre burials (Mikkola 2021). This can be considered to be fairly curious as red ochre burials mostly date to the Stone Age yet the grave goods from these possible burials are from the Late Iron Age. The problem is that the detectorists very thoroughly disturbed the contexts of the site and during the excavation it could no longer be safely verified whether the artefacts found were actual burial deposits or, for example, deposits into earlier Stone Age burials. Considering that the artefacts can be established to have been found in the features, it does seem possible that they might truly be red ochre burials dating to the Late Iron Age. However, two of the iron artefacts, a fragmented knife and an arrowhead, exhibit clear fire patina and one of the glass beads also shows signs of minor fire-damage indicating they have been on a pyre or in contact with fire. No signs of a cremation nor cremated bones were found during the excavation, so a later deposit into Stone Age burials, or something else cannot be ruled out either. If the features are burials dating to the Late Iron Age, they would represent at the moment a fairly unique form of inhumation burial in a Late Iron Age context.

Burial placement

In some cremation burials, covering the burial was apparently not done at all and there appears to have been very little – if any – structures associated with them. For example, the singular cremation burials in Heinisaari, Iso Märäntö, Sotataival 3 and Tyynelänranta in Finland seem to have been made directly on top of the ground, or very near the surface with no cover or discernible structures and/or markers. The use of wooden structures made on top of the ground, which would have left few observable traces, is possible but cannot be verified. Nevertheless, some burials might indicate the use of such – for example, the singular cremation of Heinisaari, where the grave goods were found scattered directly beneath the topsoil around the grave, perhaps implying that they might have been originally resting on a structure which had since deteriorated (Hakamäki 2018: 42–3).

Some of the singular burials were made beside a prominent boulder, such as the cremation in Kivisaari (Suomussalmi, Kainuu, Finland). This burial was found by two local boys while they were digging at the site and, as a result, the cremation was largely destroyed prior to the rescue excavation. The burial was deposited beside a large boulder into a depth of 15–20 cm with no structures observed (Huurre 1973: 82; 1983: 390). The burial contained a handful of cremated human bones, recovered from soot-stained pockets, and grave goods most of which had been damaged by fire (Huurre 1973: 85) and had thus been on the pyre. Based on artefact typology, this burial has been dated to the Crusade Period (Huurre 1973: 85; 1983: 390).

Body position

The Hiukka burial (Rovaniemi, Lapland, Finland) is a singular inhumation without visible structures. The buried individual was laid in a North-South-oriented grave in the flexed position (Jarva et al. 2001: 31–2). The grave had been partly destroyed during the historical period by a horse burial (likely dating to the 19th century), but roughly half of the burial was intact so the general layout of the grave could be reconstructed. Radiocarbon dating places the burial to the Crusade Period (Appendix 2). The flexed position could also be verified in the case of the buried individual within the singular burial on Anzersky island (Martynov 2010). In other singular inhumation burials, the body position cannot be reconstructed so it is impossible to determine whether the flexed placement of the body within singular inhumations was common to some regions and uncommon for others. Some burials with individuals in flexed position are known from Southern Finland, though it is not common there either (Moilanen 2021: 49–50).

The cemeteries of Ii Illinsaari Suutarinniemi (Ii, Northern Ostobothnia, Finland), Keminmaan Valmarinniemi (Keminmaa, Lapland, Finland), Iin Hamina (Ii, Northern Ostrobothnia, Finland), Kuzomen II (Kuzomen, Murmansk Oblast, Russia) and Hailuoto Vanha kirkko (Hailuoto, Northern Ostrobothnia, Finland) are inhumation cemeteries where the dead have been laid in the supine position into mostly East–West-oriented graves, and their hands laid either on their mid-region or straight on their sides (Ovsyannikov & Ryabinin 1989; Paavola 1998; Kallio-Seppä et al. 2011; Kuusela 2015; Ikäheimo et al. 2017). The Vanha kirkko, Iin Hamina and Kuzomen II cemeteries lack the cremation burials that are present in both Suutarinniemi and Valmarinniemi. In Suutarinniemi and Valmarinniemi, the cremations appear to be inherently associated with inhumations as they are often either found directly integrated into inhumations, or otherwise in close proximity to them (see Kuusela 2015: 19–24; Ikäheimo et al. 2017: 104; Puolakka 2020: 20–2). Both the Vanha kirkko and Iin Hamina cemeteries are younger than Suutarinniemi and Valmarinniemi as Vanha kirkko should be dated to the early to mid-15th century (Ikäheimo 2018b: 115) and Iin Hamina to the late 14th to 16th century (Kallio-Seppä 2011) at the earliest by which time the cremation burial practice seems to have largely been abandoned.

Bone distribution within cremations

Bone distribution in cremation graves generally follows three different patterns: the cremated bones were scattered over an area, the cremated bones were laid in one clearly lined deposition indicating the use of a container for the cremated bones or the cremation was deposited in several smaller depositions. However, these types do not follow any periodical or geographical pattern. The amount of bone material within the depositions also differs. Some of the cremations have only tens or hundreds of grams of bones, and some seemingly nearly all of the bone material as a human body, when cremated, is normally reduced to 1.2–3 kg of burnt bone (McKinley 1993).

For example, in Viinivaaran itäpää the excavation of the burial site revealed a cremation deposited near the rocky peak of the ridge with fragments of cremated bone and ashes from the pyre scattered in between the rocks in a loosely centralised manner (Hakamäki 2016: 36). The total amount of recovered cremated bone totalled 0.3 kg and, therefore, only a part of the remains had been deposited in the burial. Radiocarbon analyses indicate a dating between the 8th and 11th centuries (Table 2). Two cremations in the study area bear similarities to Viinivaaran itäpää. In the 12th century cremation of Iso Märäntö (Suomussalmi, Kainuu, Finland), the cremated bones (0.85 kg in total) were scattered over an area of several square metres. However, the Iso Märäntö burial was not deposited into a boulder field (Finnish Heritage Agency 2015; Hakamäki & Anttonen 2017). Likewise, the cremation of Sotataival 3 (Savukoski, Lapland, Finland) was not associated with a stone structure, but rather the bones were scattered over a few square metres of level ground with grave goods – most of which had apparently been on the pyre – either dug into a pit below the bone deposition or placed in their midst (Esa Mikkola pers.comm.).

The cremation on Heinisaari island in Lake Kiantajärvi (Suomussalmi, Kainuu, Finland), at a distance of 850 m from the previously mentioned Iso Märäntö, was deposited into a sandy and level ground patch near the shore and on the southern side of the island. It consisted of a concentration of 0.4 kg of cremated bone fragments and associated grave goods (Hakamäki 2018: 42–3). The bones had been placed on top of the ground in a relatively clear-bordered concentration indicating the use of an organic container, which would not have left archaeologically observable traces (Hakamäki 2018: 44).

The Arvidsjaur 2140:1 (Arvidsjaur, Norrbotten, Sweden) cremation was a structureless burial below ground level with bones of at least two individuals – an adult and a child between 5 and 14 years of age – identified (Hedman 2003: 92–3). The bones were found in small, concentrated pockets (Hedman 2003: 91 Fig. 3:36), but not in a single concentration as in Heinisaari, nor scattered over a larger area, as in Viinivaara.

The cremations in the Suutarinniemi (Ii, Northern Ostrobothnia, Finland) and Valmarinniemi (Keminmaa, Lapland, Finland) cemeteries are similar to each other. All of the above-mentioned types of cremations (singular concentration, several deposits, scattered) were found within the inhumations. The cremations date primarily to the Crusade Period. Most of the cremations were deposited in graves alongside the inhumations, where the cremated bones, and occasionally associated grave goods, have been placed possibly in an organic container given the concentrated distribution of the cremated remains. The burials contain varied amounts of cremated remains, occasionally enough to make it plausible that most, if not all, of the bones have been buried. Cremation 1 in Suutarinniemi contained 0.7 kg of bones and Cremation 2 in turn 1.3 kg, whereas the Valmarinniemi burials contained only between 0.3 and 1.4 kg of cremated remains though mostly below 1 kg (Ikäheimo et al. 2017: 84). It is, however, notable that some burials in Valmarinniemi included the remains of several individuals (Kuusela 2013b: 6; Ikäheimo et al. 2017: 88–90, 94–6).

Other possible cases of cremation

A fairly large number of other likely cases of cremation, which have either not been excavated or which have been so severely damaged when the site was excavated that specific details can no longer be reconstructed, are known specifically on the Finnish side of the study region. A significant majority of these have been found by metal detectorists especially in the region of Kainuu and more are found each year.

One possible cremation is currently known in the Kola peninsula. The site Liva 1 is located on the northern bank of Lake Verkhneye Chalmozero near river Liva. Some of the archaeological structures had been disturbed by wartime features, such as trenches and dugouts. The site was originally found by a local resident who further disturbed the context. The site contains seven rectangular hearths as well as some destroyed, unclear features. It is possible that some of the personal objects found further away from the hearths were a part of a burial, disturbed by the wartime features (Murashkin & Kolpakov 2019).

Grave goods

Most of the studied graves and cemeteries include grave goods of some sort. Nevertheless, variation is evident; grave goods were rare in Kyrkudden and Valmarinniemi burials, and in Suutarinniemi, the inhumation graves did not include any objects, whereas at Kuzomen II, the graves had plenty of grave goods in every grave. It is also possible that especially within Northern Finland, a bias exists as most, if not all of the new burial sites have been found using a metal detector and possible burials without metal objects might still be left unfound.

When observing the grave good types (Appendix 1, 3, 4), we note that although the exact combinations in each grave may vary, the functional categories remain largely the same throughout the study period and within the studied region. The grave goods can be loosely categorised belonging to weapons, tools and utilities as well as ornaments. The number of different grave goods in the burials is not very extensive, in general.

Weapons that have been found in the burials are primarily limited to axe blades, spearheads and arrowheads, as there is only one sword found from a possible grave context in Marikkovaara, Rovaniemi (Appelgren 1899; Kuusela 2020d). The utilities are mostly small personal items or tools such as knives or fire steels with the greatest variation occurring in their ornamentation. The ornaments consist mostly of different kinds of pendants, brooches and occasional glass beads, but there are no full sets of Late Iron Age dress jewellery known from the southern contexts, consisting of two tortoise brooches and hangings, possibly indicating a differing style of wear compared to the southern regions. The origins of the finds also vary. There are ornaments with their origins as far East as the Beloozero area or the Northern Dvina River Basin (Makarov 1991: 75), round pendants with their apparent origins in Southern Finland (Huurre 1983: 360–1) ¬and objects from the Western Scandinavia, such as the disk brooches from Liva 1 and Mikonsärkkä (Huurre 1992: 52, Murashkin & Kolpakov 2019: 85). It is notable, however, that regarding weapon finds, a distinction seems to present itself between inland and Western coastal burials as no burial on the Bothnian Bay coast includes weapon finds. This distinction has been noted before (Kuusela 2014) and it may indicate a difference in societal organisation between the coastal communities, on the one hand, and the inland communities, on the other hand, but this goes beyond the scope of the present paper. For future research, however, this distinction is intriguing.

It is important to note that the grave good assemblages do not indicate an agricultural livelihood as agricultural implements are completely missing in northern burials, as are ceramics. This is not surprising, as Iron Age and/or medieval agricultural implements in Northern Sweden, Finland and Russia are generally absent (Kuusela 2015: 16–8; Kuusela et al. 2016: 181–2; Nurmi et al. 2020: 7–11).

Variation as the norm in the North

Although many of the burials in the North bear similarities, most of them differ from each other with often only one identifying feature being a common denominator. There does not appear to be a very clear regional or chronological uniformity with the burial practises used. Importantly, there are no clear structures or other burial features limited only to inhumations or cremations. Although the differences in the burial forms used are evident, they mask behind them features that link the burials together in a shared cosmology.

Although the different types of burials within the studied area and the study period seem to cross all geographical and temporal lines, some regional trends are perhaps visible. Stone structures in inhumation burials are primarily found in the West, although the Anzersky Island site signifies its presence in the East as well. Cremation generally appears to be an Eastern feature but considering that a great majority of the Northern Finnish cremation burials were unknown only a few years ago before metal detectorists began making artefact finds and archaeological investigations resulted in the discovery of these burials, it is possible their absence in the West is an illusion as metal detecting is more regulated in Sweden than it is in Finland. Considering that some cremation burials are known in the West, the authors suspect this may well be the case. As for Russia, the situation may be similar. Very little research has been conducted in the vast, uninhabited areas of Kola Peninsula and it is possible cremation graves in the area simply have not yet been found.

The clearest difference seems to emerge at the start of the medieval period and 15th century onwards, as the cremations seem to cease, with the exception of one possible case of a late cremation from the Kyrkudden cemetery. While there is no absolute dating available, based on stratigraphy, Wallerström (1995: 139–40) suggested this cremation could be as young as from the early 17th century. The occurrence of grave goods lasts even longer.

Most of the singular burials are not located in the vicinity of known settlement sites, but most cemeteries are. There are exceptions, however, e.g., Viinivaaran itäpää (Utajärvi, Northern Ostrobothnia, Finland) and Arvidsjaur 2140:1 are combined dwelling and burial sites.

NORTHERN FENNOSCANDIAN BURIALS IN A WIDER GEOGRAPHICAL CONTEXT

We put forward that Northern Fennoscandian communities should not perhaps be viewed through a conventional territorial/cultural perspective, but rather from the perspective of a communication network populated by individual and highly independent nodes. The nature of this network and how it functioned and facilitated trade, exchange and communication has been exhaustively examined in several previously published papers (Kuusela et al. 2016; 2018; 2020; Henriksen 2019; Kuusela 2020b; Nurmi et al. 2020) and the following is based on the premise established in the cited studies. In relation to the burials specifically, this approach requires a wider perspective and, therefore, we must contextualise the northern burials within a larger geographical scale. By comparing the northern burials with burial practices in use elsewhere at the time, it may be observed where they both differ, and where they utilise common elements.

The most notable difference is that the northern burials follow a different topographical logic than the southern burials. For example, the ubiquitous cremation cemeteries in the South are often located on a prominent hillock or ridge situated near an agricultural landscape (Wessman 2010: 23–4). Traditionally, singular burials in the North have been simply thought to be burials of hunters or travelling people who died far away from home, but there are other possible, intentional reasons for these burials since most, if not all of them, are situated near bodies of water and important waterways. The fact that these northern burials favour proximity to waterbodies and travelling routes indicates a different cosmology (Hakamäki & Kuusela 2013). For example, the Viinivaaran itäpää burial is located on a ridge system connecting two large rivers – the Kiiminkijoki river in the North and the Oulujoki river in the South – and may have been used as an overland route between them (Hakamäki 2016: 42–3). The Sotataival burials in turn are located directly in the middle of a watershed connecting routes leading to diverging directions, the Kemijoki river system heading South and West as well as the Sotajoki river connecting to the East-bound water systems connecting the Bothnian Bay to the Kola Peninsula and the Barents Sea coast. The cremations and inhumations in the North do not differ much topographically from each other as both the inhumations and cremations favour locations close to water and routes of travel. The other notable difference between the southern and the northern burials is that an agricultural lifestyle is clearly not implied in the burials in the North as none of them include agricultural implements in their grave good assemblages (Appendix 1, 3, 4). The northern burials also do not include any ceramics.

A few excavated parallels for the northern-type cremations are known in the southern regions – in Southern Ostrobothnia, in Central Finland, in Karelian Isthmus, and in Jämtland in Sweden (Fig. 3). The burial or burials of Esse-Nådjärv (Pedersöre, Ostrobothnia, Finland) consisted of two burial deposits in a natural boulder field without any clear structural features, reminiscent of the Viinivaara burial in the North. The grave good assemblage consisted of jewellery and small utilities with no agricultural implements, corresponding well with the northern cremations. The find consisted of two deposits of bones, but as no analyses of the bones have been made, it is unknown whether the site consists of burials of two individuals or a burial of one individual in two deposits. There is no radiocarbon date available, but the artefactual typology indicates a Crusade Period dating (Miettinen 2001).

The Oravasaari Siilinranta site (Jyväskylä, Central Finland) excavated in 1981 (Vilkuna 1984) was much like the former – a cremation or cremations deposited into stony ground in between and under boulders together with various grave goods. No burial structures were observed. The cremated bones (~0.3 kg) were deposited into three clusters within a radius of one metre, and the grave goods had been placed around the clusters (Vilkuna 1984). The grave goods consisted of a spearhead, various pieces of jewellery, a fire steel and ceramics (Vilkuna 1984). Although, otherwise, this burial is much like the northern equivalents, the

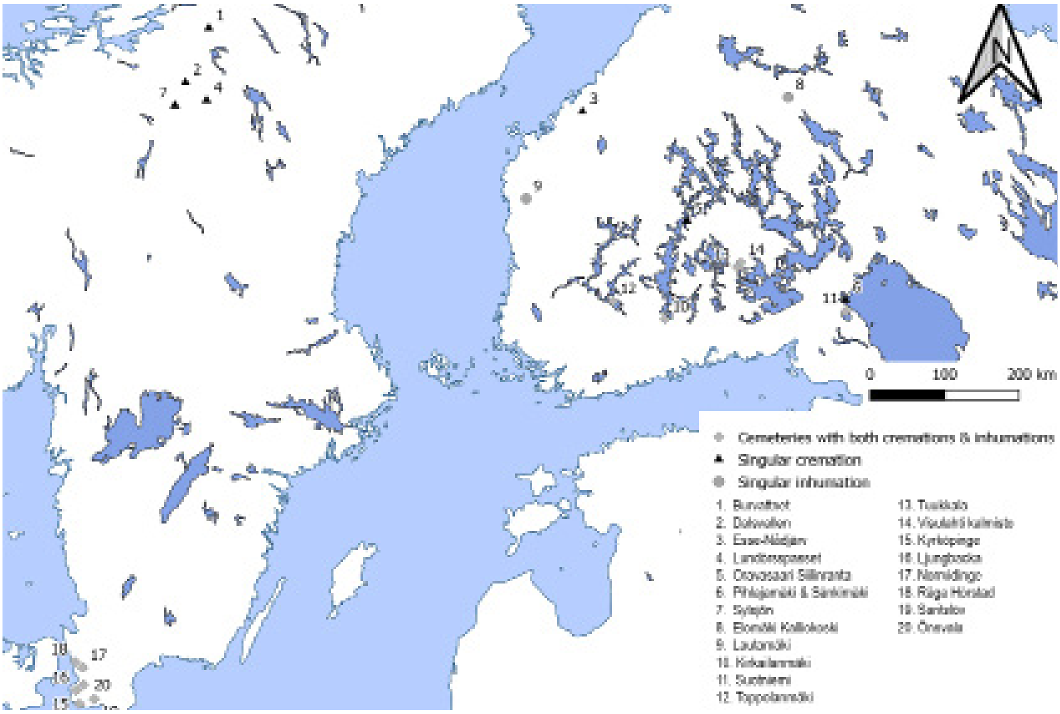

Figure 3. Comparative burial sites outside the study region.

presence of ceramics is a divergence as none of the northern burial assemblages include ceramics. The burial has not been radiocarbon dated, but based on artefact typology, Vilkuna (1984) dates it to the Viking Age.

Similar tradition of singular cremations near waterbodies, often situated at important travelling routes can be found in Karelia near the Lake Ladoga in Northwest Russia (Belskiy & Shmelev 2020: 154–5). The cremations of Pihlajamäki and Sänkinmäki are singular cremations very much reminiscent of the Heinisaari burial, with only part of the cremated remains of an individual deposited in the burial with assemblages comprising bronze jewellery and iron weapons, although like in the burial discussed previously, the assemblages also include ceramics (Belskiy & Laakso 2016: 218–9). One of these burials is radiocarbon dated to the Crusade Period with artefactual dating of the other cremation indicating a similar age (Belskiy & Laakso 2016: 213–4). A burial in Kalmaniemi in Karelia, Northwest Russia is especially very similar to the Heinisaari cremation burial. The Kalmaniemi burial included a small deposition of burnt bones as well as an assemblage of grave goods around the burial. The Kalmaniemi burial likely had a boat laid over the burial (Belskiy & Shmelev 2020: 141–56). Although there is no evidence of a boat from the Heinisaari site, the possibility of some sort of structure, on top of or next to which the grave goods in Heinisaari were deposited, has been discussed (Hakamäki 2018: 42–3). The deposition of the burnt bones near the surface or on top of the ground as well as the placement of the grave goods on both sites (possibly on top of or next to the boat or a burial structure) and the prominent location near an important waterway bear strong similarities to the northern burials. Kalmaniemi has been dated to the Viking age (Belskiy & Shmelev 2020: 146–7).

In Sweden, in the Jämtland region, four singular cremations all dating to the Viking Age were found and excavated in the 1990s (Hansson 1994). The Lunndörsspasset burial was found to be a very low stone setting (some 5 to 10 cm in height) under which the cremated bones and grave goods had been deposited. The Dalsvallen burial is seemingly like the Northern Finnish ones in that both the cremated bones and burial goods were deposited on the ground surface with the bones being concentrated on a roughly 80 x 30 cm area with no visible structure discernible on the site (Hansson 1994:

1–4). The Sylsjön burial was severely damaged by water erosion caused by water level regulation and no details of the burial could be reconstructed, but based on the patina on the finds, the site is assumed to be a cremation (Hansson 1994: 4–6). The fourth case, Burvattnet, was also damaged by erosion, but excavation revealed the burial to have likely been a structureless cremation deposited on the ground surface with finds and cremated bones found on an area roughly 2 x 1.5 m wide (Ingers 2013: 3). The Jämtland burials all differ from each other slightly but find good equivalents from the northern cases and are roughly contemporaneous with them. Notably the burial assemblages of all of these burials are similar to the northern cases in that in none of them contain agricultural implements – instead the grave good assemblages are composed of weapons, arrowheads, knives, fire steels etc. (Hansson 1994; Ingers 2013). Interestingly, however, three of the four Jämtland burials include a sword, which is a rare find in the North, as only the possible Marikkovaara burial contains a sword.

Cases of combining cremations and inhumations akin to Valmarinniemi and Suutarinniemi are known within a fairly wide region. Examples exist in Southern and Eastern inland Finland, Karelian Isthmus and Scania in Southern Sweden (Schwindt 1897: 1–11; Uino 1997: 68–9; Mikkola 2009; Taavitsainen et al. 2009: 205; Kuusela 2015: 18–9; Satalecki 2016; Puolakka 2019; Moilanen 2021: 69–70). Furthermore, at the end of the Viking Age, inhumation burials begin to appear in cremation cemeteries under level ground in Southern Finland prior to inhumation cemeteries becoming common (Wessman 2010: 27–8; see also Fahlander 2018; Moilanen 2021: 70–1). Thus, the relationship between inhumations and cremations during the Late Iron Age and Middle Ages finds several variations in various regions around the Baltic Sea, and whereas there are divergences in how this feature is exhibited, the idea itself seems to have a fairly wide geographical distribution.

Two inhumations in Southern Finland bear similarities to specifically the northern singular inhumation burials. The first, Lautamäki (Teuva, Southern Ostrobothnia, Finland), was located on a swamp-surrounded sandy ridge and consisted of a richly furnished North-South-oriented inhumation and was excavated in 1958 (Paloniemi 1959). The skeleton had decomposed completely, so its position in the grave cannot be reconstructed, but based on the artefact distribution, with the brooches and other ornaments being located in the north-end of the burial, it is possible the head of the deceased has been in the north. The assemblage included various pieces of ornaments, an axe blade, utilities, a bronze vessel and a scythe blade. Based on artefactual typology, the burial has been dated to the Crusade Period (Paloniemi 1959). The following year, another excavation was conducted on the site and another grave was discovered, but it was completely empty with neither a sign of a skeleton nor grave goods (Luho 1959). The Lautamäki burial is reminiscent of the singular inhumations present in the North with two distinctive differences – firstly, the assemblage included an agricultural implement but those are missing in the northern burials and, secondly, the burial was accompanied by another burial. However, being completely empty, its nature could not reliably be discerned. The other case, Elomäki Kalliokoski (Nurmes, North Karelia, Finland), was found in the late 19th century and consisted of a human skeleton and a sword dated to the Crusade Period (Lönnberg 1972: 24). The site was not excavated so no further details of the burial can be reconstructed.

Different but similar

With this contextualisation of the northern burial material, we note that although the Northern Fennoscandian burial practices do diverge from the prevalent burial practices in use in the South, they still find counterparts sometimes far in the Baltic Sea region. Yet certain nuances – for example in burial assemblages – still set the northern burials apart from their southern equivalents.

When we closely observe all the burials in the North, we note that the variation between the burials becomes evident, but the differences between the burial practices do not exclude similarities, even when inhumations are compared with cremations. This extensive variation within and between burials can be seen in burials also in Southern Finland (Moilanen 2021: 79–81).

The burials examined in the present paper span across a large geographical region encompassing a wide variety of topographical landscapes ranging from coastal lowlands and river valleys to inland lake districts and fell-dominated high grounds. However, if we exclude the different landscapes of the burials, resulting from the geographic preconditions of the regions they are in, similarities surface.

Most notably, although especially the inland burials often appear to be somewhat remote, they are closely related to waterbodies and routes of travel (e.g., Bergman et al. 2014).

NORTHERN FENNOSCANDIAN COMMUNITIES – A DECENTRALISED NETWORK

As already noted, the Northern Fennoscandian network and the manner in which it functioned have been studied previously in several publications (Kuusela et al. 2016; 2018; 2020; Henriksen 2019; Kuusela 2020b; Nurmi et al. 2020), but it will be examined here briefly, as it is of relevance for the present discussion. The network was composed of coastal and inland gateway communities forming a system of independent but interlinked hubs. Key in the formation of the network were two factors acting in synergy – the natural conditions imposing cyclical restrictions on travel, and the absolute dependence of the network on information. The so-called ice winter phenomenon is a natural condition that affected northern trade on the coast of the Bothnian Bay and its neighbouring areas. During winter, due to pack ice, maritime access to the coast was cut off for roughly six months of the year, while at the same time inland travel was convenient when frozen waterways, swamps and lakes could be utilised as travelling routes (Okkonen 2012; Bergman et al. 2014; Kuusela et al. 2018: 770). During summer, the situation was reversed as the roadless swamp-riddled and heavily forested landscapes made an overland trek difficult, funnelling summertime traffic to the most traversable waterways, which also were of limited utility due to frequent and at times energetic rapids making travel by boat arduous. The situation along the White Sea coast and the inland was likely similar.

In addition to the difficult terrain and the restrictions on travel caused by natural conditions, the vast distances of the inland made it necessary for anyone who wanted to trade with the inland communities to know where they would be at a given time and have suitable contacts among them. The Swedish Priest Olaus Magnus Gothus (2010 [1555]: 4:3) in his 16th century work Historia de Gentibus Septentrionalibus (the History of the Northern Peoples), comments how the inland dwellers could not be found without their consent, being able to easily avoid unwanted visitors. Considering that, especially in the inland, the most opportune time of travel would have been winter – during which not only the weather but also the distinct lack of daylight would have caused severe complications – travellers in the inland likely followed well-set and known paths to set destinations at more or less predetermined schedules.

The same kind of network of coastal hubs could plausibly have existed in the Eastern part of Northern Fennoscandia on the coasts of the White Sea and the Lake Ladoga. The Kola peninsula and the coast of the White Sea have been of great interest to researchers who have been debating the location of Bjarmia. A recollection in Ohthere's tales mentions sailors of the northern sea route reaching a mouth of a big river, beyond which the inhabited land was said to be situated, indicating perhaps a coastal hub. Because of the virtual absence of archaeological finds in the area between the Varanger Fjord and Kuzomen, however, it has been proposed that this northern sea route may not have been of as much use or interest to the traders as the river routes through the inland, and the sea route in the Gulf of Bothnia, which allowed travel and trade from Karelia and the Northern Dvina basin to the very northern parts of present-day Finland, Sweden and Norway, were of greater utility (Makarov 1991: 75–8; 2007: 142–9).

Thus, the coastal communities held a gateway position where they could supervise traffic along the network on the sea-coast axis. On the one hand, they occupied geographical key locations where the main river routes towards the inland began, and where overseas traders arrived during the sailing season and, on the other hand, they possessed information regarding the inland dwellers and knowledge of where they would be at a given time (for an in-depth analysis of the system, see Kuusela et al. 2016; 2018). The inland communities for their part possessed a gateway position based on the knowledge of inland travelling routes and where and when they would meet their trading partners and on what conditions – thus they controlled the network along its coast–inland axis (see Henriksen 2019). Therefore, every node along a trading route was a potential lockdown point of the network and its function was dependent on the goodwill of whoever controlled the node. These lockdown points, or gateways, can also be called constriction points or bottlenecks (see Earle & Spriggs 2015) creating a considerable comparative advantage (Ling et al. 2018) for the community holding a respective gateway.

Essentially, the northern network was an information network – information of travelling routes and personal acquaintances were necessary in facilitating contact. Due to the gateway position all parties held, the nature of the network was such that it effectively prevented centralisation; in a situation where all the parties hold the information required for a system to function, the creation of a centralised structure within the system becomes unlikely (see Kuusela et al. 2018; Nurmi et al. 2020). This implies that, while the northern communities were resistant towards control from outside the network, they were equally resistant to control from within as in an information network-based system, members can only exert influence over their immediate links and the system does not easily develop a hierarchical structure where one party gains dominance over the others. Furthermore, as contact in general relied on personal acquaintances and relations, and trust between the individual partners (Kallioinen 2012; Hermanson 2013), the relationships in the network were highly individual. From the perspective of transmission, adaptation and exhibition of practices, a decentralised network lacking hegemonic structures, and reliant on individual contacts, may have a high level of variation. In a position of comparative advantage, a seemingly weaker party can prevent the birth of an asymmetrical power relationship and maintain peer interaction, even when at the outset the power balance between the interacting parties would appear to heavily favour another party (see Kuusela et al. 2018).

This has important implications for the spread and adaptation of practices, as the comparative advantage held by communities holding their respective gateways caused a situation where centralised structures that could facilitate the spread of homogeneous practices was unlikely to form and would have been difficult to enforce in any case. Such homogeneous structures would include, for example, dogmatic Christian burial practices. Each gateway, or node, maintained independence due to their respective comparative advantage. Accordingly, and largely irrespective of others in the network, they could choose and adapt various practices into their lives in a manner of their choosing without pressure from centralised oversight. This variability is discernible in the northern burials.

DISCUSSION – ADAPTATION OF PRACTICES IN A DECENTRALISED NETWORK

Ville Hakamäki (2016) has argued in his examination of the Viinivaaran itäpää burial that the northern cremation burial zone should be viewed as a transcultural space where cultural hybridity results in an archaeological record that appears as a "hybrid" of different practices formed in a northern cultural context. In the present paper, this view is developed further, and it is suggested that all of Northern Fennoscandia was a zone where experimentation was practised relatively readily and the social orders and practices that created the various burial forms were not subjected to high levels of conformity. This is more than simply a combination of "Southern" and "Northern" or "Western" and "Eastern" traits and thus more than a hybrid – rather the whole region should be viewed as a dynamic area where the fluctuation and variation of practices have been the norm. Accordingly, although enough similarities between the burials in the North exist to suggest that there was a common base to the cosmologies that resulted in the burials, i.e., a common superstructure, the variation suggests that, to a fairly significant degree, these cosmologies were fluid and in flux.

We put forward the suggestion that it was the way in which the interaction network in Northern Fennoscandia worked that facilitated a situation where high levels of uniformity of practices were not prone to be born. The archaeological remains of the study period in the North have a tendency to be located near or along travelling routes (Hakamäki & Kuusela 2013). Because the communities living in the North quite likely had multiple directions of contact, and as the region was subjected to a fair amount of traffic during the study period (see Kuusela et al. 2016; 2018; Hakamäki 2018), members of the northern communities met and interacted with visitors from several directions regularly and became familiar with different practices. This facilitated a situation where the northern communities adapted different practices to their specific circumstances on what effectively could be considered a case-by-case basis. Different practices and influences were merged to form new ones in a persistent state of fluidity. These communities constantly renegotiated parts of their cosmologies, creating practices which were distinctly their own in the process (Puolakka 2020). As the interactions in the North were strongly based on personal contacts and were thus not under centralised supervision (Kuusela et al. 2018), a situation was created where the communities individually decided how practices would be adapted into their cultural context if they were adapted at all (see Kuusela 2020b).

It appears that, while some of the burial forms examined in the present paper, namely singular cremations and inhumations, appear as a distinctively Northern Fennoscandian practice, they also appear in southern regions. This further highlights the role of networks and networking in the study region. The southern parallels to the northern burials are in many ways similar to their northern counterparts, but there are also differences specifically in the functional categories of the grave good assemblages. For example, the singular inhumation burial of Lautamäki, although otherwise similar to the northern singular inhumations, includes a scythe blade indicating an agricultural lifestyle, which the northern burials lack. Furthermore, two of the three southern cremation parallels examined herein include ceramics in an assemblage that would otherwise be identical to the northern burials.

While some inhumation cemeteries in the South also have singular cremations within inhumation cemeteries, their grave good assemblages differ from the northern cemeteries. While only the Karelian counterparts include agricultural implements and ceramics, the Southern and Eastern Finnish cemeteries with both inhumations and cremations have richer assemblages, with more ornaments and weapons, such as axe blades. Therefore, although it appears that these southern burials have taken influences from northern practices, they still include adaptations born in a southern context. These southern parallels indicate contacts towards the North, on the one hand, and that burial forms in the South may also not necessarily have been subject to a high level of conformity, on the other hand. In other words, each community in the North had independent contacts and, therefore, the adaptations of practices of these communities were not wholly dependent on each other. This would have resulted in a level of variation in practices such as burials and burial rituals.

The results demonstrate that local northern communities had an active role in negotiating their cosmologies and burial practices. Local-born variation and resilience of local customs were likely to be high in the decentralised network these northern communities were a part of. This may be demonstrated in the relatively wide range of variation in the burial practices in use in Northern Fennoscandia during the Late Iron Age and Medieval Period.

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REFERENCES

Personal communication

E. Mikkola, archaeologist, personal communication to the author, 25 August 2020.

T. Rostedt, archaeologist, personal communication to the author, 15 May 2020.

Electronic sources

Finnish Heritage Agency/FHA 2015. Suomussalmelta löytyi ristiretkiaikainen hauta. <https://www.epressi.com/tiedotteet/kulttuuri-ja-taide/suomussalmelta-loytyi-ristiretkiaikainen-hauta.html> Read 7 February 2022.

Finnish Heritage Agency/FHA 2021. Kulttuuriympäristön palveluikkuna. Arkeologiset kohteet. <https://www.kyppi.fi/palveluikkuna/mjreki/read/asp/r_default.aspx> Read 14 November 2021.

Pilø, L., Finstad, E., Bronk Ramsey, C. et al. 2018. The chronology of reindeer hunting on Norway's highest ice patches. *Royal Society Open Science* 5: 17138. doi: 10.1098/rsos.171738

Stuiver, M., Reimer, P. J. & Reimer R. W. 2018. CALIB 7.1. WWW calibration program. <http://calib.org> Read 18 December 2018.

YLE 2020. Arkeologinen jättilöytö Suomussalmella: ensin löytyi rannerengas ja ohimokoru rautakaudelta ja sitten hauta – katso video tutkimuksista. <https://yle.fi/uutiset/3-11346012> Read 26 September 2022.

Unpublished sources

Appelgren, Hj. 1899. Marikkovaara. Rautaesineiden KM 3631 löytöpaikan tarkastus 1898.

Inspection report, National Heritage Agency, Helsinki.
Hakamäki, V. 2015b. Suomussalmi Märännönkangas. Myöhäisrautakautisen löytöpaikan tarkastus 14.5.2015. Inspection report, Laboratory of Archaeology at the University of Oulu, Oulu.
Heinerud, J. 2002. Rapport över arkeologisk undersökning av samisk grav, RAÄ 195:1, Tärna socken, Storumans kommun, Västerbottens län. Excavation report, Västerbottens museum, Umeå.
Ingers, E. 2013. Vikingatida fjällgravar i Jämtland. Jägare, krigare elled smeder? B.A. thesis, Stockholm University.
Koponen, T. & Pelttari P. 2016. Keminmaa, Valmarinniemi. Keskiaikaisen kirkkomaan kaivaus 25.5.–1.7. ja 3.8.–16.9.1981. A collated report based on excavation notes, Archaeology of Laboratory at the University of Oulu, Oulu.
Kuusela, J.-M. 2013b. Ii Illinsaari Suutarinniemi (IIS-13). Myöhäisrautakautisen kalmiston kaivaus kesällä ja keväällä 2013. Excavation report, Archaeology of Laboratory at the University of Oulu, Oulu.
Kuusela, J.-M. 2020c. Salla. Pyhäjärvi, Onkamo ja Märkäjärvi. Arkeologisten kohteiden tarkastus 21.–23.7. & 12.9.2020. Inspection report, The Regional Museum of Lapland, Rovaniemi.
Kuusela, J.-M. 2020d. Rovaniemi Korkalo. Marikkovaaran arkeologinen tarkastus 8.6.2020. Inspection report, The Regional Museum of Lapland, Rovaniemi.
Kuusela, J.-M. 2021. Savukoski. Siella-aavan kivilatomuksen tarkastus 5.8.2021. Inspection report, The Regional Museum of Lapland, Rovaniemi.
Luho, V. 1959. Teuva kirkonkylä Lautamäki. Rautakautisen kalmiston kaivaus. Excavation report. National Heritage Agency, Helsinki.
Larsson, T. & Rathje, L. 2001. Arkeologisk undersökning av stensättningar, skärvstenshögar och kokgrop i Skäran, Nysätra socken (RAÄ 10 & 240), Västerbottens län. Excavation report, Umeå, Insitutionen för arkeologi och samiska studier, Umeå universitet.
Liedgren, L. & Backman, L. 2002. Rapport över efterundersökning av gravläggning på Fårholmen, Egglatj, Arjeplogs sn. Lappland 2002. Excavation report, Silvermuseet & Norrbottens museum, Arjeplog & Luleå.
Liedgren, L. & Bacman, L. 2006. Arkeologisk efterundersökning, Fårholmen, Eggelatj, RAÄ 301, Arjeplog sn, Norrbottens län. Excavation report, Norrbottens museum, Luleå.
Lönnberg, M. 1972. Valtimon kunnan kiinteiden muinaisjäännösten inventointi. Survey report, Finnish Heritage Agency, Helsinki.
Mikkola, E. 2021. Koekaivausryhmä, kenttätöiden perustietolomake. Sotataival 3 (1000039032). Preliminary excavation report, Finnish Heritage Agency, Helsinki.
Mujunen, J. 2014. Solki, neula ja 189 murkulaa – polttohauta 1 ja sen metalliesineistö Iin Illinsaaren Suutarinniemessä. B.A. thesis, Archaeology, University of Oulu.
Östlund, O. 1996. Rapport över arkeologisk slutundersökning av stensättningar från järnåldern i kvarteret Hallen, Stg 3149 c, Hedensbyn, Skellefteå sn och kommun. Västerbotten län. Excavation report, Skellefteå museum, Skellefteå.
Paloniemi M. 1959. Teuva Kirkonkylä Lautamäki. Rautakautisen kalmiston kaivaus. Excavation report, Finnish Heritage Agency, Helsinki.
Rathje, L. 2003. Arkeologisk undersökning av stensettningar och kokgrop i Skäran, Nysätra socken, Västerbottens län. Excavation report, Umeå universitet, Umeå.
Vilkuna, J. 1984. Jyväskylän mlk Oravasaari Siilinranta. Rautakautisen haudan kaivaus. Excavation report, Finnish Heritage Agency, Helsinki.

Literature

Barrett, J. H. 2018. Studying medieval sea fishing and fish trade: How and why. In J. H. Barrett & D. C. Orton (eds.) *Cod and Herring. The Archaeology and History of Medieval Sea Fishing*: 1–10. Oxford: Oxbow Books.
Barrett, J. H., Orton, D., Johnstone, C. et al. 2011. Interpreting the expansion of sea fishing in medieval Europe using stable isotope analysis of archaeological cod bones. *Journal of Archaeological Science* 38: 1516–24.
Belskiy, S. V. & Laakso, V. 2016. Two burial traditions of the crusade period on the Karelian Isthmus and in Ladoga Karelia. In P. Uino & K. Nordqvist (eds.) *New Sites, New Methods. Proceedings of the Finnish-R*ussian

Archaeological Symposium, Helsinki, 19–21 November, 2014: 210–22. Iskos 21.
Belskiy. S. V. & Shmelev, K. V. 2020. Kalmaniemi 1 – Pogrebal'nyi kompleks epokhi vikingov v severnom priladozh'ye. *Rossiyskaya Arkheologiya* N. 1 2020: 141–56.
Bergman, I. 2018. *Kulturarv, landskap och identitetprocesser i norra Fennoskandien 500–1500 e.Kr: Slutrapport från ett forskningsprogram.* Stockholm: Riksbankens jubileumsfond.
Bergman, I. & Edlund, L.-E. 2016. Birkarlar and Sámi – inter-cultural contacts beyond state control: Reconsidering the role of external tradesmen (birkarlar) in medieval Sámi societies. *Acta Borealia* 33(1): 52–80.
Bergman, I. & Ramqvist, P. H. 2018. Hunters of forests and waters: Late Iron Age and medieval subsistence and social processes in coastal northern Sweden. *Acta Borealia* 35(1): 1–28.
Bergman, I., Zackrisson, O. & Östlund, L. 2014. Travelling in boreal forests: Routes of communication in pre-industrial northern Sweden. *Fennoscandia Archaeologica* 31: 45–60.
Earle, T. & Spriggs, M. 2015. Political economy in prehistory. A Marxist approach to Pacific sequences. *Current Anthtopology* 56(4): 515–44.
Fahlander, F. 2018. Grave encounters. Ontological aspects of post-burial interaction in the Late Iron Age of central eastern Sweden. *Primitive tider* 20: 51–63.
Gurina, N. N. 1997. Istoriya kul'tury drevnego naseleniya Kol'skogo poluostrova. Sankt-Peterburg: Tsentr Peterburgskoe Vostokovedenie.
Haggrén, G. 2015. Keskiajan arkeologia. In: Ge. Haggrén, P. Halinen, M. Lavento, S. Raninen & A. Wessman (eds.) *Muinaisuutemme jäljet. Suomen esi- ja varhaishistoria kivikaudelta keskiajalle*: 369–536. Helsinki: Gaudeamus.
Hakamäki, V. 2016. Late Iron Age transculturalism in the northern "periphery": Understanding the long-term prehistoric occupational area of Viinivaara E, Finland. *Acta Borealia* 33(2): 30–51.
Hakamäki, V. 2018. *Seeing Behind Stray Finds. Understanding the Late Iron Age Settlement of Northern Ostrobothnia and Kainuu, Finland*. Acta Universitatis Ouluensis. Series B, Humaniora 168.
Hakamäki, V. & Anttonen, P. 2017. Several new Late Iron Age sites and finds discovered between 2014 and 2016 in Suomussalmi, northeast Finland. *Faravid* 44: 21–38.
Hakamäki, V. & Kuusela, J.-M. 2013. Examining the topography and social context of Metal Age artefact finds in northern Finland. *Fennoscandia Archaeologica* XXX: 95–106.
Hakamäki, V., Kuusela, J.-M., Sarkkinen, M. & Vilkama, R. 2013. Utajärven Viinivaaran itäpään rautakautisen löytöpaikan kaivaus ja kartoitus kesällä 2013. *Muinaistutkija* 2013(4): 2–11.
Hansen, L. I. & Olsen, B. 2014. Hunters in Transition. An Outline of Early Sámi History. Leiden: Brill.
Hansson, A. 1994. Jämtlandska fjällgravar. *Fornvännen* 89(1): 1–11.
Hedman, S.-D. 2003. *Boplatser och offerplatser. Ekonomisk strategi och boplatsmönster bland skogssamer 700–1600 AD*. Studia archaeologica Universitatis Umensis 17.
Helle, K. 2003. Introduction. In: K. Helle (ed.) *The Cambridge History of Scandinavia. Vol 1, Prehistory to 1520*: 1–12. Cambridge: Cambridge University Press.
Henriksen, J. E. 2019. Trade, manufacture, dismantling and reassembling? Metal processing and eastern ornaments at Brodtkorbneset and Steintjørna. In P. Halinen & B. Olsen (eds.) *In Search of Hearths. A Book in Memory of Sven-Donald Hedman*: 40–66. Iskos 22.
Hermanson, L. 2013. Holy unbreakable bonds: Oaths and friendship in Nordic and western European societies, c. 900–1200. In J. V. Sigurðsson & T. Småberg (eds.) *Friendship and Social Networks in Scandinavia, c. 1000–1800*: 15–42. Turnhout: Brepols.
Huurre, M. 1973. Ristiretkiajan polttohauta Suomussalmella. In P. Sarvas & A. Siiriäinen (eds.) *Honos Ella Kivikoski*: 82–8. SMYA 75.
Huurre, M. 1983. *Pohjois-Pohjanmaan ja Lapin historia I. Pohjois-Pohjanmaan ja Lapin esihistoria*. Oulu: Pohjois-Pohjanmaan maakuntaliiton ja Lapin maakuntaliiton yhteinen historiatoimikunta.
Huurre, M. 1992. Suomussalmi esihistoriallisella ajalla. In M Huurre & O. Turpeinen (eds.) *Leipä luonnosta: Suomussalmen historian kymmenen vuosituhatta*: 15–78. Helsinki: Otava.

Ikäheimo, J. 2018a. Labiilit ikäykset ja stabiilit isotoopit: Lisää 14C-ajoituksia Keminmaan Valmarinniemeltä. *Faravid* 45: 5–22.

Ikäheimo, J. 2018b. Somnium pro templo – on the date and location of the first ecclesiastic building on the Hailuoto island. *Fennoscandia Archaeologica* 35: 107–19.

Ikäheimo, J., Maijanen, H. & Paavola, K. 2017. Keminmaan Valmarinniemen polttohautaukset – luonne, löydöt ja konteksti. *Faravid* 43: 81–105.

Jarva, E., Niskanen, M. & Paavola, K. 2001. Anatomy of Late Iron Age inhumation burial of Hiukka at Nivankylä (Rovaniemi, Finnish Lapland). *Fennosandia Archaeologica* 18: 27–49.

Julku, K. 1986. *Kvenland. Kainuunmaa*. Studia Historica Septentrionalia 11.

Kallioinen, M. 2012. *The Bonds of Trade: Economic Institutions of Pre-Modern Northern Europe.* Newcastle upon Tyne: Cambridge Scholars Pub.

Kallio-Seppä, T. 2011. Tietoja Iin kirkoista ja kirkkomaista kirjallisten ja arkeologisten lähteiden perusteella. In T. Kallio-Seppä, J. Ikäheimo & K. Paavola (eds.) *Iin Vanhan haminan kirkko ja hautausmaa. Arkeologisia tutkimuksia*: 34–44. Oulu: Oulun yliopisto.

Kallio-Seppä, T, Ikäheimo J. & Paavola, K. (eds.). 2011. *Iin Vanhan haminan kirkko ja hautausmaa.* Arkeologisia tutkimuksia. Oulu: Oulun yliopisto.

Karpov, S. P. 2003. *Istoriya srednih vekov.* Moskva: Izdatel'stvo Moskovskogo yniversiteta.

Kuusela, J.-M. 2013a. *Political Economy of Bronze- and Iron Age Societies in the Eastern Coast of the Bothnian Bay ca. 1500 BC–AD 1300*. Oulu: University of Oulu.

Kuusela, J.-M. 2014. From coast to inland – activity zones in Northern Finland during the Iron Age. In J. Ahola, Frog & C. Tolley (eds.) *Fibula, Fabula, Fact. The Viking Age in Finland*: 219–41. Studia Historica Fennica 18.

Kuusela, J.-M. 2015. Iin Illinsaaren Suutarinniemen kalmisto ja sen konteksti. *Faravid* 40: 5–30.

Kuusela, J.-M. 2018. Food and tension. Feasting as means to alleviate social tension in the 14th–15th century trading places of the Bothnian Bay region. *World Archaeology* 50(2): 323–36.

Kuusela, J.-M. 2020a. La lente Christianisation des côtes septentrionale de la Finlande: une perspective archéologique. *Revue d'Historie Nordique* 26: 119–34.

Kuusela, J.-M. 2020b. Signs of cultural diversity in the 13th to 15th centuries AD coastal regions of the Bothnian Bay in northwestern Fennoscandia. *Arctic Anthropology* 57(1): 53–71.

Kuusela, J.-M., Ikäheimo, J., Hakamäki, V. & Salmi, A.-K. 2013. Suutarinniemi: The Late Iron Age/early medieval cemetery of Ii (Northern Ostrobothnia, Finland). *Fennoscandia Archaeologica* 30: 126–32.

Kuusela, J.-M., Nurmi, R. & Hakamäki, V. 2016. Co-existence and colonisation. Re-assessing the settlement history of the pre-Christian Bothnian Bay coast. *Norwegian Archaeological Review* 49(2): 177–203.

Kuusela, J.-M., Nurmi, R. & Hakamäki, V. 2018. Unhierarchical and hierarchical core-periphery relations: North Fennoscandian trade network from the Middle Ages to the post-sixteenth century. *American Anthropologist* 120(4): 766–80.

Kuusela, J.-M., Äikäs, T. & Salmi, A.-K. 2020. Hunters, fishers, traders – An archaeological and zooarchaeological perspective on the development of the Late Iron Age and medieval northern Fennoscandian trade network. *Estonian Journal of Archaeology* 24(1): 141–60.

Ling, J., Earle, T. & Kristiansen, K. 2018. Maritime mode of production. Raiding and trading in seafaring chiefdoms. *Current Anthropology* 59(5): 488–524.

Makarov, N. A. 1991. "Eastern" ornaments of the 11th–13th centuries in the Sami areas: Origins and routes. *Acta Borealia* 8 (2): 57–80.

Makarov, N. A. 2007. The land of the Beormas. In J. Bately & A. Englert (eds.) *Ohthere's Voyages: A Late 9th-Century Account of Voyages along the Coasts of Norway and Denmark and Its Cultural Context*: 140–49. The Viking Ship Museum/ National Museum of Denmark: Copenhagen.

Manker, E. 1961. *Lappmarks gravar. Döds-föreställningar och gravskick i lappmarkerna.* Stockholm: Almqvist & Wiksell.

Martin, J. 1986. *Treasures of the Land of Darkness: The Fur Trade and Its Significance for Medieval Russia.* Cambridge: Cambridge University Press.

Martin, J. 1995. *Medieval Russia 980–1584.* Cambridge: Cambridge University Press.

Martynov, A. Y. 2010. *Pervobytnaya arkheologiya ostrovov yuzhnoy chasti Belogo Morya.* Arkhangelsk: Solti Poltorak Press.

McKinley, J. I. 1993. Bone fragment size and weight of bone from modern British cremations and the implications for the interpretation of archaeological cremations. *International Journal of Osteoarchaeology* 3: 283–87.

Miettinen, M. 2001. Ähtävän Nådjärven myöhäisrautakautinen hautalöytö. In H. Ranta (ed.) *Kentältä poimittua* 5: 69–83. Helsinki: Museovirasto.

Mikkola, E. 2009. The Mikkeli Tuukkala cemetery – the 2009 excavations and new interpretations. *Fennoscandia Archaeologica* 26: 177–85.

Moilanen, U. 2021. *Variations in Inhumation Burial Customs in Southern Finland (AD 900–1400): Case Studies from Häme and Upper Satakunta.* Annales Universitatis Turkuensis, Series B, Humaniora 555.

Murashkin, A. I. & Kolpakov, E. M. 2019. Liva 1 – The first medieval Sami site with rectangular hearths in Murmansk Oblast (Russia). In P. Halinen & B. Olsen (eds.) I*n Search of Hearths: A Book in Memory of Sven-Donald Hedman:* 75–87. Iskos 22.

Nurmi, R., Kuusela, J.-M. & Hakamäki, V. 2020. Swedenization of the north – the early medieval Swedish northern expansion and the emergence of Birkarls. *Acta Borealia* 37(1–2): 1–26.

Okkonen, J. 2012. Ympäristötekijät ja yhteisöjen vuorovaikutus Itämeren piirissä keskineoliittisella kaudella. In K. Alenius (ed.) *Itämeren itälaidalla III. Vallankäyttö Suomen ja Baltian historiassa*: 157–71. Studia historica septentrionalia 67.

Olaus Magnus Gothus 2010 [1555]. *Historia om de Nordiska Folken.* Hedemora: Gidlunds Förlag. [Originall published in Latin in 1555]

Ovsyannikov, O. V. & Ryabinin, E. N. 1989. Srednevekovye gruntovye mogil'niki Terskogo berega. *Sovetskaya arkheologiya* 2 1989: 197–216.

Paavola, K. 1991. *Hailuodon kirkon arkeologiset tutkimukset vuosina 1985–1987*. Arkeologian tutkimusraportti 3.

Paavola, K. 1998. *Kepeät mullat. Kirjallisiin ja esineellisiin lähteisiin perustuva tutkimus Pohjois-Pohjanmaan rannikon kirkkohaudoista*. Acta Universitatis Ouluensis, Series B, Humaniora 28.

Puolakka, H. 2019. Cremation burials in inhumation cemeteries in Late Iron Age Finland and the Karelian Isthmus. *Transactions of the Institute for the History of Material Culture* 20: 53–63.

Puolakka, H. 2020. Ancestors and additional bones: Mixing of burial traditions in Late Iron Age Finland. In T. Äikäs, S.Lipkin & M. Ahola (eds.) *Entangled Beliefs and Rituals: Religion in Finland and Sápmi from Stone Age to Contemporary Times*. Monographs of the Archaeological Society of Finland 8.

Salmi, A.-K. & Heino, M. 2019. Tangled worlds: The Swedish, the Sámi, and the reindeer. *International Journal of Historical Archaeology* 23(1): 260–82.

Satalecki, F. 2016. Pyre-related material in inhumation graves. Investigating traces of Viking Age biritualism in south-western Scania. *Lund Archaeological Review* 22: 39–60.

Sawyer, B. & Sawyer, P. 1993. *Medieval Scandinavia – From Conversion to Refor-mation circa 800–1500*. Minneapolis: University of Minneapolis Press.

Schanche, A. 2000. *Graver i ur og berg. Samisk gravskikk og religion fra forhistorisk tid*. Karasjok: Davvi Girji OS.

Schwindt, T. 1897. *Tietoja Karjalan rauta-kaudesta ja sitä seuraavilta ajoilta Käki-salmen kihlakunnan alalta saatujen löytöjen mukaan*. SMYA 13.

Serning, I. 1960. *Övre Norrlands järnålder.* Umeå: Umeå universitet.

Star, B., Boessenkool, S., Gondek, A. T. et al. 2017. Ancient DNA reveals the arctic origin of Viking Age cod from Haithabu, Germany. *PNAS* 114(34): 8152–9157. doi: 10.1073/pnas.1710186114

Taavitsainen, J.-P., Hiekkanen, M. & Oinonen, M. 2009. Keminmaan Valmarinniemen polttohautaukset. In J. Ikäheimo & S. Lipponen (eds.) *Ei kiveäkään kääntämättä. Juhlakirja Pentti Koivuselle*: 203–12. Oulu: Pentti Koivusen juhlakirjatoimikunta.

Taskinen, H. 1998. Suomussalmen Tyynelänrannan hautalöytö. In K. Julku (ed.) *Rajamailla* IV: 147–58. Rovaniemi: Pohjois-Suomen historiallinen yhdistys.

Uino, P. 1997. *Ancient Karelia: Archaeological Studies.* SMYA 104.

Vahtola, J. 1980. *Tornionjoki- ja Kemijokilaakson asutuksen synty. Nimistötieteellinen ja historiallinen tutkimus.* Studia historica septentrionalia 3.

Wallerström, T. 1983. Kulturkontakter i Norrbottens kustland under medeltiden. *Norrbotten* 82–3: 16–55.

Wallerström, T. 1995. Norrbotten, Sverige och medeltiden. Problem kring makt och bosättning

APPENDICES

Appendix 1. Burials in Northern Fennoscandia, displayed chronologically.

Viking age, ca. 700-1000

Country	Site (Finnish site ID# in parenthesis when applicable)	Singular	Cemetery	Structures	Burial placement	Bone distribution/ body position	Grave goods	Dating	References
Cremations									
Finland	Heinisaari (1000028151)	x		No	Ground surface	Concentrated, possibly deposited in a container	Weapons, ornaments, coin	8th–10th century	Hakamäki 2018: 42–50
Finland	Mikonsärkkä (777010056)	x		No	Unknown (badly damaged)	Unknown (badly dam-aged)	Ornaments	10th century	Huurre 1983: 359–61
Finland	Sotataival 3 (1000039032	x		No	Ground surface	Scattered in an arc-like shape	Weapons, tools and utilities	9th–10th century	Esa Mikkola, pers comm.
Finland	Viinivaaran itäpää (1000022658)	x		Stone setting	Between boulder cracks	Scattered	Weapons, tools and utilities	9th–10th century	Hakamäki 2016
Sweden	Arvidsjaur 2140:1	x		No	Below ground	In scattered pockets	Weapons, orna-ments	9th–11th century	Hedman 2003: 92–4
Sweden	Skellefteå stad 179:1		x	Stone setting	Below stone cover and below ground	Concentrated	None	10th–11th century	Östlund 1996
Inhumations									
Sweden	Arjeplog 3135	x		No	Grave pit	Unknown	Ornaments, coin	9th–11th century	Serning 1960: 117
Sweden	Byske 67:2	x		Cairn & cist	Ground surface, below stone cover & in a cist	Unknown	Ornaments, coin	9th–11th century	Serning 1960: 122–3
Sweden	Vilhelmina 1:1	x		Cairn	Ground surface, below stone cover	Unknown	Weapons, orna-ments	7th–11th century	Serning 1960: 154; Manker 1961: 99–100

Crusade Period, ca. 1100-1300

Country	Site (Finnish site ID# in parenthesis when applicable)	Singular	Cemetery	Structures	Burial placement	Bone distribution/ body position	Grave goods	Dating	References
Cremations									
Finland	Iso Märäntö 1000027140	x		No	Ground surface	Scattered on a wide area	Weapons, ornaments	12th century	FHA 2015, Hakamäki & Anttonen 2017
Finland	Kivisaari (777010073)	x		No	Below the ground	In scattered pockets (assumedly, badly damaged)	Weapons, ornaments, tools and utilities	12th century	Huurre 1973
Finland	Ii Illinsaari Suutarinniemi (1000019094)		x	No	Pit	Concentrated	Ornaments	11th–12th century	Kuusela 2015
Finland	Tyynelänranta(*	x		No	Ground surface	Unknown (badly damaged)	Arrowheads, ornaments	12th–13th century	Taskinen 1998
Finland	Valmarinniemi (241010037)		x	No	Pit	Concentrated	Ornaments, tools and utilities	11th–13th century	Taavitsainen et al. 2009; Ikäheimo et al. 2017
Sweden	Kyrkudden		x	Burial cairn, timber burial chamber	Below stone cover	Concentrated	Tools and utilities	10th–13th centuries	Wallerström 1995
Inhumations									
Finland	Hiukka (699010411)	x		No	Grave pit	Foetal position	Tools and utilities	11th–14th century	Jarva et al. 2001
Finland	Ii Illinsaari Suutarinniemi (1000019094)		x	No	Grave pit	Supine	None	14th–15th century	Kuusela 2015
Finland	Sotataival 3 (1000039032)**		x (two, possibly three, graves)	No	Grave pits filled with red ochre	Unknown	Arrowhead, ornaments, tools and utilities	9th–13th century (artefacts)	Kuusela 2021: 2–4; Esa Mikkola pers comm.

*) This burial was badly destroyed by water erosion by the time it was investigated by an archaeologist. Helena Taskinen (1998) interprets the Tyynelänranta burial as an inhumation burial as the majority of the grave goods show no signs of being burnt. However, as this is not at all an uncommon trait in the northern cremation burials – and because a fragment of burnt bone was found nearby the artefacts – Tyynelänranta should be classified as being a cremation burial rather than an inhumation. The site is destroyed and is no longer in the database of the Finnish Heritage Agency.

**) The nature of the Sotataival 3 red ochre burials remain ambiguous as the relationship between the artefact finds and the burials could not be verified. Nevertheless, the site is listed here with this caveat being made known.

Crusade Period, ca. 1100-1300

Country	Site (Finnish site ID# in parenthesis when applicable)	Singular	Cemetery	Structures	Burial placement	Bone distribution/ body position	Grave goods	Dating	References
Inhumations									
Finland	Valmarinniemi (241010037)		x	No	Grave pit	Supine	Ornaments, coins	12th–15th century	Taavitsainen et al. 2009; Koponen & Pelttari 2016; Ikäheimo et al. 2017; Ikäheimo 2018a
Sweden	Jokkmokk 24:1	x		No	Grave pit	Unknown	Weapons, ornaments	11th–14th century	Serning 1960: 128–9
Sweden	Jukkasjärvi 533:1	x		Stone setting	Ground surface, below stone cover	Unknown	Weapons, ornaments, tools and utilities	11th–14th century	Schanche 2000: 407
Sweden	Skäran			Cairn & cist	Ground surface, below stone cover and in a cist	Unknown	None	10th–15th centuries	Larsson & Rathje 2001; Rathje 2003
Sweden	Överluleå 436:1	x		No	Grave pit	Unknown	Ornaments, tools and utilities	11th–14th century	Serning 1960: 160–1
Russia	Kuzomen 1		x	No (possibly destroyed)	Grave pit	Unknown	Arrowhead, ornaments, tools and utilities	11th-12th century	Gurina 1997: 127–1, Ovsy-annikov & Ryabinin 1989: 201–4
Russia	Kuzomen 2		x	Timber burial structures	Grave pit	Supine	Weapons, jewellery	12th-13th century	Ovsyannikov & Ryabinin 1989: 201–10
Russia	Anzersky Island	x		Cairn	Grave pit	Foetal position	Ornaments	12th-14th century	Martynov 2010: 338–41

Medieval period, ca. 1300-1600

Country	Site (Finnish site ID# in parenthesis when applicable)	Singular	Cemetery	Structures	Burial placement	Bone distribution / body position	Grave goods	Dating	References
Inhumations									
Finland	Iin Hamina (1000011507)		x	No	Grave pit	supine	Ornaments, coins	15th–16th century	Kallio-Seppä et al. 2011
Finland	Vanha kirkko (72010005)		x	Timber burial chambers	Grave pit	Supine	Ornaments, tools and utilities, coins	15th–17th century	Paavola 1991; 1998
Sweden	Arjeplog 301:1	x		Cairn (possibly, badly damaged)	Ground surface and below stone cover	Unknown	Weapons	14th–16th century	Liedgren & Backman 2006
Sweden	Godejaure	x		Cairn & cist	Ground surface, under stone cover and in a cist	Unknown	Tools and utilities	15th–17th century	Manker 1961: 138–41
Sweden	Gutuberget nära Forsbäck	x		Cist	Ground surface, under stone cover and in a cist	Unknown	Ornaments, tools and utilities	14th–16th century	Manker 1961:97; Schanche 2000: 408
Sweden	Kyrkudden		x	Cairn	Ground surface, below stone cover	Unknown	Tools and utilities	13th–17th century	Wallerström 1995
Sweden	Tärna 195:1	x		Cist	Ground surface, in a cist	Unknown	Weapons	14th–16th century	Manker 1961: 156–60; Schanche 2000: 408; Heinerud 2002

Appendix 2. Radiocarbon datings (of the sites discussed in the text.*

Site	Laboratory ID#	14C age BP	Cal AD (2σ)	Reference
Arvidsjaur 2140:1	Beta-100079	1080 ± 40	890–1040 (0,979) 1100–1120 (0,021)	Östlund 1996
Heinisaari	Ua-52340	1177 ± 28	770–900 (0,919) 920–960 (0,161)	Hakamäki 2018: 44, footnote 17
	Ua-52341	1168 ± 29	770–900 (0,839) 920–960 (0,161)	
Hiukka	Hel-2337	830 ± 100	1010–1310 (0,979) 1360–1390 (0,021)	Jarva et al. 2001: 31
Ii Illinsaari Suutarinniemi	Ua-50693 (cremation 1)	926 ± 40	1020–1190	Kuusela 2015: 10, footnote 19
	Beta-382690 (cremation 2)	940 ± 30	1030–1160	
	Ua-50694 (inhumation 2)(***	563 ± 36	1320–1350 (0,05) 1390–1460 (0,95)	Kuusela 2015: 10, footnote 20
	Ua-50695 (inhumation 2, cervid skull)	554 ± 34	1310–1360 (0,48) 1390–1430 (0,52)	Kuusela 2015: 10, footnote 21
	Beta-382691 (inhumation 3)(***	610 ± 30	1300–1400 (uncorrected) 1510–1870 (corrected)	Kuusela 2015: 10, footnote 20
	Ua-50696 (inhumation 3, additional human skull)	588 ± 36	1300–1370 (0,693) 1380–1420 (0,307)	Kuusela 2015: 10, footnote 21
Kyrkudden(**	St 7973 (Grave A18)	945 ± 80	900–910 (0,004) 970–1260 (0,996)	Wallerström 1995: 158
	Ua-3522 (Grave A25)	395 ± 50	1430–1530 (0,607) 1540–1640 (0,393)	Wallerström 1995: 177
Skellefteå stad 179:1	Beta-100079	1080 ± 40	890–1020	Östlund 1996
Tärna 195:1	Ua-18196	460 ± 55	1320–1350 (0,036) 1390–1520 (0,856) 1560 (0,003) 1571–1630 (0,106)	Heinerud 2002
Valmarinniemi(****	Hela-2010 (cremation G)	934 ± 32	1020–1160	Taavitsainen et al. 2009
	Hela-2006 (cremation A)	680 ± 30	1270–1320 (0,635) 1350–1390 (0,365)	
	Beta-451054 (inhumation 128)	910 ± 30	1070–1080 (0,009) 1150–1270 (0,967)	Ikäheimo 2018a
	Beta-451053 (inhumation 123)	730 ± 30	1220–1240 (0,033) 1240–1300 (0,967)	
	Beta-451050 (inhumation 39)	630 ± 30	1320–1350 (0,078) 1390–1450 (0,922)	
Vanha kirkko(*****	Hel-2480 (grave 182)	540 ± 80	1320–1350 (0,046) 1390–1640 (0,954)	Paavola 1998; Ikäheimo 2018b
	Hel-2991 (grave 110)	370 ± 100	1520–1600 (0,111) 1610–1950 (0,889)	
Viinivaara E	Beta-375718	1200 ± 30	715–743 (0,061) 765–895 (0,925) 929–940 (0,014)	Hakamäki 2016: 36–8
	Beta-375719	1080 ± 30	894–930 (0,284) 940–1020 (0,716)	
Kuzomen II	Ua-3522 (Grave A25)	750 + - 10	1200-1210	Ovsyannikov & Ryabinin 1989

*) All dates calibrated using the Calib ^{14}C online calibration program (Stuiver et al. 2018), which includes tools for applying a marine reservoir correction (see note ***) when necessary.

**) Kyrkudden has a very extensive radiocarbon sequence available that has been fully published in Wallerström 1995. The ones listed here are chosen as representative of the dating range.

***) These samples contain high δ^{13}N levels indicating that they may be subject to the marine reservoir effect (see Ikäheimo 2018a, b). However, the extent to which the marine reservoir effect could affect the radiocarbon dates of the Bothnian Bay region – as the bay is both shallow and fed by multiple major rivers increasing the freshwater content – is unknown in lieu of an extensive study (Ikäheimo 2018b: 111). That the marine reservoir effect correction – when applied with the available data – exaggerates the results is evident in the corrected date of inhumation 3 (Beta-382691). The uncorrected date of this burial is in line with the other radiocarbon datings from the cemetery, and in general agrees with the archaeological features of the site, whereas the corrected date pushes the burial to the 16th century or beyond. Based on archaeological, historical and cartographic evidence available for the site, such a dating is very unlikely (see Kuusela 2020b for more discussion). It is likely that the marine reservoir correction – which is based on insufficient data as the Bothnian Bay region currently lacks the accurate ΔR values necessary for the correction (Ikäheimo 2018b: 111–2) – overexaggerates the age difference between the uncorrected and corrected dates. The correction is likely detrimental in the case of inhumation 3 as the $\delta^{13}N$ level in this sample was particularly high, possibly aggravating the correction effect. In Table 3, marine reservoir correction has nevertheless been applied (following Ikäheimo 2018a: 9–12), but in the case of inhumation 3, both the corrected and uncorrected dates are displayed. For the other corrected datings, the age differences between the corrected and uncorrected datings are not significant which is likely due to much lower $\delta^{13}N$ levels.

****) The Valmarinniemi cemetery has a wide radiocarbon dating sequence made and published in multiple publications (referred to in the table). Due to multiple problematic – with some possibly contaminated – samples (see Ikäheimo 2018a), it will not be reproduced here in its entirety, but the datings selected represent the range of the sequence.

*****) The Vanha kirkko sequence has been fully published previously, and subsequently re-examined due to the marine reservoir effect possibly affecting the datings (see note *** above). The full radiocarbon sequence will not be reproduced here, but the selected datings represent the dating range of the cemetery. The datings presented here are ones where the marine reservoir effect correction has been applied.

******) The article does not include the Laboratory ID for these datings, but the analysis was done in the Leningrad branch of the Institute of Archaeology (LOIA) of the USSR Academy of Sciences.

*Appendix 3. Artefact finds, cremations & possible cremations (**

Country	Site	Finds	Unburnt	Burnt	References
Finland	Heinisaari länsi (1000028151)	Axe blade x 2	x		Hakamäki 2018: 42–50; Hakamäki & Maijanen forthcoming
		Penannular silver brooch	x		
		Silver coin (perforated) x 3	x		
		Knife	x		
		Spearhead x 2	x		
		Fire steel	x		
		Bronze strap tag	x		
Finland	Ii Illinsaari Suutarinniemi (1000019094)	Oval bronze tortoise brooch x 2		x	Kuusela et al. 2013, Mujunen 2014
		Silver necklace		x	
		Bronze chain divider		x	
Finland	Iso Märäntö (1000027140)	Axe blade x 3		x	FHA 2015, Hakamäki & Anttonen 2017
		Glass beads		x	
		Bronze curb chain links		x	
		Knives		x	
		Bronze belt mountings		x	
		Bronze neck ring fragments		x	
		Round bronze pendant		x	
		Iron pot handle		x	
		Bronze knife sheath mountings		x	
		Fire steel x 2		x	
Finland	Jysmänniemi (1000028683)	Spearhead x 2	x		Hakamäki & Anttonen 2017
		Knife	x		
Finland	Järvenpää (1000034809)	Penannular bronze brooch		x	Kuusela 2020c
		Arrowhead	x		
		Knife x 2	x		
		Fire steel		x	
Finland	Kannusniemi (1000031097)	Axe blade x 2	Unknown		FHA 2021
Finland	Kivisaari (777010073)	Axe blade x 2	x		Huurre 1973
		Bone comb fragments		x	
		Penannular bronze brooch		x	
		Penannular bronze brooch	x		
		Penannular silver brooch	x		
		Fragmented bronze chain		x	
		Fragmented bronze curb		x	
		Fragmented knife		x	
		Bone knife hilt		x	
		Fragmented bronze knife sheath mountings		x	
		Bone spoon fragments		x	
		Fire steel		x	
Finland	Lehtolampi lounas (1000032888)	Axe blade	x		
		Unidentified bronze artefact	x		
Finland	Luukkosenlahti (1000036690)	Arrowhead	Unknown		FHA 2021
		Axe blade			
		Bronze belt buckle			
Finland	Marikkovaara (1000016629)	Arrowheads	Unknown		Appelgren 1898, Kuusela 2020d, FHA 2021
		Axe blade		x	
		Knives	Unknown		
		Spearhead x 2		x	
		Sword		x	

Country	Site	Finds	Unburnt	Burnt	References
Finland	Mikonsärkkä (777010056)	Round bronze pendant x3		x	Huurre 1983: 359–61
		Melted glass beads		x	
Finland	Märännönkangas (1000030868)	This site has been excavated in 2020 and verified to have been a cremation burial. As of the writing of this article, the report is not yet available.			YLE 2020, FHA 2021
Finland	Onnela 2 (1000040739)	Temporal ring	x		YLE 2020, Tapani Rostedt pers. comm.
		Silver bracelet	x		
Finland	Pieni Märäntö	Bronze pendant (a so-called “ear-spoon”)	x		Hakamäki 2015b
Finland	Sotataival 3 (1000039032)	Axe blade		x	Esa Mikkola pers.comm.
		Arrowheads		x	
		Fire steel		x	
		Bronze belt mounting		x	
		Bronze chain		x	
Finland	Tyynelänranta (777010281)	Arrowhead x 2	x		Taskinen 1998
		Bronze belt buckle x 2	x		
		Bronze belt mountings	x		
		Bronze bird pendant	x		
		Fragmented penannular bronze brooch	x		
		Fragmented penannular silver brooch	x		
		Iron ring		x	
		Knife	x		
		Bronze strap divider x 2	x		
Finland	Valmarinniemi (241010037)	Silver coin x 6		x	Ikäheimo et al. 2017
		Glass bead		x	
		Iron purse mounting		x	
		Bone artefact		x	
Finland	Viinivaaran itäpää (1000022658)	Axe blade	x		Hakamäki 2016
		Bronze belt mounting	x		
		Knife	x		
		Fire steel	x		
Sweden	Arvidsjaur 2140:1	Axe blade	x		Hedman 2003: 92–4
		Penannular bronze brooch	x		
		Silver coin x 4	x		
Sweden	Kyrkudden	Knife		x	Wallerström 1995: 155–6
Sweden	Skellefteå stad 179:1	No grave goods	N/A	N/A	Östlund 1996
Russia	Liva 1	Bronze pendant			Murashkin & Kolpakov 2019: 75–84
		Bronze penannular brooch			
		Arrow heads			
		Axe			
		Copper sheet fragments			
		Bronze convex brooch			

*) Cemetery assemblages are not presented grave by grave but rather by artefact types

*Appendix 4. Artefact finds, inhumations (**

Country	Site	Finds	References
Finland	Iin Hamina (1000011507)	Copper pendant	Kallio-Seppä et al. 2011
		Silver coins	
		Bronze mountings	
		Textile fragments	
		Seal tooth pendant	
Finland	Hiukka (699010411)	Knife	Jarva et al. 2001
Finland	Ii Illinsaari Suutarinniemi (1000019094)	No artefact finds	FHA 2015, Hakamäki & Anttonen 2017
Finland	Sotataival 3 (1000039032)	Knife (burnt)	Artefacts examined by the authors
		Arrowhead (burnt)	
		Bronze chain divider	
		Bronze bird pendant	
		Fragmented bronze chain	
		Glass beads (at least one exhibit-ing fire damage)	
		Iron pot handle	
		Fire steel	
		Iron hook	
Finland	Valmarinniemi (241010037)	Bronze brooch	Koponen & Pelttari 2016
		Silver coins (some perforated)	
		Silver buttons	
		Silver finger-ring	
		Silver ring	
		Bronze finger-rings	
		Tin mountings (fragments)	
		Circlet (bronze & glass beads)	
		Iron artefacts	
		Textile fragments	
		Leather fragments	
Finland	Vanha kirkko (72010005)	Glass beads	Paavola 1991; 1998
		Copper coins	
		Silver coin	
		Textile fragments	
		Bronze circlet	
		Bronze hair jewellery	
		Bronze needles	
		Glass bead necklace	
		Iron artefacts	
Sweden	Arjeplog 301:1	Axe blade	Manker 1961: 128; Liedgren & Backman 2002
		Spearhead	
Sweden	Arjeplog 3135	Bronze oval tortoise brooch	Serning 1960: 117
		Silver coin (Arab)	
Sweden	Byske 67:2	Bronze oval tortoise brooch	Serning 1960: 122–3
Sweden	Godejaure	Iron belt buckle	Manker 1961: 138–41
		Knife	
		Leather knife sheath	

Country	Site	Finds	References
Sweden	Gutuberget nära Forsbäck	Birch-bark artefact	Manker 1961:97; Schanche 2000: 408
		Bone artefacts	
		Bronze plate fragment	
		Bronze ring brooch	
		Antler comb	
		Iron mounting	
		Iron artefact	
Sweden	Jokkmokk 24:1	Silver arm-ring	Serning 1960: 128–9
		Axe blade	
		Bead fragment (possibly tin)	
		Bronze mounting	
		Spearhead (barbed)	
		Fragmented leather strap, several bronze mountings & bronze strap tag attached	
		Bronze strap buckle	
		Bronze strap divider x 3	
		Unidentified fragmented iron artefact	
Sweden	Jukkasjärvi 533:1	Axe blade	Schanche 2000: 407
		Penannular bronze brooch x 2	
		Bronze chain fragment	
		Copper kettle rim	
		Bronze neck ring	
Sweden	Kyrkudden	Copper sheet	Wallerström 1995: 118, 140
		Bronze wire	
		Bronze mountings	
		Knife	
		Iron fragments	
		Whetstone	
Sweden	Skäran	No finds	Larsson & Rathje 2001, Rathje 2003
Sweden	Tärna 195:1	Axe blade	Manker 1961: 156–60; Schanche 2000: 408; Heinerud 2002
		Knife	
Sweden	Vilhelmina 1:1	Axe blade	Serning 1960: 154; Manker 1961: 99–100
		Glass bead x 15	
		Oval bronze tortoise brooch	
		Knife	
		Flint flake	
Sweden	Överluleå 436:1	Glass bead	Serning 1960: 160–1
		Copper sheet fragments	
		Fragmented silver finger-ring	
		Bronze mounting x 46	
		Bronze strap buckle	
		Bronze strap divider x4	
		Leather strap fragments	
		Textile fragments	
		Whetstone	

Country	Site	Finds	References
Russia	Anzersky Island	Penannular brooch bronze/silver	Martynov 2010: 338–41
Russia	Kuzomen 1	Large Iron chain	Manker 1961: 138–41
		Arrowhead	
		Bronze penannular brooch	
		Fragments of an iron object, possibly a kettle	
		Zoomorphic bronze pendants	
		Bronze chain holders	
		Bronze chain fragments	
		Bronze belt buckles	
		Iron Buckle	
		Coin	
		Round bronze brooch	
		Bronze rings strung on a strap	
		Glass bead	
Russia	Kuzomen 2	Temporal ring	Ovsyannikov & Ryabinin 1989: 201–11
		Bronze penannular brooch	
		Round bronze pendants x 15	
		Flipper shaped bronze pendant	
		Glass beads	
		Lyre-shaped bronze belt buckle	
		Bronze rings	
		Bronze strap dividers	
		Axe blade	
		Knife	
		Textile fragments, some including bronze spiral decoration	
		Leather and fur fragments	

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PROVENANCING ARCHAEOLOGICAL CHERT FINDS WITH pXRF: INITIAL RESULTS FROM THE EASTERN COAST OF THE BOTHNIAN BAY

Abstract

We present the initial results of a research combining non-destructive chemical analyses with a quantitatively and chronologically representative research assemblage – 52 specimens from five sites – to examine the provenance of Late Neolithic and Bronze Age chert finds from the cluster of sites located near the city of Oulu on the eastern coast of the Bothnian Bay. The results confirm the previously observed transition in the use of raw material sources: eastern Carboniferous cherts high in iron were replaced by calcium-rich Cretaceous flints of Scandinavian or southern Baltic origin. We also consider the overall applicability of pXRF as a non-destructive research method to determine the provenance for archaeological chert finds recovered from the coniferous boreal zone, characterized by the impact of post-depositional weathering on the chemical composition of objects found in the soil matrix.

Keywords: Bronze Age, Bothnian Bay, chert, provenance, pXRF, weathering

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INTRODUCTION

This paper presents the initial results of a research program combining non-invasive chemical analyses with a quantitatively and chronologically representative assemblage of chert finds from two site clusters located on the eastern coast of the Bothnian Bay in northwest Finland to answer not only methodological but also archaeological research questions. The research method, an X-ray fluorescence analysis performed with a portable analyzer (pXRF), has become very common over recent years in archaeology, but the ways the method is applied and the results interpreted have also been intensively debated (e.g., Frahm 2013; Speakman & Shackley 2013). Here, the intention is to assess the applicability of pXRF as a non-invasive method to establish a provenance for a quantitatively significant number of archaeological chert finds recovered from the coniferous boreal zone, where the impact of post-depositional alteration can possibly have an effect on the chemical composition of objects found in the soil matrix.

From the archaeological standpoint, the aim of the article is to revitalize the Finnish scholarship focusing on the provenance of chert, which is an umbrella term for a group of sedimentary rocks consisting primarily of microcrystalline quartz (Luedtke 1992: 5). Especially in Scandinavia, these rocks are commonly discussed in archaeological literature under the 'folk category' term flint (e.g., Johanson 2021 et al.: 123–4). However, as this term is also used in more restricted sense to define a black, nodular subcategory of highly siliceous chert associated with Cretaceous deposits (e.g., Stow 2005: 184), the term chert is preferred throughout this article. The specific archaeological research question to be dealt with here concerns the provenance of Late Neolithic and Bronze Age chert finds of northern Finland. As indicated below, this subject has only been touched upon in previous Finnish archaeological scholarship.

To sufficiently succeed in communicating various aspects related to these two goals, the remainder of the paper is structured as follows. First, a concise literature review is offered on the state of chert studies in northernmost Europe, the area of Fennoscandia and adjacent regions in particular. Here, special attention will be paid to the recent scholarship focusing on geological deposits and the geochemistry of local cherts. Next, the two prehistoric activity areas yielding the research material for this study will be introduced together with arguments justifying their selection and the characterization of archaeological finds. As the authors are well aware of the advantages and pitfalls that the use of pXRF incorporates (see, e.g., Drake et al. 2009; Shackley 2010; 2012), materials and methods will be described in detail, and special attention has been paid to the analyses of research materials. The results and their interpretation will be followed by a discussion about their wider implications that touches upon both the suitability of pXRF in the analysis of archaeological chert finds from the boreal zone and the picture regarding long-distance contacts of trade and exchange in the research are during the Bronze Age.

LITERATURE REVIEW

Virtually every study touching upon the use of chert and related siliceous rock types in prehistoric Finland begins with a laconic statement pointing out the absence of chert – "sedimentary rocks of biogenic, biochemical or chemogenic origin" (Stow 2005: 184, see also Luedtke 1992: 5; Burke 2018: 1) – from the local bedrock (e.g., Huurre 1986: 53). Thus, when found in an archaeological context, these siliceous rocks bear evidence of long-distance contacts that might have taken the form of gift-giving, exchange, or trade. Prehistoric chert imports in Finland are traditionally thought to fall into two main groups according to their geographic and lithologic origin (Fig. 1). First, siliceous nodules that occur in Cretaceous chalk are available in an east-west oriented, ca. 1400 km long belt that extends from southern Sweden and northern Denmark through Lithuania to Russia (e.g., Baltrūnas et al. 2006; Hughes et al. 2012). On the other hand, Carboniferous deposits containing chert form a north-south oriented and ca. 1100 km long belt in northwest Russia that extends from the Valdai region to the White Sea (e.g., Zhuravlev 1982; Zhilin 1997; see also Kinnunen et al. 1985: 7, fig. 1). Minor deposits of Ordovician and Silurian chert have also been identified in Estonia and Latvia (Yurgenson 1958; Kröger 2007; Kriiska et al. 2011: 67; Johanson et al. 2021: 124–5). Thus, the geological setting corresponds well with Shackley's (2008: 205–6) observation concerning the wide distribution of chert deposits and the potential elemental and isotopic variation within them.

Reflecting this reasoning, in order to use quantitative elemental analysis on provenance, the research activity on various chert deposits of Scandinavian and Baltic origin has intensified significantly during the past decade. This is mainly due to the extensive chemical characterization program carried out by Anders Högberg, Richard E. Hughes, and Deborah Olausson. While mainly focusing on geological outcrops of Scania (southern Sweden) and Denmark (Hughes et al. 2010; 2012; Högberg et al. 2012), these scholars have not only studied additional deposits on the Swedish islands of Gotland and Öland (Högberg et al. 2016) but also extended their activity to the Baltic and beyond (Högberg et al. 2013; 2014). The main outcome of their research program is the observation that geochemical methods, the determination of Ca/Fe-ratio in particular (Hughes et al. 2010: 21–2; Olausson et al. 2017; see also Johanson et al. 2021: 127), can be used to distinguish various chert deposits

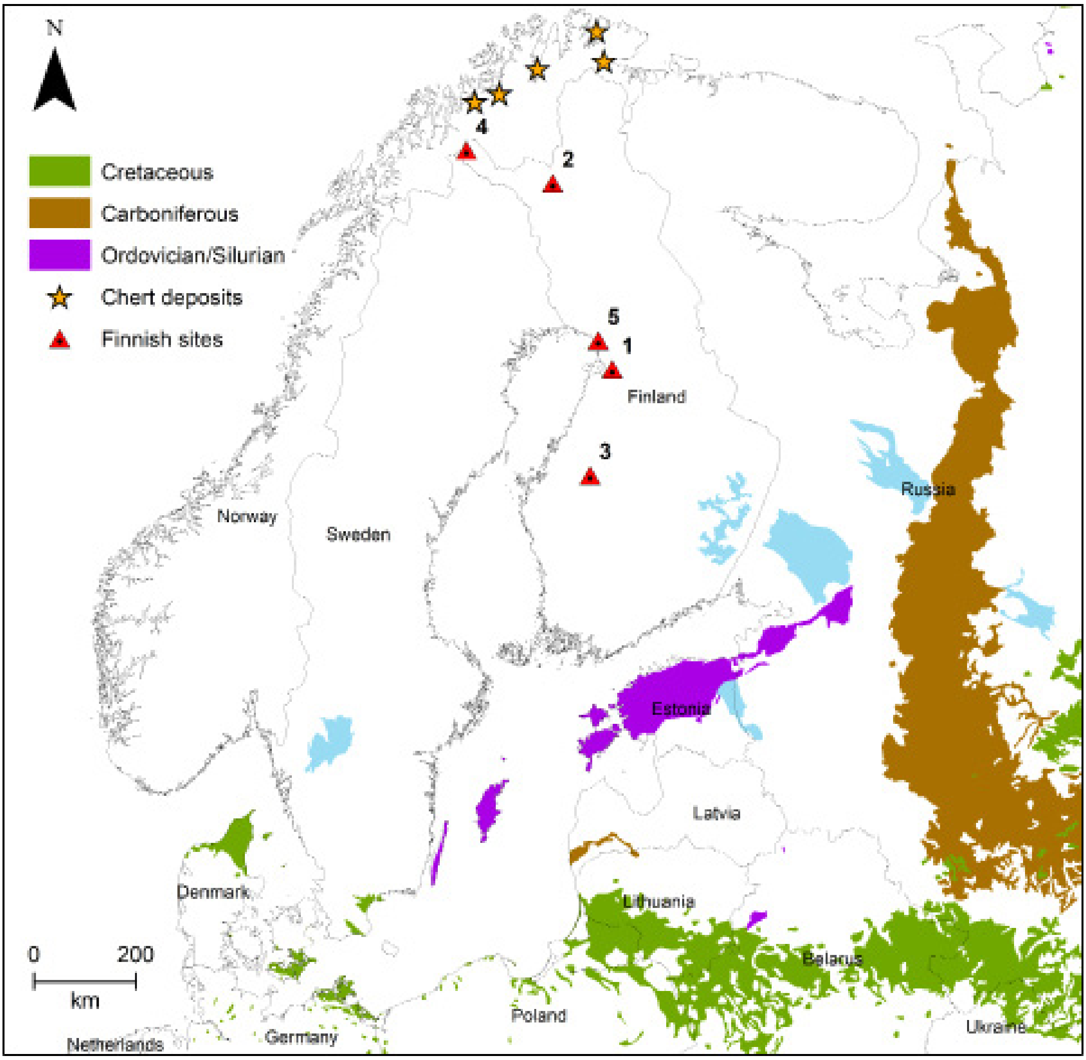

Figure 1. Overview map of the Rautajärvi area. Dots mark archaeological sites (black) and stray find (white) locations. The Järvensuo 1 site is marked with a star. Background data by Finnish Heritage Agency (2020a; 2020b) and National Land Survey of Finland. (Map: Janne Ikäheimo.)

from one another. Therefore, the results of their research have been adapted as the framework for this paper, which is further complemented with the observations of other scholars that have recently touched upon the topic in Scandinavia, the Baltic, and northwestern Russia (e.g., Olofsson & Rodushkin 2011; Zariņa et al. 2014; Zariņa & Segliņš 2017; Sinitsyna & Kolokol'tsev 2018).

It is also worth pointing out here that while the last Ice Age deprived the Finnish bedrock of Phanerozoic formations, save the southernmost part and the northwesternmost tip of the country, deposits of metamorphosed Precambrian cherts are known from the area. The best-known case to Finnish archaeologists is the occurrence of red jasperoid in the Kittilä area in Finnish Lapland (Kinnunen 1982; Vartiainen 2017), but deposits of red jasper have recently been also reported from Vimpeli, southern Ostrobothnia (Kinnunen 2008). In addition, several geological research reports contain references to other deposits of metamorphosed Precambrian cherts than jasperoid (e.g., Lehto & Niiniskorpi 1977; Sipilä et al. 2008; Öhman 2017), which might be of interest for the future research. Moreover, traces of small-scale quarrying of Cambrian sedimentary deposits have been discovered in northwestern Lapland by the Norwegian border at Kuonjarvarri (Guonjarvárri) in Enontekiö (e.g., Halinen 2005: 27–8). It is uncertain, however, whether the quarried rock is actually chert or quartzite, because recrystallized chert and fine-grained quartzite are difficult to tell apart (Luedtke 1992: 27) without petrographic analyses.

While cherts and related rock types (e.g., flint, chalcedony, and jasper) in Finnish archaeological assemblages have been studied quite intensively (for research history, see e.g., Manninen et al. 2003: 162–8); the provenance of the raw materials has been studied with scientific research methods rather sparingly. Nonetheless, two important contributions were published already in the late 1980s. Kinnunen et al. (1985) explored various properties of chert, such as texture, mineralogy, and microfossil content, whereas Matiskainen et al. (1989) applied atomic absorption spectrometry (AAS) to carry out the only sufficiently comprehensive geochemical study of chert-like materials published to date in Finland. Most samples they examined, 70 in total, were archaeological finds that were destroyed in the analysis along with a selection of geological reference materials. The results suggested a rather clear-cut and temporally significant division between the provenance of Neolithic and Bronze Age cherts with a chronological shift from the exploitation of the eastern to the western chert sources (Matiskainen et al. 1989: 636–7).

Thereafter, only a re-examination of Matiskainen's research group results incorporating some new data has been published by Costopoulos (2003). This new data was acquired with electron probe microanalysis (EPMA), but no further information was provided about the conditions under which these analyses had been performed. The analyses were carried out on six fragments chipped off from two chert finds – a late Neolithic basal biface fragment from Ii Hiidenkangas and an early Bronze Age flake from Muhos Halosentörmä – found at two dwelling-sites in northern Finland. Based on these new results, Costopoulos (2003: 52) concluded that contrary to the southern parts of the country, no synchronous re-alignment of the trade networks could be observed with the introduction of bronze metallurgy to northern Finland.

As Costopoulos based his far-reaching conclusions on quantitatively limited research material, it was deemed appropriate to re-examine his hypothesis about the change in chert supplies from the Late Neolithic to the Bronze Age in northern Finland using a larger research assemblage. Simultaneously, it was also essential to form the research assemblage in a way that the methodological goals of this article – assessing the applicability of pXRF as a non-destructive research method to determine the provenance for archaeological chert finds recovered from the coniferous boreal zone – could be reached. This twofold objective, in addition to the small number of excavated archaeological sites pertaining to the period of interest, left very few options regarding the choice of materials to be studied. The rationale behind their selection will be described next.

MATERIALS

The Sites

Only a few Bronze Age dwelling sites are known from northern Finland, comprising the provinces of Lapland, Kainuu, and Northern Ostrobothnia, as they customarily lack any features that could be detected as visible anomalies on the ground surface. Instead, these sites are characterized by tightly clustered scatters of lithic debitage, charred bone, and fire-cracked rocks found within few hundred square meters of space. Due to these reasons, "pure" Bronze Age dwelling-sites are seldom spotted in archaeological surveys unless the ground has been recently disturbed by earth-moving activity. In addition, a great amount of the existing material evidence on the Bronze Age in northern Finland pertains to multi-period inland sites located in the provinces of Kainuu and Lapland (e.g., Huurre 1986: 56, fig.) that were used either periodically or permanently from the Stone Age to the Iron Age. When some of these sites were excavated between the 1950s and 1970s, not enough attention was paid to their stratigraphy. Thus, while the resulting find assemblages may contain a fair amount of chert finds, the absence of sufficiently precise information about their chronological position enforces their exclusion from this study.

The situation is drastically different on the coastal area of the Bothnian Gulf characterized by active and still-ongoing land uplift caused by the post-glacial isostatic rebound. There, prehistoric dwelling-sites were often used for a relatively short period of time, because the people exploiting marine resources had to relocate their settlements once in a while closer to the “escaping” seashore (e.g., Hakonen 2017). The current rate of land uplift in this area can be utilized to estimate the vertical position of the seashore in the past, indicating the altitudes of 20–40 meters above the current sea level as those corresponding roughly with the late Neolithic and Bronze Age shorelines.

The area of Hangaskangas – a 7 km^2 wide glacial sand esker located by the Oulujoki River ca. 20 kilometers southeast of the city of Oulu in the province of Northern Ostrobothnia – comes here to the fore. It is the sole locality on the coast of the Bothnian Gulf with several dwelling sites that are chronologically successive and datable either to the Late Neolithic or the Bronze Age based on their location altitude above the sea level. Furthermore, the archaeological excavations that have taken place at these sites in recent years were carried out with modern archaeological methods thus yielding significant amounts of datable chert finds.

This archaeological evidence from the area of Hangaskangas pertains to two main clusters (Fig. 2, Table 1), one belonging administratively to the city of Oulu and another to the municipality of Muhos. Located by the southeastern tip of the Hangaskangas esker, the Muhos Halosentörmä site was subjected to several campaigns of excavation between 1968 and 2012 (Kopisto 1968; Ikäheimo 1999; 2001a; 2003; 2015), and the site of Muhos Hangaskangas, excavated in 2000 (Ikäheimo 2001b), is located a few hundred meters west of it. The Oulu Hangaskangas E site cluster, excavated in its entirety (Pesonen 2013; Mikkola 2015), on the eastern flank of the esker turned out to consist of several activity areas located on different altitudes and commonly referred to as dwelling-sites. Radiocarbon dates obtained from the sites in the area of Hangaskangas corroborate, although in a somewhat ambiguous manner, the positive correlation between the vertical position of the site and its date (Table 1). As indicated by the table, the Oulu Hangaskangas E1 site on the highest elevation was probably in use during the last centuries of the 3rd millennium BC, while the lowermost radiocarbon dated site of Oulu Hangaskangas E2 falls with high probability to the early 1st millennium BC. Thus, the chronological coverage of these sites extends from the Late Neolithic period at least to the early Late Bronze Age, assuming that the beginning of the Bronze Age is placed around 1950/1900 cal. BC (Kristiansen 2018) and that the Late Bronze Age begun ca. 1000 cal. BC.

Finds and specimens

The 118 chert and related siliceous rock finds recovered in various archaeological excavations form just a fraction of the total lithic assemblage found from the sites located in the Hangaskangas

Table 1. The sites with chert finds discussed in the article.

Site	Elevation	^{14}C-dates	cal.BC	Material
Oulu Hangaskangas E1	40.85–.90	Ua-45450 3695+35BP1)	2200–1972	charred bone
Muhos Halosentörmä	36.25–.75	Hela-154 3420+105BP	2019–1463	chewing resin
		GrA-63888 3000+35BP	1386–1121	charred bone
Muhos Hangaskangas	33.00	GrA-63520 3195+35BP	1518–1410	chewing resin
Oulu Hangaskangas E2	30.50–.75	Ua-45447 2775+40BP	1013–824	pot crust
		Ua-45451 2710+35BP	920–806	charcoal
Oulu Hangaskangas E8	26.00	–	–	–

Elevation: meters above sea level in Finnish N2000 vertical coordinate reference system.
Cal. BC= dates calibrated to 2σ with OxCal 4.4 on-line calibration program (Bronk Ramsey 2009) using IntCal20 calibration curve (Reimer et al. 2020).
1) Date from Oulu Hangaskangas E3 -site located at the same elevation Oulu Hangaskangas E1.

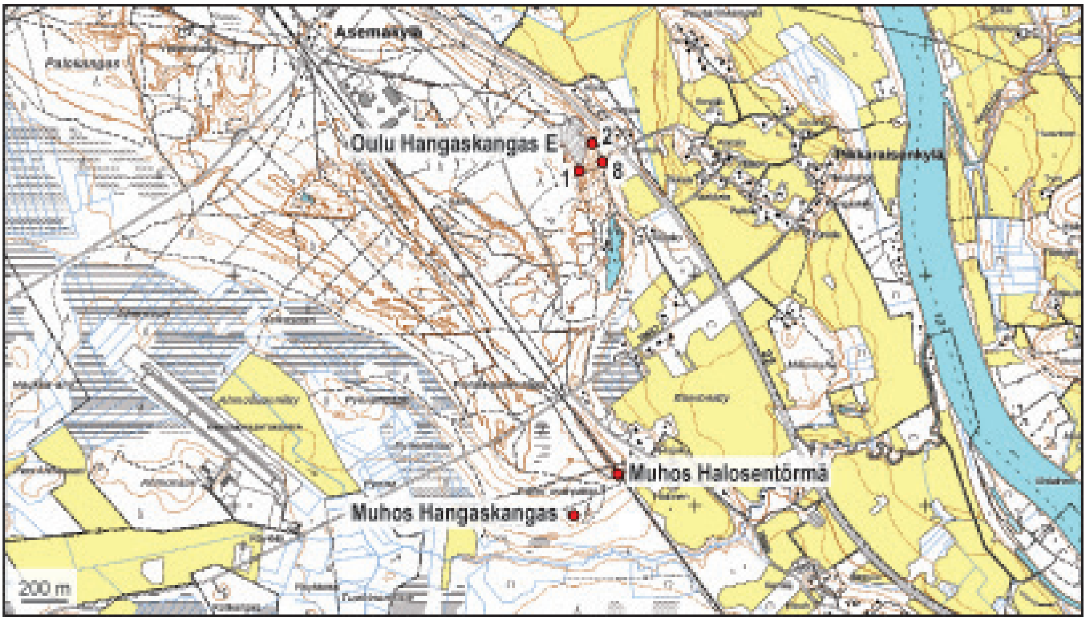

Figure 2. The location of archaeological sites with chert finds in the Hangaskangas area. Base map: National Land Survey of Finland, CC BY 4.0.

area (Table 2). Most likely due to its availability with several venous outcrops located within a 10-kilometer radius from the two site clusters, quartz was the most common raw material used for the making of small stone artifacts followed in importance by various types of quartzite. While the quartz assemblage totals nearly 25 kilograms in weight, the chert assemblage weighs only 82.69 grams in total. A considerable number of the chert finds (Fig. 3) can be classified as flakes detached from the artifact as it was gently rejuvenated to suit better for the intended purpose. Besides the size and formal attributes of these fragments, this is reflected by the average weight of the specimens in the assemblage; half of the finds weigh 0.1 grams or less. Of the proper artifacts identified, most are scrapers or their fragments, while a nearly intact bifacial arrowhead of black chert (Appendix 1: 14; Fig. 3) is the only find standing out in the assemblage. However, the chert assemblage is both quantitatively large and visually heterogeneous enough – ranging from fine-grained translucent black and greenish specimens with traces of chalky cortex to coarser, opaque reddish-brown or brown pieces with layered structure – to potentially include finds pertaining to several geological outcrops and source areas.

The research material is currently stored by the Finnish Heritage Agency in Helsinki, the Museum of Northern Ostrobothnia in Oulu, and the Archaeology Laboratory of Oulu University. All these institutes granted a swift access to the materials in their storage only after finding out that the aim was to apply a non-destructive research method on a large sample of archaeological finds. Therefore, the physical modification of the finds to fit them better over the instrument's analysis window was excluded at the outset. Yet, common recommendations for performing elemental analysis of lithics with a pXRF (e.g., Williams-Thorpe 2008: 181) were followed as closely as possible.

While flat and substantially large sample surfaces offering uniform conditions for analysis would have been desirable, they were infrequently available. In such cases, convex surface geometry was preferred over concave, to minimize the distance variations between the sample and the analyzer window. Catalog numbers inked on some specimen surfaces were intentionally avoided (see also Hughes et al. 2012: 787). Each sample was also visually assayed for

Table 2. Excavated sites and their chert assemblages.

Site	Year	m²	CHERT FINDS N	x wgt	pXRF
Oulu Hangaskangas E1	2012	52	4	0.66	3
Muhos Halosentörmä	1968	180	14	2.73	14
	1998–9, 2012	47	57	0.20	16
Muhos Hangaskangas	2000	62	2	5.04	2
Oulu Hangaskangas E2	2012	44	40	0.42	16
Oulu Hangaskangas E8	2012	24	1	8.26	1

pXRF= the number of finds analyzed for this article

other impurities and defects that could have affected the results. Compensation for the possible chemical heterogeneity known as the nugget effect (see Burke 2018: 3) that results from mineral inclusions potentially present in the sample due to the differences in the deposition of the parent material was sought by analyzing each specimen three times.

Sample diameter and thickness can also influence the analysis results, as previously demonstrated by experimental studies of archaeological basalt and obsidian finds (Lundblad et al. 2008; Davis et al. 2011). For example, the analyses of the lightest elements like MgO, Al_2O_3, and K_2O are most prone to a bias resulting from sample thinness (Lundblad et al. 2008: 7–8; see also Desroches et al. 2018: 38, 40). The heaviest element to be included in the present analysis was iron (Fe), for which the depth of analysis in aluminosilicates is ca. 200 microns, whereas it is much less for the lighter elements (see Grave et al. 2012: 1676, fig. 2) implying that the many specimens in the assemblage met well the requirement for infinite thickness (e.g., Ferguson

Figure 3. A selection of chert finds from the Muhos Halosentörmä and Muhos Hangaskangas sites (finds by row [see Appendix 1 for details] – top : 11, 20, 24, 12, 6, 19; middle: 1, 14, 9, 8; bottom: 31, 23, 30, 29). (Photo: Janne Ikäheimo.)

2012: 413–4). After all the variables potentially influencing the results had been considered with each find, altogether 52 archaeological specimens were analyzed for the study (see Appendix 1).

It goes without saying that as the chert assemblage has been exposed to chemical processes through soil alteration and weathering, the chemical stability of these lithics is not comparable to samples that have been recently hammered off from respective geological deposits. This is especially evident at the area of Hangaskangas. While the two site clusters are located only 1.4 kilometers apart from one another (Fig. 2) in environmentally uniform conditions, the finds have been embedded for several millennia in a matrix formed by podzol soil that typifies subarctic coniferous forests. It is characterized by extensive leaching and enrichment of various elements that become visually discernible in the soil profile as distinct vertical layers over the time (e.g., Tyler 2004).

In podzol, the grayish-white eluvial layer underneath the topsoil is depleted from many compounds, while the underlying illuvial layer is visually discernible from the bottommost stratum of 'sterile soil' (parent material) due to its reddish-brown color resulting from the enrichment of iron and aluminum. Therefore, the compositional data measured from a chert specimen might be influenced by its position in the soil matrix and this must be taken into account when drawing any conclusions about the assemblage. As any invasive chemical or mechanical procedure (e.g., acid treatment or ultrasonic bath) to remove or to significantly diminish the effect potentially caused by weathered outer surface was not allowed due to the status of these specimens as archaeological finds (see also Gauthier & Burke 2011: 270), each of them was carefully wiped with a cotton pad soaked in pure ethanol before the analysis.

METHODS

Instrumentation

The Bruker Tracer IV-SD (S/N T4S1945) portable XRF-analyzer (pXRF) manufactured by Bruker AXS Elemental Inc. was used for this study. This instrument has a rhodium target X-ray tube and is equipped with a Peltier-cooled 10mm^2 X-Flash silicon drift detector. Instrument-specific analytic parameters were controlled with X-ray Ops -software (version 1.2.21), while the spectra used to establish an instrument-specific chert calibration and the subsequent chert analysis were acquired with S1 PXRF S1 MODE -software (version 3.8.32), both designed and distributed by Bruker AXS Elemental Inc. The instrument was operated under vacuum (<1 torr) for improved light element performance (see Shackley 2011: 30) at 15 kV and 55 μA without tube filters from an external power source.

An alternative investigative approach suggested by Conrey et al. (2014: 292) with the voltage set to 45 KeV and tube current to 25 μA was also briefly explored. Higher voltage would have enhanced intensities for heavy elements while simultaneously diminishing intensities of the lighter elements, and it would have also yielded Compton scattered RhK_α intensities for matrix correction. However, as these settings resulted in a serious instrument instability over prolonged times of operation, this line of investigation had to be terminated before respective data on all samples had been collected.

All analyses, including both reference materials to be described shortly and archaeological finds, were performed 'from below' as the instrument was sitting in a stand with the beam pointing upward. The sample was in atmospheric conditions under the safety shield of the instrument with an Ultralene™ gridded window (P/N 485315-400) separating it from the vacuum. In all cases, the instrument registered spectra using 2048 channels with an average resolution of 20.03eV and with the time of analysis fixed to 240 live seconds. Previous research (Newlander et al. 2015: 542–5) has shown that while the counting error does not generally decrease significantly when the count time exceeds 180 seconds, the analysis of cherts can be enhanced by using longer count times. This is because other elements than silicon are normally present in cherts, particularly in flints, in low concentrations.

Reference materials

The calibration of the chert matrix was performed with the use of appropriate certified reference

Table 3. Certified reference materials and the elements used in the calibration.

	SiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	K_2O	TiO_2	P_2O_5	S	Cl
AC-E	70.35	14.7	2.53	0.058	0.03	0.34	4.49	0.11	0.014	0.007	0.018
AMIS0305	96.7	1.2	1.36	–	0.04	–	0.27	0.07	0.01	–	–
FK	88.2	6.18	0.261	0.004	0.15	0.11	4.23	0.058	0.077	–	–
FLX-13	46.93	3.63	0.42	0.42	2.28	4.96	4.93	0.45	0.53	0.42	0.37
GSD-10	88.98	2.84	3.86	0.13	0.12	0.7	0.125	0.21	0.62	0.009	0.0053
GSD-8	82.92	7.71	2.2	0.04	0.25	0.25	2.83	0.61	0.03	0.01	–
GSD-9	64.89	10.58	4.86	0.08	2.39	5.35	1.99	0.92	0.15	0.015	0.005
GSR-4	90.36	3.52	3.22	0.02	0.082	0.3	0.65	0.26	0.22	0.086	0.0042
JCh-1	97.81	0.734	0.356	0.017	0.754	0.0449	0.221	0.032	0.017	0.0004	0.0014
J-Gb1	43.44	17.66	15.16	0.17	7.83	11.98	0.24	1.62	0.05	0.195	–
NBS-91	67.53	6.01	0.081	0.008	0.008	10.48	3.25	0.019	0.022	–	–
NIM-L	52.4	13.64	9.96	0.77	0.28	3.22	5.51	0.48	0.06	–	0.12
Q1	99.9	–	–	–	–	–	–	–	–	0.002	0.018
Q2	99.9	–	–	–	–	–	–	–	–	0.002	0.022

Origin and type: Institute of Geophysical and Geochemical Exploration, China (sediment powders GSD-8, GSD-9 and GSD-10); National Research Centre of Geoanalysis, China (sandstone powder GSR-4); Geological Survey of Japan (chert powder JCh-1 and gabbro powder JGb-1); African Mineral Standards, South Africa (blank silica chips AMIS0305); National Institute for Metallurgy, South Africa (lujavrite powder SARM3 NIM-L); Zentrales Geologisches Institut, Germany (felthspatic sand powder FK); Centre de Recherches Petrographiques et Geochimiques, France (granite powder AC-E); National Bureau of Standards, USA (opal glass NBS-91), FLUXANA, Germany (XRF monitor glass FLX-13), in-house monitor glasses (Q1 and Q2) measured with a Malvern Panalytical benchtop XRF.

materials and additional in-house parallel method determined calibration samples (see Donais & George 2018: 54–7) that would sufficiently cover the needed concentration range and match the silicon matrix of chert. A previous study focusing on the application of a hand-held XRF analyzer to monitor the quality of quartz in an industrial setting has shown that this matrix type is quite uncomplicated to analyze (Desroches et al. 2018: 37). The sixteen calibration samples selected for this study comprised both pressed powder pellets and glass discs (Table 3). While potentially running the risk of being affected by matrix effects (see Shackley 2010: 19; 2011: 18–21; Ferguson 2012: 408–9), the use of solid glass (amorphous SiO_2) and pressed pellets of powders (chert, sediments, etc.) was necessitated by the general unavailability of suitable reference materials for pXRF, particularly those high in silica (see Conrey et al. 2014: 292; Burke 2018: 3; Desroches et al. 2018: 38).

The certified reference materials chosen for the study, for which the origin, type, and the reported standard composition of elements relevant for the present study, are shown in Table 3. All glass discs were analyzed per se, while 10 % of wax (Hoechst) was used in the preparation of pressed powder pellets. In two cases (GSR-4 and JCh-1), another pellet was prepared from the same reference material using 12 % of wax to increase the stability of the sample due to minute edge crumbling observed in the 10 % pellet. At least one reference material was chosen for each element of interest with concentration well above or below the usual range present in chert and other siliceous rocks to produce a meaningful concentration estimate for extended range (see, e.g., Ferguson 2012: 406–7; Shackley 2011: 34; Conrey et al. 2014: 292).

In addition, five geological samples of known general provenance – two from Denmark and Russia and one from southern Sweden – obtained from our study collection and through collegial solidarity were analyzed together with the archaeological finds. Due to the explorative nature and limited scope of the study, the use of quantitatively and geographically more representative geological reference collection was left for the future. Yet, the inclusion of these samples in the study was necessary to determine the consistency of analysis results between pressed powder and glass samples used in calibration

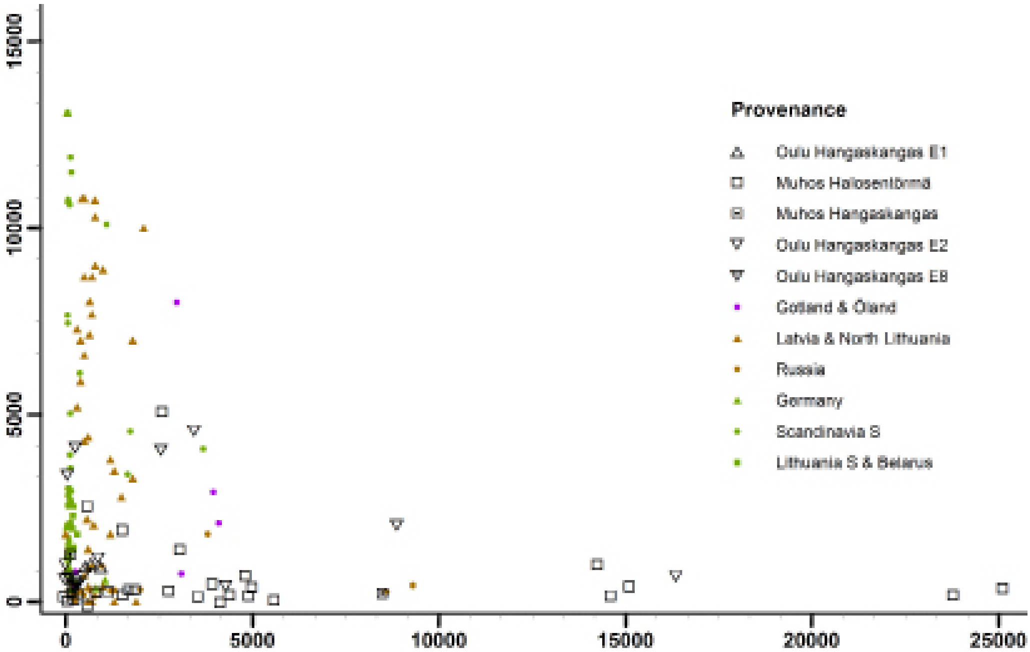

Figure 4. The Ca/Fe-ratio of all analyzed samples with reference values from published geological deposits. All values in ppm. Find chronology: up-pointing triangle= Late Neolithic, square= Early Bronze Age, down-pointing triangle= Late Bronze Age.

and irregular geological and archeological finds targeted to be measured with developed calibration.

Calibration

The authors agree on a conceptual level with Shackley's (2008: 196) statement that "nothing is ever really 'sourced'" and are aware of the challenges that the characterization of cherts with pXRF may present due to variation in lithological and chemical compositions (Newlander et al. 2015: 544). Yet, in the light of recent successful lithic provenance studies executed with a pXRF (Forster & Grave 2012; Grave et al. 2012; Newlander 2012), the authors took a positive stand in developing a calibration suited for archaeological chert finds recovered from the northern boreal zone instead of applying general rock calibrations not specifically matched to a chert matrix provided by the instrument manufacturer (cf., e.g., Carvalho & Pereira 2017).

CloudCal 3.0 software (Drake 2018) was used to calibrate each element of interest by establishing the closest fit between the spectra acquired with S1 PXRF S1 MODE -software and the published values of standard reference materials. The elements included in the calibration using K_{α} lines were the following: Mg, Al, Si, P, S, Cl, K, Ca, Ti, Mn, and Fe. Measured spectra were normalized by time averaging. For the two elements of interest in this article, calcium, and iron, linear calibration was the most reasonable approach, while non-linear regression was needed for some other elements.

RESULTS

The spectra resulting from the analysis of archaeological specimens were translated into relative element concentrations with the afore-described calibration using CloudCal 3.0. software. The analyzed finds are listed in Appendix 1. To make the results easily comparable with previous studies focusing on the geochemistry and provenance of chert around the Baltic Sea and adjacent areas, iron and calcium values were plotted (Figs. 4–6) together with previously published values for geological specimens and archaeological finds (Matiskainen et al. 1989; Hughes et al. 2011;

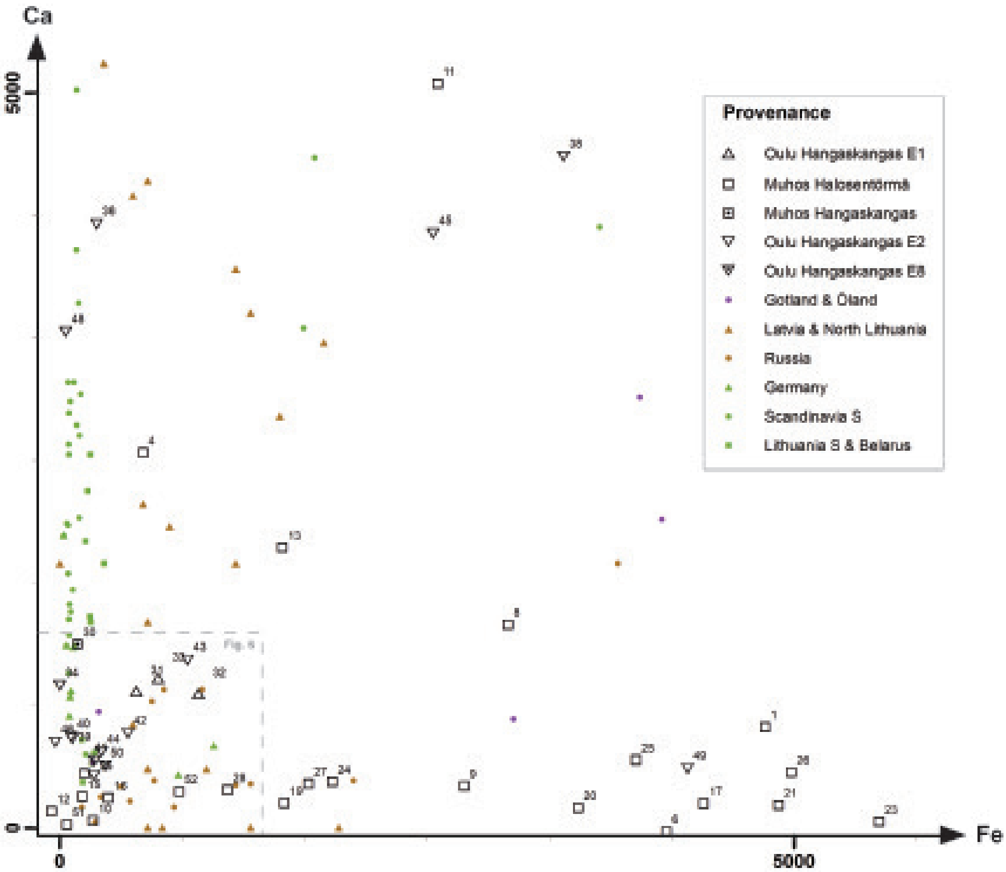

Figure 5. The Ca/Fe-ratio of samples in < 5000 ppm range with reference values from published geological deposits. Find chronology: up-pointing triangle= Late Neolithic, square= Early Bronze Age, down-pointing triangle= Late Bronze Age.

2012; Olofsson & Rodushkin 2011; Olausson et al. 2012; Högberg et al. 2014; 2016; Zarina et al. 2014; Sinitsyna & Kolokol'tsev 2018). The plotting was executed with ArcMap 10.7.1 GIS-software for improved visual scalability necessitated by the considerable variation in element concentration both in the actual results (Ca ≤5,062 ppm; Fe ≤23,781 ppm) and the reference values (Ca ≤215,000 ppm; Fe ≤50 000 ppm). Before reviewing the outcome and comparing it with previously published results, it is worth underlining here that due to variation in research methods used and analysis routines applied, their inter-comparability can reasonably be questioned. Yet, in spite of possible discrepancies, the overall pattern seems to be distinct enough for drawing generalizing conclusions.

This being said, several observations can be made regarding the results themselves (Fig. 4). First, the calcium content of many geological specimens, especially the ones from Gotland, Öland, and North Lithuania, exceeds significantly the values measured from archaeological finds. While this could be taken at face value as an indication that no chert from these sources reached the Hangaskangas area during the Late Neolithic and the Bronze Age, surface weathering must also be considered as a potential contributing factor to low calcium values (see Gauthier & Burke 2011: 278). Moreover, as all specimens yielding under 400 ppm concentration for calcium in various geological analyses pertain to the eastern deposits of Moscow, Valdai, and the White Sea, this value might be used as a threshold for assigning general provenance between the east and the west.

On the other hand, several finds from the area of Hangaskangas yielded substantially high values for iron that still fall within the same concentration range as other archaeological finds from Finland and northern Sweden. The enrichment of iron on the object surface (Gauthier & Burke 2011: 278; Hughes et al. 2012: 787; Olausson et al. 2017: 106) could explain some of this variation, but as with calcium values, the provenance and potentially also the specific rock type can be put forth as additional explanatory factors. The find in the assemblage yielding the highest value for iron, for example, can be tentatively identified as jasper or jasperoid (Kinnunen 2008: 11) by its visual properties. High concentrations of iron also characterize some Silurian and Carboniferous chert deposits (Johanson et al. 2021: 127). For example, the reported maximum value for the Valdai region (Sinitsyna & Kolokol'tsev 2018: 451, table 5) is no less than 50,000. Such cherts are often opaque with a color palette ranging from black through brown to various hues of red (Dolukhanov et al. 2017: 68; see also Kinnunen et al. 1985: 19). Apart from these extremes, the concentration of both calcium and iron values fall below 5,000 ppm in the majority of the finds (Fig. 5) while a further cluster is formed by the finds with values not exceeding 1,200 ppm (Fig. 6).

DISCUSSION AND CONCLUSIONS

When the results are projected against the temporal framework offered by the two site clusters in the Hangaskangas area, the following observations emerge. First, all the specimens analyzed from the Oulu Hangaskangas E 1, which is purportedly the oldest of the sites examined, are tightly associated with the geological samples of the Valdai-Moscow region. This supports the previous observation by Matiskainen et al. (1989: 636–7), according to which cherts of eastern origin were predominant during the Neolithic period in Finland. The picture remains quite invariable regarding finds from the Muhos Halosentörmä site with some exceptions. The most notable of them is a scraper (Appendix 1: 11; Fig. 3) of jet black chert with a Ca/Fe-ratio comparable to geological sources of southern Sweden. The presence of an artifact made of Scandinavian chert is not by any means a surprise, as also other find classes at the Halosentörmä site, most notably ceramic crucibles (see Ikäheimo 2020), contain finds of this origin. The nearby Muhos Hangaskangas site with its finds falling into both main categories, eastern and western chert, is also indicative of a transition period with overlapping chert supplies.

The finds analyzed from the Oulu Hangaskangas E 2 site, on the other hand, suggest a definitive change in the supply chain. Approximately 80 % of the material analyzed is now clustered with the reference values from specimens belonging to southern Scandinavian or southern Baltic Cretaceous deposits, and the rest of the finds are only disputably of eastern origin. Moreover, the results published on chert finds from the Bronze Age dwelling-sites located in southwestern Finland (see Matiskainen et al. 1989: 827, Map 1, open circles) fall predominantly within the same cluster. A stray find tentatively identified as a strike-a-light (for Bronze age strike-a-lights, see e.g., van Ginj 2010), the only chert object found at the lowermost, and thus chronologically youngest site of Oulu Hangaskangas 8, completes the group.

In all, the results obtained by analyzing the finds from various sites located at the area of Hangaskangas seem to confirm the hypothesis formulated by Matiskainen et al. (1989: 636–7) by suggesting a transition from the use of eastern Carboniferous to western Cretaceous chert sources during the Bronze Age. Neither do the results necessarily contradict Costopoulos' idea about the stability of the trade networks in the early Bronze Age, but as it was based on the analysis of a solitary find from the Muhos Halosentörmä site, additional samples analyzed here indicate that by that time chert imports reached the eastern coast of the Bothnian Bay both from the east and the west.

The other research question concerning the effect of weathering and other post-depositional processes on chert finds from archaeological contexts can also be evaluated here by examining the clustering or dispersal of Ca/Fe-ratios measured from finds pertaining in all likelihood to the same geological source. The two examples that can be seen in Fig. 5 are both distinct groups

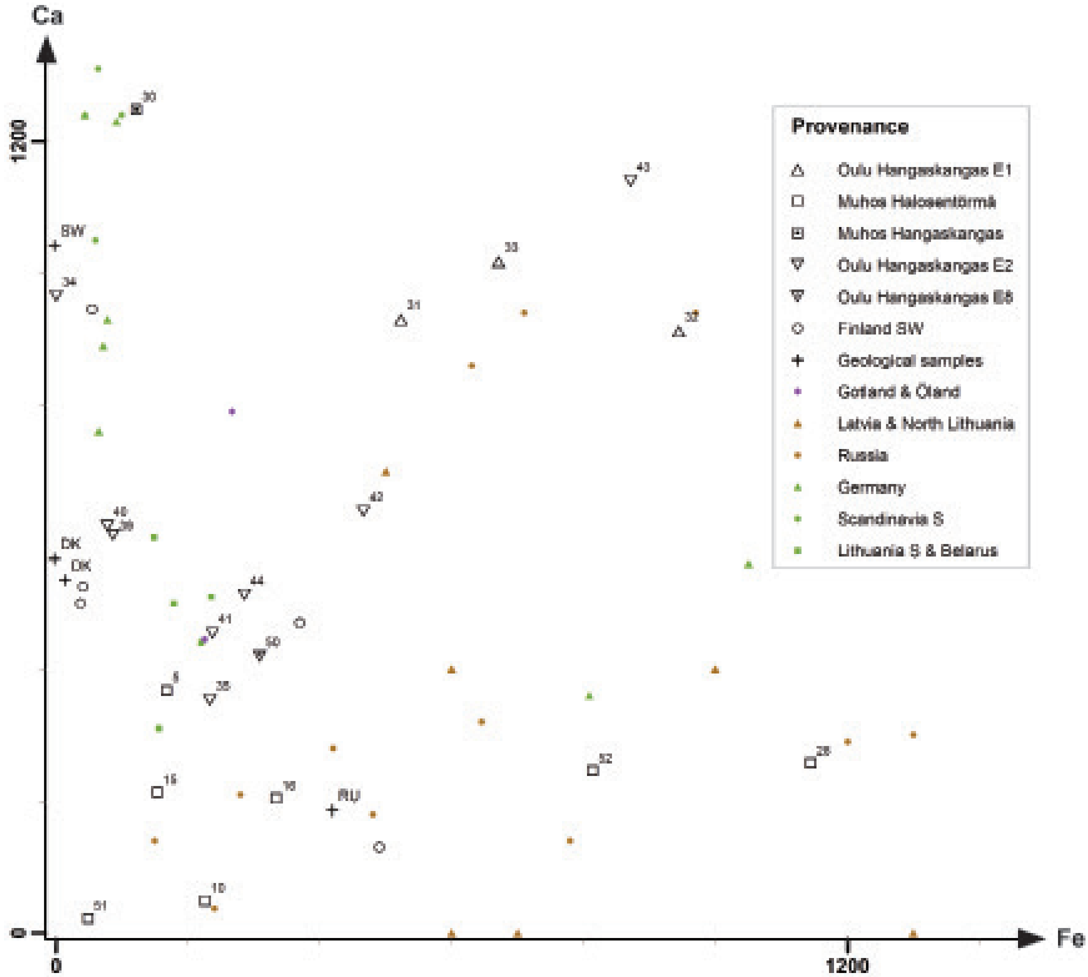

Figure 6. The Ca/Fe-ratio of samples in < 1200 ppm range with reference values from published geological deposits and Bronze Age finds from southwest Finland. Find chronology: up-pointing triangle= Late Neolithic, square= Early Bronze Age, down-pointing triangle= Late Bronze Age.

of small flakes, substantially uniform in size and thickness: one of jet black chert (Fig. 5: 19, 24 , 27) and the other of brownish-grey chert (Fig. 5: 6, 20, 21, 25). In both cases, rather than being dispersed, the results are clustered, although clustering is in both cases quite loose. While this confirms the observation about weathering as a factor increasing the chemical heterogeneity of the finds (see, e.g., Lundblad et al. 2011: 70), the clusters are still compact enough to form interpretatively significant patterns.

From this methodological point of view, these initial results suggest that calibrated and matrix-matched pXRF-analyses provide sufficiently precise information on the elemental composition of chert finds. By classifying them into meaningful groups and pairing them with chemical reference data obtained from known geological chert sources, a general provenance for archaeological chert finds may be tentatively assigned. These identifications can be strengthened by complementing the two-dimensional compositional data with analyses of other chemical elements known to be indicative in chert sourcing as well as more traditional observations regarding their macroscopic and microscopic characteristics such as color, texture, and possible microfossil content (see Lundblad et al. 2011; Olausson et al. 2017). Yet, to really be an applicable option for archaeological finds recovered from the podzol soil of the coniferous boreal zone, which is a famously geochemically harsh environment, increased attention should be paid to the immediate soil matrix from which such finds have been recovered.

Therefore, the documentation of the soil matrix should be carried out at archaeological excavations with a similar routine as one records today the precise location of every find. Because pedological conditions between the eluvial and illuvial layer in the podzol soil are starkly different, the position and orientation of a chert, or other find type, in soil is decisive for the extent and gravity of post-depositional processes it will be subjected to. For instance, as the orientation of the find in the soil can potentially impact the results of chemical analysis, logical considerations suggest that the up-facing side of a lithic fragment in the podzol soil matrix is more heavily weathered than the downfacing one. As modern survey equipment have customizable data collection interfaces, these variables are easy to record along with the positioning data on the field, while non-destructive analysis techniques such as X-ray diffraction and Raman spectrometry can provide further information about the weathering layer in laboratory conditions (Capel Ferrón et al. 2015).

In addition, the knowledge about raw material flows in the research area would clearly profit from long-lived and systematic research efforts focusing on provenance studies of chert and other siliceous rocks. For instance, due to its considerable mining potential for various metals and minerals, northern Finland continues to be the target of intensive geological surveys that produce indirectly a lot of relevant information for archaeological research. At the very least, this should promote the survey of domestic metacherts, the kind of which have constituted an important raw material resource in northern Norway from the Mesolithic period onwards (e.g., Hood 1992; Niemi 2019). The expansion in the range of geological comparison materials to be included in the investigative framework together with new samples from previously known sources and archaeological sites would likely lead into an augmented perception of prehistoric raw material flows. With the use of a non-invasive analysis method like pXRF, while simultaneously understanding its analytical limitations, the scope of research may easily be broadened to incorporate other chronological periods and geographical areas.

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REFERENCES

Unpublished sources

Ikäheimo, J. 1999. Muhoksen Hangaskangas (MH-98): Tutkimuskertomus varhaispronssikautisella rannikkoasuinpaikalla 25.–30.5.1998 suoritetusta arkeologisesta kaivauksesta. Excavation report, University of Oulu, Laboratory of Archaeology, Oulu.

Ikäheimo, J. 2001a. Muhoksen Hangaskangas (MH-99): Tutkimuskertomus varhaispronssikautisella rannikkoasuinpaikalla 24.–28.5.1999 suoritetusta arkeologisesta kaivauksesta. Excavation report, University of Oulu, Laboratory of Archaeology, Oulu.

Ikäheimo, J. 2001b. Muhos Hangaskangas: Tutkimuskertomus varhaispronssikautisella rannikkoasuinpaikalla 5. –16.6.2000 suoritetuista arkeologisista kaivauksista (MuHa-00). Excavation report, University of Oulu, Laboratory of Archaeology, Oulu.

Ikäheimo, J. 2003. Muhos Hangaskangas: Tutkimuskertomus varhaispronssikautisella rannikkoasuinpaikalla 21.7.–8.9.2002 suoritetuista arkeologisista kaivauksista (MH-02). Excavation report, University of Oulu, Laboratory of Archaeology, Oulu.

Ikäheimo, J. 2015. Muhos Halosentörmä: Tutkimuskertomus varhaispronssikautisella rannikkoasuinpaikalla 28.5.–8.6.2012

suoritetuista arkeologisista kaivauksista (MH-12). Excavation report, University of Oulu, Laboratory of Archaeology, Oulu.
Kopisto, A. 1968. Muhos Halonen 1968. Field diary, Museum of Northern Ostrobothnia, Archives, Oulu.
Mikkola, E. 2015. Oulu Hangaskangas E: Kivi- ja pronssikautisen asuinpaikan osan arkeologinen kaivaus 25.8.–5.9.2014. Excavation report, The Finnish Heritage Agency, Archives, Helsinki.
Newlander, K. 2012. Exchange, Embedded Procurement & Hunter-Gatherer Mobility: A Case Study from the North American Great Basin. Doctoral dissertation, Anthropology, University of Michigan, Ann Arbor, MI.
Pesonen, P. 2013. Oulu Hangaskangas E: Kivi- ja pronssikautisen asuinpaikan arkeologinen kaivaus 14.6.–20.7.2012. Excavation report, The Finnish Heritage Agency, Archives, Helsinki.

Literature

Baltrūnas, V., Karmaza, B., Kulbickas, D. & Ostrauskas, T. 2006. Distribution of raw material for prehistoric flint artefacts in South Lithuania. *Geografija* 42(2): 41–7.
Bronk Ramsey, C. 2009. Bayesian analysis of radiocarbon dates. Radiocarbon 51(1): 337–60.
Burke, A. L. 2018. Chert, silex & obsidian sourcing. In S. L. López Varela (ed.) *The Encyclopedia of Archaeological Sciences*: 1–5. Malden, MA: JohnWiley & Sons.
Capel Ferrón, C., León-Reina, L., Jorge-Villar, S., Compaña, S. J. M., Aranda, M. A. G., López Navarrete, J. T., Hernández, V., Medianero, F. J., Ramos, J., Weniger, G.-C., Domínguez-Bella, S., Linstaedter, J., Cantalejo, P., Espejo, M. & Durán Valsero, J. J. 2015. Combined Raman spectroscopic and Rietveld analyses as a useful and non-destructive approach to studying flint raw materials at prehistoric archaeological sites. *Archaeological and Anthropological Sciences* 7: 235–43.
Carvalho, A. F. & Pereira, T. 2017. Flint variability in a Cardial context: A preliminary evaluation by portable x-ray fluorescence of artefacts from Cerradinho do Ginete (Portuguese Estremadura). In N. Bicho, T. Pereira & X. Terradas (eds.) T*he Exploitation of Raw Materials in Prehistory: Sourcing, Processing and Distribution*: 265–83. Newcastle upon Tyne: Cambridge Scholars Publishing.
Conrey, R. M., Goodman-Elgar, M., Bettencourt, N., Seyfarth, A., Van Hoose, A. & Wolff, J. A. 2014. Calibration of a portable X-ray fluorescence spectrometer in the analysis of archaeological samples using influence coefficients. *Geochemistry: Exploration, Environment, Analysis* 14(3): 291–301.
Costopoulos, A. 2003. Prehistoric flint provenance in Finland: Reanalysis of southern data and initial results for the North. *Fennoscandia archaeologica* XX: 41–54.
Davis, M. K., Jackson, T .L., Shackley, M. S., Teague, T. & Hampel, J. H. 2011. Factors affecting the energy-dispersive X-Ray fluorescence (EDXRF) analysis of archaeological obsidian. In M. Shackley (ed.) *X-ray Fluorescence Spectrometry (XRF) in Geoarchaeology*: 45–63. New York, NY: Springer.
Desroches, D., Bédard, L. P., Lemieux, S. & Esbensen, K. H. 2018. Suitability of using a handheld XRF for quality control of quartz in an industrial setting. *Minerals Engineering* 126: 36–43.
Dolukhanov, P. M., Kosheleva, E. A., Lisitsyn, S. N. & Subetto, D. A. 2017. Eastern Fennoscandia and the adjacent regions of the northwestern East European Plain. In V. M. Kotlyakov & A. A. Velichko & S. A. Vasiljev (eds.) H*uman Colonization of the Arctic: The Interaction between Early Migration and the Paleoenvironment*: 51–72. Amsterdam: Academic Press.
Donais, M. K. & George, D. B. 2018. *X-ray Fluorescence Spectrometry and its Applications to Archaeology: An Illustrated Guide*. New York, NY: Momentum Press LLC.
Drake, B .L. 2018. CloudCal v3.0. GitHub. https://github.com/leedrake5/CloudCal. doi: 10.5281/zenodo.2596154
Drake, B. L., Nazaroff, A. J. & Preufer, K. M. 2009. Error assessment of portable X-ray fluorescence spectrometry in geochemical sourcing. *SAS Bulletin* 32(3): 14–7.
Ferguson, J. R. 2012. X-ray fluorescence of obsidian: Approaches to calibration and the

analysis of small samples. In A. N. Shugar & J. L. Mass (eds.) *Handheld XRF for Art and Archaeology*: 401–22. Leuven: Leuven University Press.

Forster, N. & Grave, P. 2012. Non-destructive pXRF analysis of museum-curated obsidian from the Near East. *Journal of Archaeological Science* 39(3): 728–36.

Frahm, E. 2013. Validity of "off-the-shelf" handheld portable XRF for sourcing Near Eastern obsidian chip debris. *Journal of Archaeological Science* 40(2): 1080–92.

Gauthier, G. & Burke, A. L. 2011. The effects of surface weathering on the geochemical analysis of archaeological lithic samples using non-destructive polarized energy dispersive XRF. *Geoarchaeology* 26(2): 269–91.

Gijn, A. van 2010. Not at all obsolete! The use of flint in the Bronze Age Netherlands. In B. E. Eriksen (ed.) *Lithic technology in metal using societies. Proceedings of a UISPP Workshop, Lisbon, September* 2006: 45–60. Århus: Århus University Press.

Grave, P., Attenbrow, V., Sutherland, L., Pogson, R. & Forster, N. 2012. Non-destructive pXRF of mafic stone tools. *Journal of Archaeological Science* 39(6): 1674–86.

Hakonen, A. 2017. Shoreline displacement of the Finnish Bothnian Bay coast and the spatial patterns of the coastal archaeological record of 4000 BCE – 500 CE. *Fennoscandia archaeologica* XXXIV: 5–31.

Halinen, P. 2005. *Prehistoric Hunters of Northernmost Lapland: Settlement Patterns and Subsistence Strategies*. Iskos 14. Helsinki: Suomen Muinaismuistoyhdistys.

Hood, B. C. 1992. Chert sources and distribution patterns in the stone age of West Finnmark, North Norway: A preliminary view. *Acta Borealia: A Nordic Journal of Circumpolar Societies* 9(2): 69–84.

Hughes, R. E., Baltrūnas, V. & Kulbickas, D. 2011. Comparison of two analytical methods for the chemical characterization of flint from Lithuania and Belarus. *Geologija* 53(2): 69–74.

Hughes, R. E., Högberg, A. & Olausson, D. 2010. Sourcing flint from Sweden and Denmark. A pilot study employing non-destructive energy dispersive X-ray fluorescence spectrometry. *Journal of Nordic Archaeological Science* 17: 15–25.

Hughes, R. E., Högberg, A. & Olausson, D. 2012. The chemical composition of some archaeologically significant flint from Denmark and Sweden. *Archaeometry* 54(5): 779–95.

Huurre, M. 1986. The eastern contacts of Northern Fennoscandia in the Bronze Age. *Fennoscandia archaeologica* III: 51–58.

Högberg, A., Olausson, D. & Hughes, R. E. 2012. Many different types of Scandinavian flint: Visual classification and energy dispersive X-ray fluorescence. *Fornvännen* 107: 225–40.

Högberg, A., Hughes, R. E. & Olausson, D., 2013. Comparing Polish and Scandinavian flint using visual and chemical analysis: Some preliminary results. *Fornvännen* 108: 257–61.

Högberg, A., Hughes, R. E. & Olausson, D. 2014. Chemical analysis of red and black Heligoland flint: Initial results and comparisons with flint from Scandinavia. *Siedlungs- und Küstenforschung im südlichen Nordseegebiet = Settlement and coastal research in the southern North Sea Region* 37: 59–66.

Högberg, A., Hughes, R. E. & Olausson, D. 2016. Chemical and visual analysis of flint from Gotland and Öland. *Fornvännen* 111: 145–52.

Ikäheimo, J. 2020. From obvious to ambiguous: A comparative case study of crucible fragments from a Bronze Age site in northern Finland. *Fennoscandia archaeologica* XXXVII: 25–44.

Johanson, K., Kriiska, A., Aruväli, J., Somelar, P., Sikk, K. & Sepp, L. 2021. Local or imported? Tracking the provenance of flint raw materials of the Mesolithic habitants of Estonia and northern Latvia with the help of geochemical methods. In D. Borić, D. Antonović & B. Mihailović (eds.) *Foraging Assemblages: Proceedings of the Ninth International Conference on the Mesolithic in Europe, held in Belgrade in September* 14–18, 2015, vol.1: 123–8. Belgrade: Publikum.

Kinnunen, K. 1982. Primary sedimentary features in Kittilä jasper. Finnish Lapland. *Bulletin of the Geological Society of Finland* 54: 69–76.

Kinnunen, K. 2008. Jaspista Vimpelin Ryytimaalta. *Geologi* 60(1): 6–11.

Kinnunen, K., Tynni, R., Hokkanen, K. & Taavitsainen, J.-P. 1985. *Flint raw materials of prehistoric Finland: Rock types, surface textures and microfossils*. Geological Survey Bulletin of Finland 334. Espoo: Geological Survey of Finland.

Kriiska, A., Hertell, E. & Manninen, M. A. 2011. Stone Age flint technology in south-western Estonia: Results from the Pärnu Bay Area. In T. Rankama (ed.) *Mesolithic Interfaces: Variability in Lithic Technologies in Eastern Fennoscandia*: 65–86. Monographs of the Archaeological Society of Finland 1. Helsinki: Suomen Arkeologinen Seura.

Kristiansen, K. 2018. The rise of Bronze Age peripheries and the expansion of international trade 1950–1100 BC. In K. Kristiansen, T. Lindkvist & J. Myrdal (eds) *Trade and Civilisation: Economic Networks and Cultural Ties, from Prehistory to the Early Modern Era*: 87–112. Cambridge: Cambridge University Press.

Kröger, B. 2007. Concentrations of juvenile and small adult cephalopods in the Hirnantian cherts (Late Ordovician) of Porkuni, Estonia. *Acta Palaeontologica Polonica* 52(3): 591–608.

Lehto, T. & Niiniskorpi, V. 1977. *Pohjois- ja Itä-Suomen rautamuodostumat.* Tutkimusraportti 22. Helsinki: Geologinen tutkimuslaitos.

Luedtke, B. E. 1992. *An Archaeologist's Guide to Chert and Flint.* Archaeological Research Tools 7. Los Angeles: University of California.

Lundblad, S. P., Mills, P. R. & Hon, K. 2008. Analysing archaeological basalt using non-destructive energy-dispersive X-ray fluorescence (EDXRF): Effects of post-depositional chemical weathering and sample size on analytical precision. *Archaeometry* 50(1): 1–11.

Lundblad, S. P., Mills, P. R., Drake-Raue, A. & Kekuewa Kikiloi, S. 2011. Non-destructive EDXRF analyses of archaeological basalts. In M. Shackley (ed.) *X-ray Fluorescence Spectrometry (XRF) in Geoarchaeology*: 65–79. New York, NY: Springer.

Manninen, M. A., Tallavaara, M. & Hertell, E. 2003. Subneolithic bifaces and flint assemblages in Finland. Outlining the history of research and future questions. In C. Samuelsson & N. Ytterberg (eds.) *Uniting Sea. Stone Age Societies in the Baltic Sea Region*: 161–79. Uppsala: Uppsala universitet.

Matiskainen, H., Vuorinen, A. & Burman, O. 1989. The provenance of prehistoric flint in Finland. In Y. Maniatis (ed.) *Archaeometry: Proceedings of the 25th international symposium*: 625–43. London: Elsevier.

Newlander, K., Goodale, N., Jones, G. T. & Bailey, D. G. 2015. Empirical study of the effect of count time on the precision and accuracy of pXRF data. *Journal of Archaeological Science: Reports* 3: 534–48.

Niemi, A. R. (ed.) 2019. *Undersøkelse av chertbrudd, utvinningsteknologi og bosetningsspor fra tidlig eldre steinalder i Melsvik, Alta k., Finnmark f.* Tromura: Tromsø Museums Rapportserie 50. Tromsø: Tromsø Museum – Universitetsmuseet, UiT Norges Arktiske Universitet.

Olausson, D., Hughes, R. & Högberg, A. 2012. A new look at Bjurselet: The Neolithic flint axe caches from Västerbotten, Sweden using non-destructive energy dispersive X-ray fluorescence analysis for provenance determination. *Acta Archaeologica* 83(1): 83–103.

Olausson, D., Högberg, A. & Hughes, R. & 2017. The use of non-destructive energy dispersive X-ray fluorescence (EDXRF) analysis for sourcing flint in northern Europe: Progress to date and prospects for the future. In T. Pereira, X. Terradas & N. Bicho (eds.) *The Exploitation of Raw Materials in Prehistory: Sourcing, Processing and Distribution*: 98–112. Cambridge: Cambridge Scholars Publishing.

Olofsson, A. & Rodushkin, I. 2011. Provenancing flint artefacts with ICP–MS using REE signatures and Pb isotopes as discriminants: Preliminary results of a case study from northern Sweden. *Archaeometry* 53(6): 1142–70.

Reimer, P., Austin, W., Bard, E., Bayliss, A., Blackwell, P., Bronk Ramsey, C., Butzin, M., Cheng, H., Edwards, R., Friedrich, M., Grootes, P., Guilderson, T., Hajdas, I., Heaton, T., Hogg, A., Hughen, K., Kromer, B., Manning, S., Muscheler, R., Palmer, J., Pearson, C., van der Plicht, J., Reimer, R., Richards, D., Scott, E., Southon, J., Turney, C., Wacker, L., Adolphi, F., Büntgen, U., Capano, M., Fahrni, S., Fogtmann-Schulz, A., Friedrich, R., Köhler, P., Kudsk, S., Miyake, F., Olsen, J., Reinig, F., Sakamoto, M., Sookdeo, A. & Talamo, S. 2020. The IntCal20 Northern Hemisphere radiocarbon age calibration curve (0–55 cal kBP). *Radiocarbon* 62(4): 725–57.

Shackley, M. S. 2008. Archaeological petrology and the archaeometry of lithic materials. *Archaeometry* 50(2): 194–215.

Shackley, M. S. 2010. Is there reliability and validity in portable x-ray fluorescence spectrometry (PXRF)? *The SAA Archaeological Record* Nov. 2010: 17–20.

Shackley, M. S. 2011. An introduction to X-Ray Fluorescence (XRF) analysis in archaeology. In M. S. Shackley (ed.) *X-ray Fluorescence Spectrometry (XRF) in Geoarchaeology*: 7–44. New York, NY: Springer.

Shackley, M. S. 2012. Portable X-ray fluorescence spectrometry (pXRF): The good, the bad & the ugly. *Archaeology Southwest Magazine* 26(2): (online exclusive essay).

Sinitsyna, G. V & Kolokol'tsev, V. G. 2018. Kremnevoe syr'e v materialakh stoyanok-masterskikh Podol III/1 i vyshegora i na vodorazdele volgi i dnepra. In I. N. Chernykh (ed.) *Materialy 18-go-20-go zasedaniy nauchno-metodicheskogo seminara "Tverskaya zemlya i sopredel'nyye territorii v drevnosti"*: 414–58. Tverskoy arkheologicheskiy sbornik 11. Tver: Triada.

Sipilä, P., Kujala, H. & Torssonen, M. 2008. *Oravaisten–Lapuan Alahärmän–kallioperä*. Tutkimusraportti 270. Helsinki: Geologian tutkimuskeskus.

Speakman, R. J. & Shackley, M. S. 2013, Silo science and portable XRF in archaeology: A response to Frahm. *Journal of Archaeological Science* 40(2): 1435–43.

Stow, D. A. V. 2005. *Sedimentary Rocks in the Field: A Colour Guide.* Boca Raton, FL: CRC Press.

Tyler, G. 2004. Vertical distribution of major, minor, and rare elements in a Haplic Podzol. *Geoderma* 119: 277–90.

Vartiainen, R. 2017. Kittilän jaspis. In K. A. Kinnunen (ed.) *Suomen korukivet. Gemstones of Finland:* 296–300. Espoo: Geologian tutkimuskeskus.

Williams-Thorpe, O. 2008. The application of portable X-ray fluorescence analysis to archaeological lithic provenancing. In P. J. Potts and M. West (eds.) *Portable X-ray Fluorescence Spectrometry: Capabilities for In Situ Analysis*: 174–205. Cambridge, UK: RSC Publishing.

Yurgenson, E 1958. *O kremnevykh obrazovaniyakh v ordovikskikh i siluriyskikh karbonatnykh porodakh Estonskoy SSR*. Eesti NSV Teaduste Akadeemia Geoloogia Instituudi uurimused II: 87–93.

Zariņa, L., Kostjukovs, J., Segliņš, V. & Burlakovs, J. 2014. Flint XRF analysis for geoarchaeological application. In *14th International Multidisciplinary Scientific GeoConference SGEM 2014 conference proceedings* 1(1): 79–86. Bulgaria: Albena.

Zariņa, L. & Segliņš, V. 2017. Chert chemical composition analysis for geoarchaeological application. In N. Bicho, T. Pereira & X. Terradas (eds.) *The Exploitation of Raw Materials in Prehistory: Sourcing, Processing and Distribution*: 148–60. Newcastle upon Tyne: Cambridge Scholars Publishing.

Zhilin, M. G. 1997. Flint raw material from the Upper Volga basin and its use in the Final Palaeolithic-Neolithic. In R. Schild & Z. Sulgostowska (eds.) *Man and Flint. Proceedings of the VIIth International Flint Symposium Warszawa – Ostrowiec Świętokrzyski September* 1995: 331–3. Warszawa: Polish Academy of Sciences.

Zhuravlev, A. P. 1982. Syr'evaja baza kremnevyh orudnij bassejna Onežskogo ozera. *Sovetskaja arheologija* 1: 204–7.

Öhman, T. 2017. *Geologisesti merkittävät luonto- ja kulttuuriperintökohteet Kauhavalla ja Lapualla.* Loppuraportti, hanke 35461. Lapua: Aisapari.

APPENDIX

Appendix 1. Catalogue of analyzed finds.

#:	KM-cat. n:o	Item type	Munsell color[1]
Muhos Halosentörmä			
1.	17646:104	scraper	GLEY1 8/N
2.	17646:157	flake	GLEY1 8/N
3.	17646:15	flake	10R 3/4
4.	17646:164	scraper	7.5YR 8/1
5.	17646:167	flake	7.5YR 8/1
6.	17646:168	flake	10R 4/6
7.	17646:171	flake	2.5YR 6/1
8.	17646:31	scraper	10R 4/6
9.	17646:50	scraper	7.5YR 5.5/3
10.	17646:56	flake	10YR 7/1
11.	17646:8	scraper	GLEY2 4/10B
12.	17646:86	scraper	2.5Y 4/2
13.	17646:9	flake	GLEY2 4.5/10B
14.	17646:95	arrowhead	GLEY1 8/N
15.	30888:11	flake	GLEY1 5/10Y
16.	30888:15	flake	GLEY1 4/N
17.	30888:33	point frg.	GLEY1 7/N
18.	30888:56	flake	10YR 4/6
19.	30888:90b	flake	5YR 3/3
20.	32048:115	flake	3/N
21.	32048:136	flake	7.5YR 5/6
22.	32048:1478	flake	10YR 4/4
23.	32048:167	scraper	10YR 5/6
24.	32048:176	flake	7.5YR 4/7
25.	32048:209	flake	GLEY1 2.5/N
26.	32048:262	flake	7.5YR 5/6
27.	32048:292	flake	2.5YR 4/6
28.	32048:387	flake	GLEY1 2.5/N
29.	32048:894	cutter	2.5YR 4/4
Muhos Halosentörmä			
30.	32171:23	cutter	10R 4/3
31.	32171:24	scraper	7.5YR 7/1
Oulu Hangaskangas E1			
32.	39158:1016	flake	GLEY1 4/N
33.	39158:1018	flake	2.5YR 6/2
34.	39158:1019	flake	2.5YR 6/2
Oulu Hangaskangas.E2			
35.	39158:114	flake	5YR 5/1
36.	39158:115	flake	10R 5/3
37.	39158:120	flake	GLEY1 8/N
38.	39158:121	scraper	10R 3/3
39.	39158:122	flake	2.5YR 3/2
40.	39158:124a	strike-a-l.	GLEY1 5/10YR
41.	39158:124b	strike-a-l.	GLEY1 3/N
42.	39158:125	flake	GLEY1 6/N
43.	39158:126	flake	GLEY1 5/10Y
44.	39158:128	scraper	2.5Y 4/1
45.	39158:134	flake	2.5YR 4/6
46.	39158:135a	flake	GLEY1 6/10Y
47.	39158:135b	flake	7.5YR 5/6
48.	39158:138	flake	10YR 7/1
49.	39158:139	flake	10R 3/4
Oulu Hangaskangas E3			
50.	39158:995	strike-a-l.	GLEY1 7/N
Muhos Halosentörmä			
51.	39187:19	flake	10YR 4/2
52.	39187:24	flake	GLEY1 2.5/N

[1]Munsell soil color charts 2000: washable edition

Fennoscandia archaeologica XXXIX(2022)

Anja Mansrud, Ellen Mette Nielsen, Axel Mjærum & Elling Utvik Wammer

ENCIRCLING THE CRAFT TRADITIONS OF FRESHWATER FISHING: AN ARCHAEOLOGICAL AND EXPERIMENTAL STUDY OF WHEEL-SHAPED NET SINKERS IN THE SCANDINAVIAN INTERIOR (AD 800–1300)

Abstract

This paper investigates wheel-shaped net sinkers, that is hoops made of rods and with plaited birch bark fibres, clasping a sinker stone in the centre. Recently recovered from forest and mountain lakes of central Scandinavia, and dated to AD 800–1300, these sinkers offer a glimpse into the use of birch bark during the Viking Age and the medieval period. By combining archaeological analysis and experimental replication, this paper firstly aims to explore the knowledge and skills involved in the making. Secondly, we investigate the relationship between the specific crafting process and the broader craft traditions and technologies of which the sinkers were a part, and we suggest that birch bark plaiting represents a technological and aesthetic craft tradition originating in Karelia and Estonia. The sinkers were utilised in freshwater fishing and attached to the bottom line of gill or seine nets. We propose that this specific net fishing technology was introduced to central Scandinavia as a result of agricultural expansion from east to west around AD 800.

Keywords: Fishing gear, sinkers, birch bark plaiting, experiments, chaîne opératoire, Viking Age, Middle Ages

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INTRODUCTION

Archaeological surveys in the interior regions of South Norway unearthed a rare collection of composite organic artefacts: wheel-shaped net sinkers with preserved birch bark fibres. Such sinkers were initially discovered by local fishermen in the 1940s and 1950s, when the mountain lakes were established as dammed basins for hydroelectric power production. Every spring, the water was lowered, exposing large lacustrine areas, and the sinkers would appear on the dredged lake floor. In 2014, a systematic survey revealed several wheel-shaped net sinkers *in situ* on the silty bottom of Lake Tesse, a lake located 850 m.a.sl. (Wammer 2015; Bjørkli et al. 2016) (Fig. 1d). The organic components of wood and bark permit a direct dating, and ten sinkers have so far been C14-dated to c. 800–1300 BC. These finds thus make up a unique corpus of organic material culture, which provides novel insight into the utilisation of birch bark fibres during the Viking period and medieval times.

A wheel-shaped sinker consists of a hoop made of rods. In the centre, a pebble stone wrapped in birch bark is attached, and carefully fastened. The wheel-shaped net sinkers found in South Norway are of a similar basic form and composition. Weaving with narrow bands or strips of birch bark is essential to the technique (Fig. 1). However, the material shows a significant variety. On some of the net sinkers, the stone is tied unsystematically with bark strips to be fastened in the centre of the net (Fig. 1a), while on others, the stone is nicely woven into the bark strips, in a plaiting-like technique, giving these sinkers a more decorative appearance (Fig. 1b & 1c). The hoop is often partly or completely lashed with bark strips. The outer diameter of the hoops varies somewhat, between approx. 9–16 cm (commonly around 11–12 cm), and the weight of the sinkers is between approx. 90 and 170 g when dry (the majority being approx. 150 g).

The crafting technique, in particular the weaving and plaiting of birch bark strips to fasten the sinker stone, stands out as remarkable in central Scandinavia. Similar artefacts are, however, documented ethnographically in Finland, Karelia and the Baltic states (Valonen 1953) (Fig. 2, 3). This situation has raised a long-standing debate about the invention, origin, distribution and chronology of the wheel-shaped sinkers (e.g., Hagen 1959; Wammer 2016). The plaiting technique used in the production of shoes, baskets and other items is

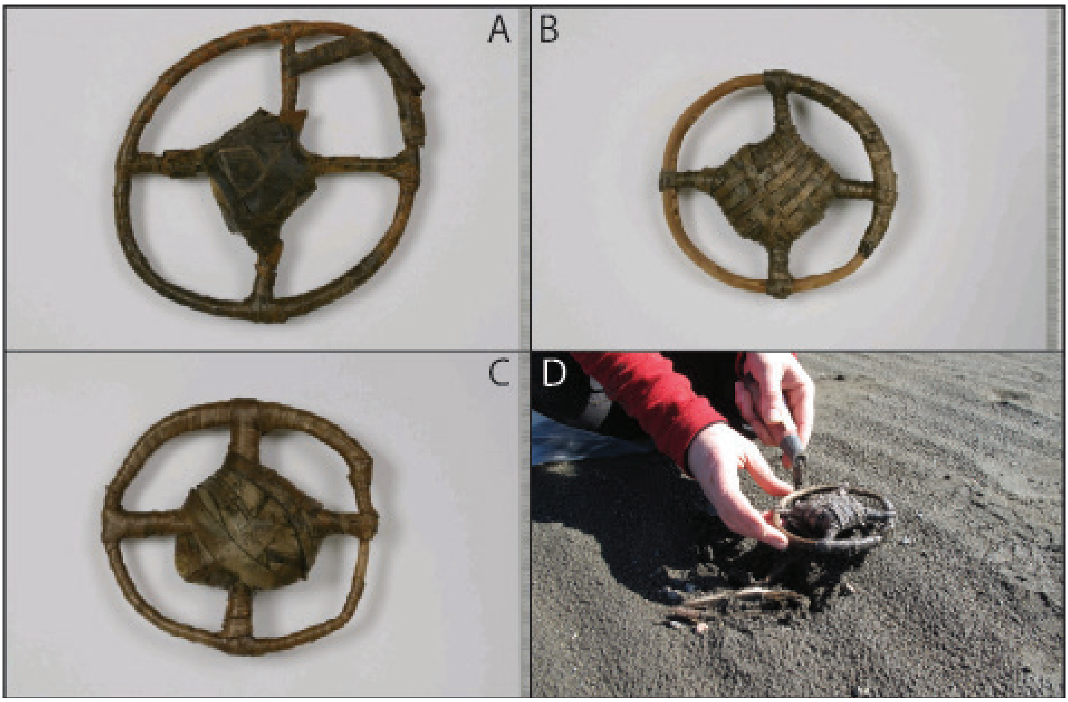

Figure 1. A selection of wheel shaped net sinkers discovered at the dredged lake floor of Lake Tesse, Norway. Some sinkers are made with simple, random plaiting (A and C), while others are regular and symmetrically woven (B). Sinkers found in situ during surveys in 2014 (D). (Pictures A–C: Vegard Vike, Museum of Cultural History.Picture D: Elling Utvik Wammer, Norwegian Maritime Museum.)

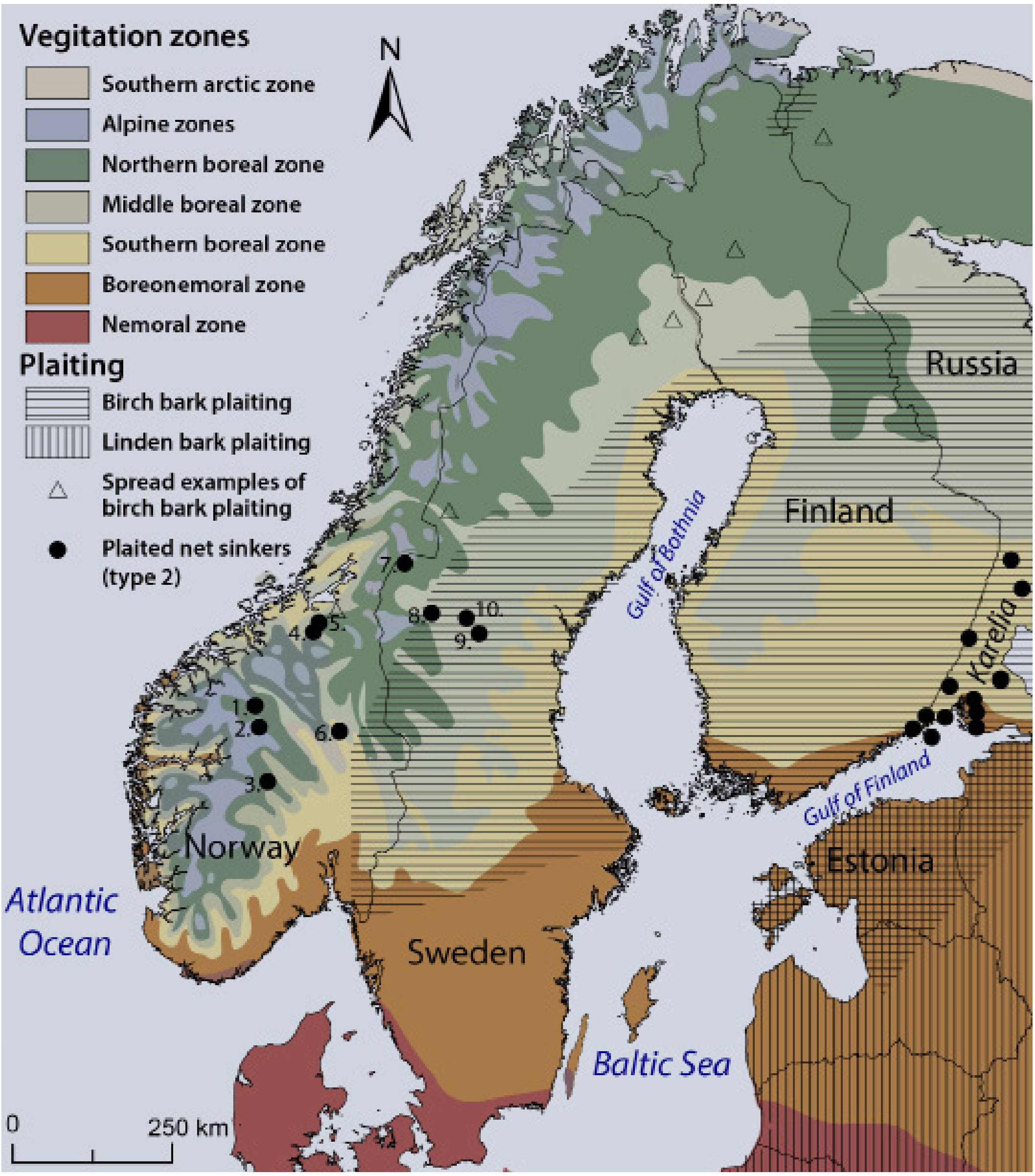

Figure 2. Lakes with wheel shaped net sinkers of Valonen's Type 2 in Central Scandinavia (1. Strandfjorden, 2. Tesse, 3. Lesjavannet, 4. Samsjøen, 5. Selbuvatnet, 6. Storsjøen, 7. Edeviken ved Torrön, 8. «a small lake» in Mattmar sokn, 9. Mellansvartsjön, 10. Locknesjön, cf, Tab.1) and in Karelia (based on Valonen 1952: abb. 219). The map also displays the distribution area for linden and birch bark plaiting in recent times (cf. Valonen 1953: 4). Vegetation zones are drawn in accordance with A. Moen (1999).

widespread in north-eastern Europe (cf. Fig. 2; Valonen 1953; Ågren & Lundholm 1970; Yarish et al. 2009; Dahlqvist 2019), and the presence of this form of craft in the interior of Sweden and Norway has commonly been associated with a westward migration of people from the interior areas of Southern Finland between the late 16th to the middle 17th century (Bjørshol 1979:

26–7; Welinder 2002). This migration wave is often referred to as the “Forest Finn” migration (Brochmann & Kjeldstadli 2008: 77–8; Valonen 1952: 258) and Lennart Björkquist (1938: 30) was among the first to maintain that the wheel-shaped sinkers are a material legacy of these Finnish settlers.

The recent radiocarbon dating to AD 800–1300 contests the link between the wheel-shaped sinkers and the later Finnish settlers, as is predates this migration wave by approximately 800 years (Fig. 4). By focusing on how the wheel-shaped sinkers were made, this paper asks: can a broader understanding of the plaiting techniques provide insight into the makers of the wheel-shaped sinkers? Since substantial parts of the original items are preserved, raw material utilisation and technological details can be examined and reconstructed. This paper takes advantage of this and moves beyond a typological approach to explore the origin of the sinkers and the question of who made them.

The aim of the present paper is twofold. Our first objective is to investigate the making of the wheel-shaped sinkers, by combining archaeological analysis and experimental replication, in collaboration with present-day birch bark crafters. Wood and plant material rarely survive in the archaeological record, and our knowledge of how plant fibres were gathered, treated, and utilised during these periods is limited and largely unexplored (Hurcombe 2014). By undertaking actualistic experiments, employing the *chaîne opératoire* (CO) approach (Lemonnier 1986) and focusing systematically on the initial steps involved in making a sinker, in particular the use of weaving and plaiting techniques for birch bark, we aim to provide hands-on acquaintance of the knowledge and skills involved in making a wheel-shaped sinker.

Secondly, we aim to encircle the relationship between the individual crafting process and the broader craft traditions of which they were a part (cf. Klepp 1980; Wollan 2006). Notably, cultural traditions and identity are most often expressed in the *non-functional* aspects of craft, such as decorative elements. Ethnographic craft studies suggest that devotion to tradition constitutes a stabilising element of cultural transmission, while individual creativity and diffusion are processes contributing to cultural and technological change (Klepp 1980: 199–210; Lemonnier 1986: 159–64). Therefore, studies of crafting techniques and processes are useful approaches for archaeologists to situate craft traditions in wider cultural-historical contexts. We use such a framework to attempt to encircle the origins of the central Scandinavian wheel-shaped sinker tradition. Other extraordinary finds of well-preserved wooden artefacts from these periods, found in snow patches on melting glaciers, are primarily related to hunting and transport (Pilø et al. 2022). The wheel-shaped sinkers give unique evidence of everyday subsistence practices and technologies related to freshwater fishing and indicate that a novel fishing technique – involving a particular type of gill or seine net – was introduced at the beginning of the Viking Age.

DEFINITION, GEOGRAPHICAL DISTRIBUTION, AND RADIOCARBON DATING OF THE WHEEL-SHAPED SINKERS

Net fishing is an ancient technique, and sinkers, utilised for both net and line fishing, are fundamental components of composite fishing gear with a wide geographic and temporal distribution. In Europe, the oldest gillnet so far discovered is from Antrea in Karelia and radiocarbon dated to before 8000 BC (Carpelan 2008; Miettinen et al. 2008). Sinkers are known from the Mesolithic and Neolithic up to recent times and occur in various archaeological contexts, such as dwellings and harbours, in the coastal as well as the interior regions of Scandinavia and the Baltics (Indreko 1956; Bergsvik 2002: 290–1; 2017; Bērziņš 2008; Piličiauskas et al. 2019; 2020). They are often discovered in the sea and on lake floors, where they were accidentally lost during fishing.

From archaeological contexts, the most common type is a simple stone sinker, made by creating one or two pierced holes or engraved lines/notches for fastening the net. Functional sinkers vary in size and weight from small pebbles used for fishing with hook and line (Bergsvik 2017), to medium-sized cobbles used for weighing down the net and holding it taut, to large rocks or assemblages functioning as anchors. As stray finds, sinkers are usually made of heavy, inorganic materials (stone, metals, or clay) and are generally difficult to date when found outside a stratigraphic

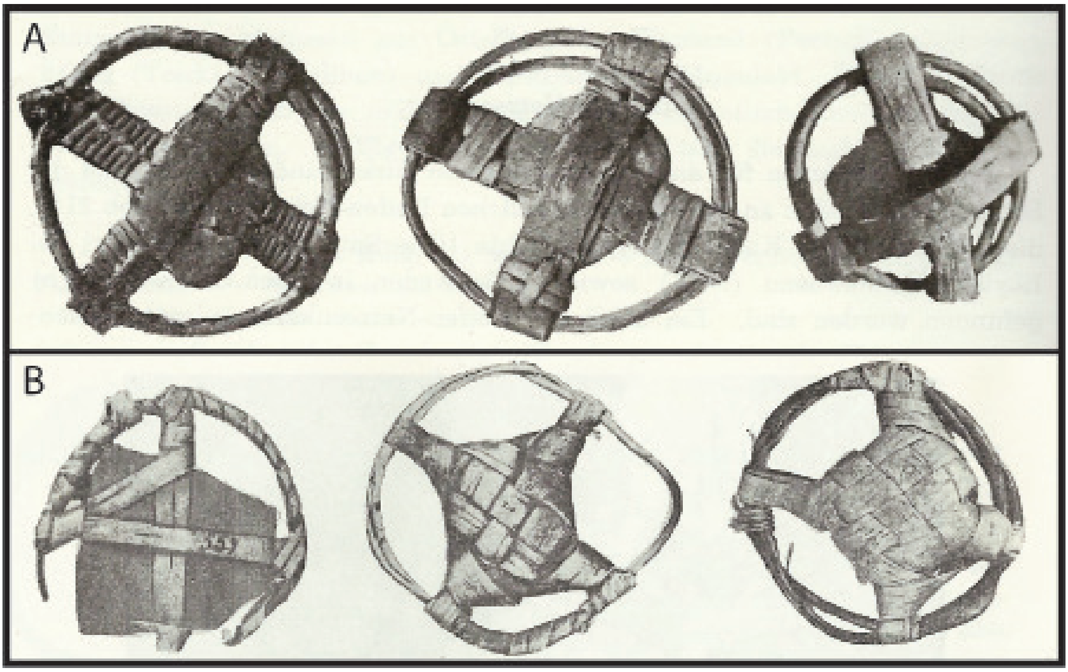

Figure 3. Sompa sinkers of Valonen`s Type 1 (top) and type 2 at bottom. Type 2 closely resembles the sinkers found in the Central Scandinavian interior. Ill. Valonen 1952: Abb. 215 and 217.

context, marine or lacustrine (Indreko 1956; Broadbent 1979: 127–8; Lannerbro 1997: 25–6; Bang-Andersen 2009; Stene et al. 2010: 516). In some cases, the stone sinkers are made in combination with organic materials, such as skin, wood, or bark, and can be directly dated. For example, pebbles placed in a bark container were in use in South Norway from the Late Middle Ages until recently, and in historical times, various materials were used as weights on fishing nets (Sirelius 1908: 147, 155; 1919: 171; Hesthagen & Kleiven 2016: 98–101; Severinsen 2016: 171). However, the wheel-shaped net sinkers stand out in a central Scandinavian context.

Definitions

Niilo Valonen (1952: 257–60) was the first to study the wheel-shaped sinkers with centre stones in detail (see however also Sirelius 1908: 147, 155). He denoted them *sompa-sinkers*[1] and divides them in two main types (Fig. 3). The two types have 1) a stone in the centre, 2) a wooden hoop of pliable twigs surrounding the stone, and 3) crossing strips made of bark fibres that fix the sinker.

Type 1 (Fig. 3) has a stone inserted in a hoop made of twigs held in place by a cross made of broad strips of birch bark. Valonen knew this type from the north-eastern part of the Bothnian Bay, where they were utilised as sinkers on seine nets and salmon gillnets until relatively recently (e.g., Finna.fi 2022a). Later, similar finds have been discovered in archaeological context across Scandinavia and the Baltics, such as Hedeby, Novgorod and Vefsen in Northern Norway (Rybina 2007: 126, 130; Schietzel 2014: 314–5; Wammer 2016: 97–8).

Valonen's Type 2 (Fig. 3) have a centre stone fastened to the hoop of twigs with thinner, plaited birch bark strips. They are somewhat smaller than Type 1, commonly with a diameter of 11–14 cm. Two of the sinkers depicted by Valonen (see Fig. 3) are made with a double hoop of twigs. This is also known from central Scandinavia but seems to be uncommon. One of the archaeological finds from Lake Tesse has a double hoop. In every other aspect, Valonen's Type 2 are morphologically identical to the sinkers found in Central Norway.

Geographical distribution and find contexts in interior Scandinavia

Valonen (1952: 259) describes Type 2 based on archaeological finds from Karelia, Finland and Estonia (cf. Sirelius 1908: 147; Björkquist 1938: 30; see also e.g., Finna.fi 2022b). Piličiauskas et al. (2020: 297) recently published a similar wheel-shaped sinker from the Žeimena River in East Lithuania and dated it to c. 1500 AD. However, in central Scandinavia, the distribution of wheel-shaped sinkers is geographically restricted, and they occur only as archaeological finds from lake beds. The sinkers are found at sites situated approx. 160–860 m above present sea level, and distributed within the southern, middle and northern boreal forest zones (Fig. 2). This is a region which is relatively flat on the Swedish side, with partly navigable watercourses that flow eastward from the Swedish-Norwegian border to the Gulf of Bothnia. The Norwegian side is characterised by a hillier landscape with watercourses draining towards the Skagerrak Sea. The northernmost sinkers are found in lakes with an outflow towards the Atlantic coast.

At present, wheel shaped net sinkers of Valonen`s Type 2 are documented from five different lakes in South Norway (n=61). The sinkers have been discovered on the dredged floor of these lakes, which are all regulated due to hydroelectric power production. Most sinkers have been found accidentally by non-archaeologists and delivered to museums since the hydropower production commenced in the early 20th century (Hagen 1959; Eknæs 1975; Wammer 2016).

Parallel finds in Scandinavia have been described briefly in the literature (Björkquist 1932), but not studied in detail. As far as possible, we have included the information of Valonen`s Type 2 finds from Sweden (n=4, Fig. 2, Table 1). All specimens have been reported from the mid-Swedish county of Jämtland, in lakes lying in, or in the vicinity of, the mountainous and forested region along the national border. Valonen's type 1 sinkers, however, have been found further south, in the county of Dalarna. Hence, the distribution of type 2 is similar on the Swedish and Norwegian side of the border. The only known specimen from Northern Norway, mentioned earlier, is of Valonens type 1.

Radiocarbon dating

The outer bark (phellem layer) of birch (likely *Betula pubescens*) from 10 out of 62 (16 per cent) wheel-shaped net sinkers has been radiocarbon dated. The dated material comprises thin layers of dead cork tissue, formed during the trees' lifetime (Evert 2006: 534; Klügl & Di Pietro 2021). Consequently, the dates represent the tree's lifespan, not necessarily the moment the sinker was crafted. However, since the fibres are normally used shortly after harvesting, the problem of "old wood" is presumably relatively limited, and it is unlikely that the C14 results predate the production of the sinkers by more than a few decades. Birch is short-lived, and most trees of *Betula pubescens* grow less than 100 years (Wehberg et al. 2005). When the trees grow old, the bark becomes deeply furrowed and cracks irregularly when harvested. This makes it less suitable for craftwork and weaving. The bark used for the net sinkers is most likely from relatively young trees.

The ten radiocarbon-dated items of Valonens type 2 are distributed evenly between c. 800 and 1330 calAD (Fig. 4). Several sinkers from the lakes Tesse and Selbusjøen, respectively, have been dated. In both cases, there is a significant time span between sinkers from the same lake. This suggests that the making and use of wheel-shaped sinkers *represent a continuous tradition.* These dates, with a low inherent age offset, are well suited for statistical modelling by using the *Boundary* function in the radiocarbon calibration program OxCal (Bayliss et al. 2011: 41; cf. Bronk Ramsey 2009; Reimer et al. 2020), based on the assumption that we have succeeded to randomly analyse samples from a uniform tradition (cf. Buck et al. 1992). Such a model points towards a start of this tradition around the onset of the Viking Age (712–847 calAD), while it is likely that the production of wheel-shaped sinkers ended in the middle of the Swedish and Norwegian Middle Ages (AD 1251–1331, Fig. 4).

METHOD: EXPERIMENTAL REPLICATION AND THE CHAÎNE OPÉRATOIRE

We have shown that the wheel-shaped sinkers from the interior of Central Norway are morphologically similar to the sinkers from Eastern

Table 1. Finds of wheel-shaped net sinkers of Valonen`s Type 2 from Norway and Sweden. All with context information are reported to have been found on lake beds.

Lake	County	Country	No. of finds	Context	Museum No	Reference
Tesse	Innlandet	Norway	57	Open forest/ mountain, c. 850 m.a.s.l.	C59636, C29405, C29406, C29614, C58794–6, C56056, C32763, C60749, C61146, C61147, C61148, C61149, C58948, C60750, SJF.05297–9, SJF.02099–100, SJF.03834, and three unmarked specimens on exhibition at Norwegian mountain museum	Unimus 2022; Wammer 2016
Storsjøen	Innlandet	Norway	1	Forest and farmland,	–	0.27
Strondafjorden	Innlandet	Norway	1	Forest and farmland,	0.11	4.23
Selbusjøen	Trøndelag	Norway	2	Forest and farmland, c. 160 m.a.s.l.	T28050	Unimus 2022
Samsjøen	Trøndelag	Norway	1	Open forest/moun-tain, c. 480 m.a.s.l.	T17199	Unimus 2022; Wammer 2017
Locknesjöen	Jämtland	Sweden	1	Farmland area, 328 m.a.s.l.	JLM13306	Björkquist 1932: 96; Wammer 2016
Torrön	Jämtland	Sweden	1	Forest, 417 m.a.s.l.	JLM22370	Wammer 2016
Mellan-svartsjön	Jämtland	Sweden	1	Forest, 443 m.a.s.l.	JLM29767	Wammer 2016
Lake (unknown)	Jämtland	Sweden	1	Not known	Unmarked specimen	Wammer 2016
Total			66			

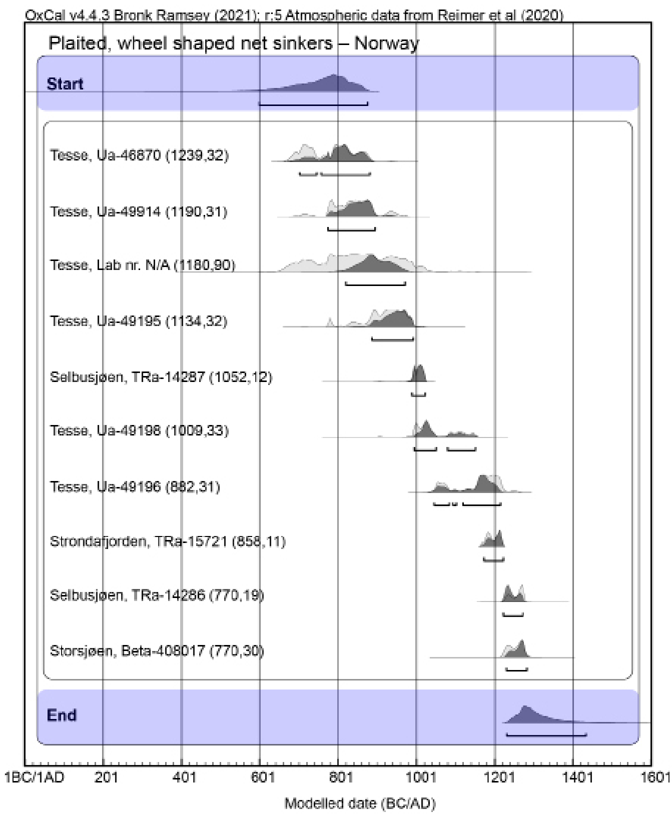

Figure 4. Calibration model of dated wheel shaped net sinkers from interior regions of Central Scandinavia. Light grey curves display unmodelled calibration curves, while modelled curves are displayed in grey curves. The start of the production is dated to AD 712–847 (1σ)/AD 600–876 (2σ) while the production most likely ended AD 1251–1331 (1σ)/AD 1232–1434 cal. (2σ).

Europe, and in the following, we examine the technological details and how they were crafted. We have investigated the crafting of wheel-shaped net sinkers through experimental replication, in collaboration with a local farmer/fisherman from Lom municipality, Torstein Bjørgen, and basket-maker Ellen Mette Nielsen (Nielsen & Wammer 2018). Following O'Neil & O'Sullivan (2019: 26), experimental archaeology is here understood as the reconstruction of technologies based on archaeological evidence, which subsequently can provide useful analogies for interpreting the archaeological record. An archaeological investigation of technical choices often relies on production debris among archaeological remains to identify technique (for example Harris 2014: 15), but in the case of the wheel-shaped sinkers, we only have the finished items available for study.

Since we as archaeologists lack experience and hands-on knowledge of the use of plant fibres (cf. Hurcombe 2007; 2008), and there is no direct connection with craft traditions that exist in Norway today, experimental replication in collaboration with present-day crafters may provide useful practical parameters and insights, enabling us make interpretations based directly on the archaeological remains. The role of specialised crafters is underestimated in archaeological research and experimental archaeology (Kristoffersen & Stoltz, forthcoming; see also Guldberg 2014; Molander 2018). Experienced crafters possess the skills and know-how involved in crafting techniques, and modern "multi-makers" like Bjørgen afford a valuable contribution to a more profound understanding of the craft involved in the making of the sinkers and the weaving/plaiting techniques. We use the term craft to avoid the economic, ahistorical implications of the word industry and to emphasise the skilled, small-scale and socially embedded character of making wheel-shaped sinkers. Personal observation of the particular and the distillation of these experiences into generalised observations both have their place in the concept of *actualistic* experimentation, i.e., experimental approaches aiming to identify and test techniques and materials which would have been available to the past crafters (Outram 2008). As noted by Outram (2008: 5), such attempts are "*best addressed through good collaborations between craftspeople and academics. Perhaps the most effective experiments are those that are totally integrated into a larger scheme of academic research with the experimentation being just one of the methods being employed in pursuit of a research goal. Where possible, there should be close collaboration between different specialists and those with academic and practical skills*". This study represents such an attempt.

Furthermore, following Sofaer (2006: 128) we regard this alliance between archaeologists and crafters as a productive form of cross-crafting, where different types of knowledge – embodied, practical and academic – are explored and fused to complement each other. In archaeological technological studies, materiality and human behaviour are commonly linked using the CO approach, a method for investigating the operational sequences underpinning tool production, which provides insight into the prehistoric practice and the interrelated tasks involved in artefact crafting. The steps involved in making a sinker – finding and harvesting raw material and the waving/plaiting techniques – also elucidate the knowledge underlying technical choices (Lemonnier 1986; 2012; Leroi-Gourhan 1993; Ingold 2010). Understanding the complexity of knowledge involved is key to unravelling each particular step of the sequence of making, enabling an appreciation of the knowledge and skill embedded in the steps that the crafter would have to master and identifying where individual choices can be made with regard to raw materials. While practical attempts can illuminate the various possibilities inherent in crafting material culture, the CO approach – defined as "the overall process that leads from a given state of matter to its transformed state" (Lemonnier 2012: 300) – is productively employed as an academic analytical device to grasp the sequenced operations of the crafting processes underlying the making of the wheel-shaped sinkers.

Furthermore, the CO approach as currently used in archaeology is not merely a method for investigating the crafting, use and discarding of tools, it also comprises a theoretical framework emphasising the link between material culture, technology and society. Techniques are part of socialisation processes, acquired in practical settings, learned through imitation and/or improvisation, and thus over time become embodied and automatised. Through these actions, communal values and traditions are also sustained and transferred between community members.[2] In this perspective, technologies can be considered as culturally transmitted, historically formed systems of knowledge, and the execution of a certain technique is related to a set of culturally shared ideas and norms (Klepp 1980: 199–210; Wollan 2006; Lemonnier 2012; 2013). Thus, focusing on the of birch bark weaving and plaiting techniques involved in making the sinkers enables us to approach the skill of the individual crafter as well as the broader tradition of which the crafter was a part. In the following, we outline and discuss the operational sequence for the crafting of wheel-shaped sinkers with birch bark plaiting.

CRAFTING THE WHEEL-SHAPED SINKERS

Based on the fragmented sinkers and Bjørgen's extensive knowledge of, and experience with, older crafting techniques and natural materials, the wheel-shaped sinkers were recreated, resembling as closely as possible the form, techniques and materials observed on the archaeological specimens (cf. Outram 2008). Bjørgen, born in 1939, acquired substantial know-how of harvesting and crafting with birch bark during childhood, when he assisted his grandfather in collecting bark sheets for sealing the roofs of farm buildings. His traditional crafting skills also include cutting strips from the birch bark sheets for weaving small, plaited baskets. Bjørgen has been fishing in Lake Tesse since the age of 10. During this activity, he discovered several net sinkers in the lake and became interested in exploring how they were made. Since the birch wrapping and plaiting was fragmented on some of the sinkers, he was able to observe how they were constructed. He had no prior experience with making a hoop from one rod or stick and made his first sinker through trial and error. All the raw materials used in the experimental replication (Nielsen & Wammer 2018) and Bjørgen's previous reconstructions – water-rolled stones, birch bark (*Betula*) and rods or sticks of willow (*Salix*) or birch – were collected in the vicinity of Lake Tesse. Some of the investigated hoops from Lake Tesse have been identified as juniper (*Juniperus communis*), a common species in Ottadalen.

1: Gathering and preparing the birch bark for wrapping and weaving

According to Bjørgen, the best time for collecting birch bark in this particular area is mid-June. Around this time, the sap content is high, and the bark can be easily removed from the trunk (see also Valonen 1953: 101; Lindholm 2017). Bjørgen harvests his bark from birch trees growing just below the forest boundary (Fig. 5). The bark should be taken from flawless trunks on tall, straight trees. Such trees do not grow in places where the forest is too dense; they grow best in more open forest. The tree trunk should be about 15–20 cm in diameter and without branches. The quality of bark can vary, and on some trunks, the bark is too coarse to be useful.

Bark can be gathered in sheets, which are later cut into strips, and can be harvested in all kinds of weather, as long as it is not too dry. Bark sheets are best removed using a knife and later cut into strips with the preferred widths. Another

Figure 5. Torstein Bjørgen gathering birch bark from plain trunk of Betula (A and B). Preparing a sheet of bark and cutting strips (C). (Photos: Ellen Mette Nielsen and Elling Utvik Wammer.)

way to harvest bark is to remove strips or bands directly from the tree. To prevent flakes of bark from curling, they must be stored horizontally, sap-side against sap-side, with a weight on top, preferably outside and in a shady place, protected from rain. However, strips of birch bark dry quickly after being cut. They must be used immediately or kept moist and stored in a cool, dark place. Present day crafters keep them a plastic bag. Dry strips of bark can be made usable again if they are soaked in water, but the strips will not have the same degree of flexibility as fresh birch bark.

Birch bark consists of layers, which can be split to obtain thin strips for tying, wrapping and weaving/plaiting. The inner layers are the strongest, and when fresh, the bark is very flexible. The strips had a width of about 10–12 mm, similar to the strips of bark found on the old sinkers. If the strips of bark felt too thick, they were split, and layers of the bark were removed from the outside until the thickness felt suitable for weaving and wrapping.

For our experimental replications, Bjørgen used a knife and his fingers to remove the bark from the tree in sheets. After harvesting, the outer, white side of the sheets was lightly brushed by hand and cut into strips with scissors.

The diameter of a wheel-shaped sinker is 10–12 cm. When harvesting birch bark sheets, the length of each strip will equal the width of the trunk of the birch trees. A birch with a diameter of 16 cm produces strips of approx. 50 cm in length. With regard to the archaeological specimen, it is difficult to identify whether the bark was removed directly from the tree trunks or gathered as strips, because we cannot unwrap the strips to measure their length without destroying the artefacts.

2: Making the hoop

Slender rods or sticks from willow (Salix) or/and birch (Betula) were used for making the hoop (Fig. 6). Bjørgen aimed for rods with the same thickness as observed in the old wheel-shaped

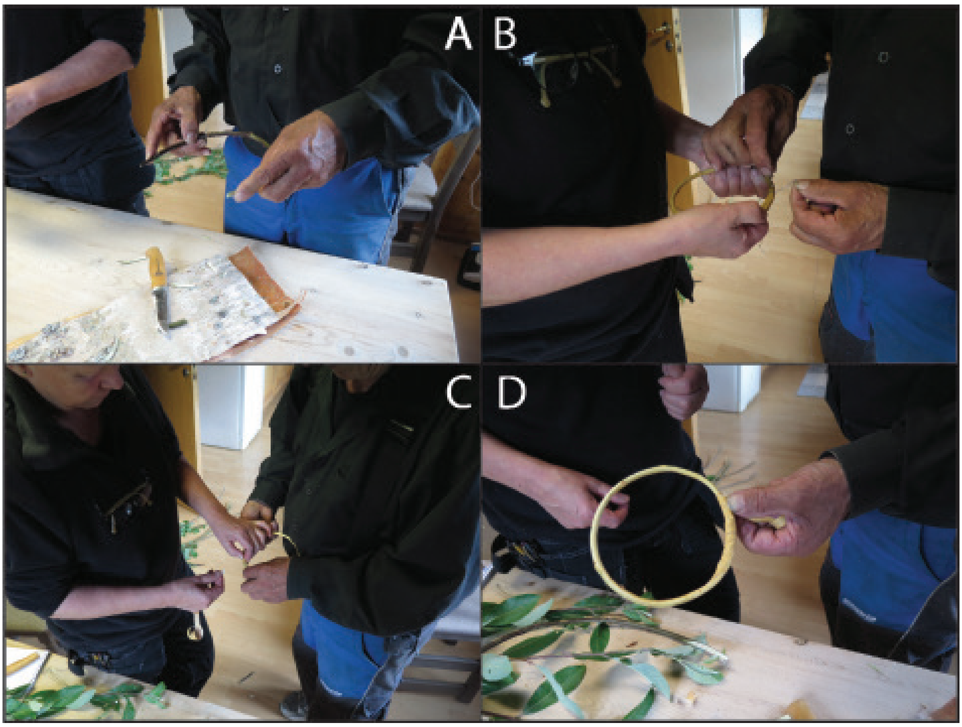

Figure 6. Bending the rod (A). Tying the ends of the rod together (B) and tying the strips on the overlapping ends (C and D). (Photos: Ellen Mette Nielsen and Elling Utvik Wammer.)

sinkers and made the hoop with the same diameter, about 11 cm. The rods need to be thin and flexible, preferably without branches. Bjørgen stripped the bark off the rods when they were fresh, using the back of his knife. This step was performed after forming the hoop but before the two ends were joined together. The rod was bent into the preferred circular shape when the wood was fresh but mellowed to dry a little before shaping (too fresh or too dry, it would most likely break). The ends were tied together with a wool string or metal wire. On a majority of the archaeological sinkers, the two ends of the rod are shaped at both ends to make the ring smooth in the overlapping part, as done in Bjørgen's reconstruction. Another locking technique has also been observed, reminiscent of the technique used on wooden hoops keeping barrels made of wood fixed together. On most of the finds, a strip of bark is tied around the overlapping ends to fasten the hoop properly. Bark strips and bands are solid and durable and could probably have been used by the past crafters for tying the ends.

On some net sinkers, this strip is continued around the whole ring. This practice does not have an obvious functional explanation and seems to represent a decorative element. However, as noted by the basket-maker (Nielsen), on some of the archaeologically retrieved sinkers, the hoop was broken, or split longitudinally. If this occurred during the crafting process, the winding around the hoop could strengthen and stabilise the rods to make a ring which is not perfect but fully functional. Another explanation could be practical; if the strips are long, you can wrap the left-over strip as far as it goes, then cut it off and fasten it around the spokes. The hoops were left to dry indoors overnight. After approximately one night, the material had lost its natural tautness. The dry hoop then retained its shape and size when continuing with the lashing and weaving.

3: Attaching the stone and making the spokes by wrapping and weaving birch bark strips

The sinker stone was attached to the hoop by taking a piece of birch bark strip, with the length approximately three times the diameter of the ring (Fig. 7a). The end of the strip was locked by turning the strip two times around the ring, so that the tension of this twist keeps the birch bark strips in place on the hoop. Then, the strip was transferred across the ring, to the other side, turned around the ring and back to the starting place.

Bjørgen locked the strip with a loop-like cross-knot around the ring and the first spoke. A second strip was placed at a 90-degree angle, perpendicular to the first strip, and the locking procedure was repeated. This stage was repeated four times, creating a cross of four birch bark strips. The sinker stone was placed in the centre, and Bjørgen went on to attach and lock a new strip around the hoop and the first spoke (Fig. 7b). He wrapped a birch bark strip round and round (several times) until it covered the stone. The end of the strip was locked by threading it under and over a birch bark strip already covering the stone. This process was repeated four times, one for each spoke, starting at each of the points where the birch bark strips cross or fasten to the ring. The tip of each birch bark strip from the wrapping procedure ends near the stone. These ends were wrapped and plaited around the stone and secured by weaving under and over the birch bark strips already in place. All four strips were woven one at a time. This process locks the stone tightly in the middle of the hoop.

Torstein Bjørgen observed differences in the final stage of making between the wheel-shaped sinkers found in Lake Tesse. Some were wrapped with birch bark strips all around the hoop, while others were just wrapped around the splice. Most of the sinkers had birch bark strips lashed randomly around the centre stone, as showed in Fig. 7c, while others had a symmetrical plaiting around the centre stone. According to Bjørgen, the last group of artefacts have a second layer of strips, woven regularly over and under, all around the stone in the centre. The birch bark strips used for this second layer were narrower than the strips in the first layer.

ENCIRCLING THE NETMAKERS: DISCUSSION

Learning from experiments: the individual crafter and the tradition

The experimental approach has provided novel information on the properties of birch plant fibres, crafting techniques and practical and aesthetic aspects of the wheel-shaped sinkers. In terms of knowledge and skill, making a wheel-shaped sinker requires:

1) Knowledge of the optimal raw materials: e.g., juniper for the hoop is better than birch and *Salix*.

2) Knowledge and skill of harvesting birch bark: time of the year, which trees have the best bark quality, and how to remove the bark without damaging the tree. In present-day society, this is not general knowledge.

3) Knowledge of the use, harvesting and handling of birch bark, and the use of bark strips for fastening and plaiting.

4) Knowledge and skill of how to make an even hoop, without cracks, and attach it in a way so it does not split open.

The experimental reconstruction demonstrates that the sinkers can be made from materials easily available in the region's local boreal forests. Making a wheel-shaped sinker involved a prolonged process, from harvesting bark to a finished product. It is labour intensive, requires large amounts of bark, and needs careful planning. This drawn-out crafting sequence, involves a spectrum of local knowledge, ranging from harvesting plant fibres and twigs at certain times of the year, to storing material in correct ways to maintain the flexibility (if the bark is not used immediately) and techniques for lashing, weaving, plaiting, and wrapping. Raw materials were probably gathered in the early summer but, considering that dozens of sinkers were required for a net, it must have been time-consuming to make them, and the use of plaiting must have added time to the process. To make a good hoop takes some attempts to master and attaching the bark to the hoop requires skill and experience. However, the crafting process is not difficult as such; it can be learned through imitation and making a wheel-shaped sinker could presumably have been mastered by anyone with some practice.

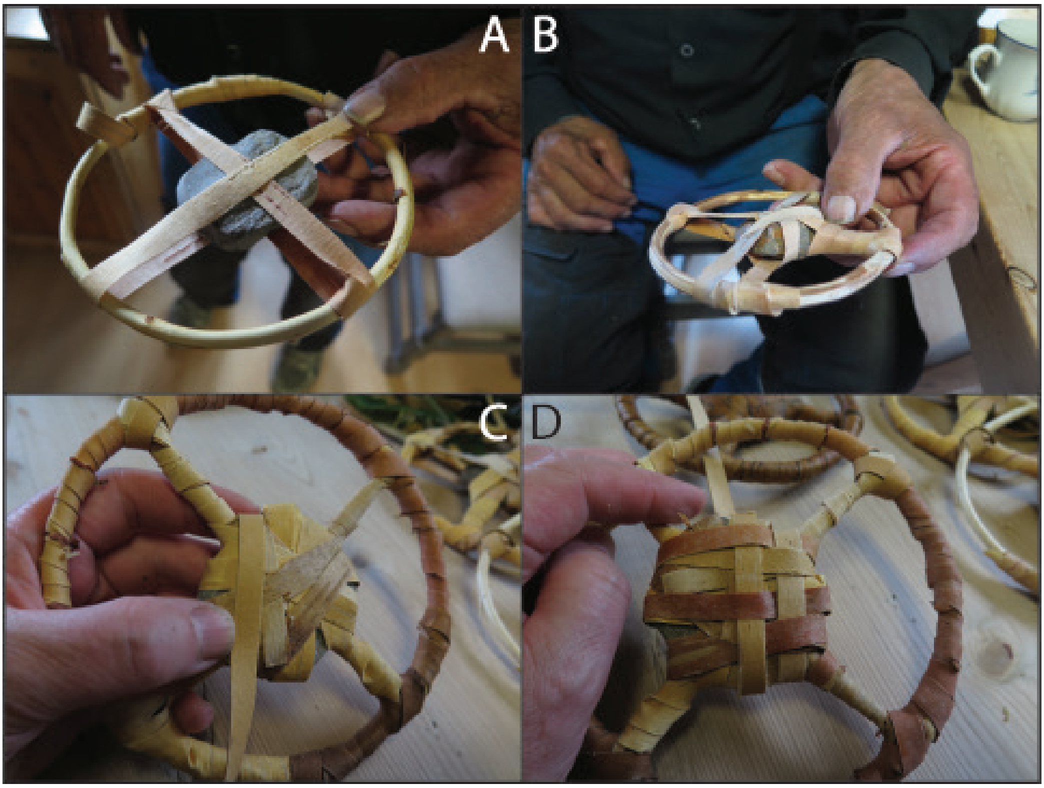

Figure 7. Fastening the stone by two crossing two birch bark strips (A). Wrapping strips around the spokes (B). Adding additional strips around th e stone (C). 4) Example of final plaiting (D). (Photos: Ellen Mette Nielsen and Elling Utvik Wammer.)

Through examination of the archaeological sinkers with fragmented birch bark strips, in combination with experimental replication, several different crafting techniques have been identified. Making strips of bark fibres and the weaving technique are two separate and independent processes of the craft. Birch bark strips were used in various ways for fastening the stone inside the hoop, locking the hoop-ends and wrapping it. Our observations of the whole corpus of wheel-shaped sinkers from South Norway support Bjørgen's suggested method. The basic production steps are the same for net sinkers with or without bark strip plaiting. Many of the archaeological specimens do not have "perfect" hoops, suggesting that most of the sinkers were made by non-specialists. From an experimental perspective, the variation in the sinkers from Lake Tesse may not represent particular groups or chronological developments. Rather, the differences may mirror individual artisans and result from adaptations to raw material constraints, length of the birch bands/strips, aesthetic standards and time invested in the crafting process, and the observed variation in wheel-shaped sinkers from Lake Tesse may be due to the production of sinkers over time. Based on a limited number of dated sinkers, we must also consider that the use of weaving and plaiting might reflect personal preferences or family traditions within the same craft.

Yet, some wheel-shaped sinkers stand out as exceptionally well-made. Arguably, the time invested in making a sinker enables a wider discussion of the relationship between functionality and the importance of aesthetics in everyday craft and subsistence technologies. Some sinkers are made with simple, random plaiting, while others are very regular and symmetrical. Bark strip plaiting probably made the net sinkers more robust, which can indicate a technical improvement, as previously suggested (Wammer 2016). However, aesthetics is not crucial for functionality, and the elaborate style of some of the wheel-shaped sinkers surpasses what is required for a sinker to work. The time invested in making a particularly aesthetic artefact may point to the presence of an overarching cultural tradition because tradition and identity are most often expressed in the non-functional aspects of craft, such as decorative elements (Klepp 1980: 199–210; Lemonnier 1986: 159–64). This interpretation is supported by the C14-datings, which suggest that the making and use of wheel-shaped sinkers persisted over a period of 500 years, from AD 800–1300. Such a recurring craft practice can be defined as a technological tradition, a specific way of creating material culture, maintained over prolonged periods of time, which becomes embedded in concepts of group identity (van Gijn 2010).

In Iron Age Norway and Sweden, the most common way of making items of bark was to harvest whole flakes of birch bark, divide them and sew them together (Valonen 1953; Granlund 1940: 33–6; Nordby 2012). Although vessels and mats of woven birch bark are known (Welinder 2002: 29), the technique of plaiting bark fibres seems uncommon in the region. Such a view is supported by the results of 15 years of archaeological surveys at glacial sites in the mountain areas of South Norway, some of them in the mountain areas around Lake Tesse. Altogether, there are 3500 finds from these sites, most of them comprising organic materials such as wood and bone. This record does not include any plaited items made from bark (cf. Pilø et al. 2018; 2021; 2022), hence pointing towards an external origin of the plaited sinker tradition recently discovered in central Scandinavia. Arguably, the birch bark plaiting technique is connected to the same overarching tradition as the finds from Karelia and Estonia (Sirelius 1908: 147; Valonen 1952: 259; Finna.fi 2022b).

Based on the geographical distribution of finds, we have shown in this paper that wheel-shaped net sinkers make up a technological, cultural, and aesthetic tradition constrained to the interior regions of central Scandinavia. The use of such sinkers is so far not documented in the southern or western coastal regions of Norway but have close morphological parallels to finds in Karelia and Estonia/Lithuania (Valonen's Type 2, cf. Figs. 2–3). Additionally, the technique of plaiting/weaving birch bark strips is primarily related to traditions in regions further east (Valonen 1952; 1953; Yarish et al. 2009).

The use of the wheel-shaped sinkers

The making of sinkers must be considered in relation to the remaining components of composite fishing equipment. The wheel-shaped sinkers are defined in time and space, and it is therefore reasonable to assume that they were also connected to *one* specific fishing tradition. The fishing gear utilised in interior lake and river fishing in Norway remains rather understudied compared to coastal and pelagic fisheries (but see Eknæs 1975; Hesthagen & Kleiven 2016). We lack ethnographic evidence for fishing with wheel-shaped net sinkers in South Norway. But, based on their non-aquadynamic shape and weight, we believe that the wheel-shaped sinkers were made for net fishing, not line fishing. The wheel-shaped sinkers were presumably fastened on a type of gillnet or seine net (Ropeid 1958; Stewart 1977).

In Scandinavia, several forms of fishing nets have been used historically. One common type is *garn* (gillnet), characterised by relatively large mesh, meant to entangle fish. Another type is the seine net (Fig. 8). These nets are made of smaller mesh compared to gillnets and function as a trapping bag (Hermundstad 1964; Eknæs 1975; Hesthagen & Kleiven 2016). We find the linguistic distinction between throttling/standing nets (No. *Garn*) and seine nets (No. *Not*) in all the Nordic languages, though in slightly different forms,[3] and the two main types of equipment for net fishing both appear in medieval texts (Stoklund et al. 1960; Granlund et al. 1967: 194–206). Earlier Norwegian researchers tends to name the wheel-shaped net sinkers garnsenker (gillnet sinkers) (Hagen 1959; Eknæs 1975; Hesthagen & Kleiven 2016: 99). Both gillnets and hauling nets need weights fastened to the bottom line (No. *Telne*) to hold the net down (Ropeid 1958). Bjørgen, who is an experienced fisherman, assumes that the wheel-shaped sinkers were attached to the bottom line of the net through two points at the hoop. This is because fastening at one point easily leads to a tangle when the net is carried or moved. When the sinker is attached in two places, it will not spin around.

In the inland and mountain lakes of South Norway, trout (*Salmo trutta*) and char (*Salvelinus alpinus*) are the two fish species that have traditionally had the greatest economic importance. Other species, like perch (*Perca fluviatilis*), appear in southern and lower parts of the region but never reached the mountains. West of the Østerdalen valley, char is practically non-apparent and trout dominate (Huitfeldt-Kaas 1918). It is reasonable to believe that, in the westernmost lakes with finds of wheel-shaped net sinkers, these two species were the main targets for the fisheries. However, the fisheries could have been more varied in the lakes at lower altitudes further east.

It is not possible to determine the type of net fishing for which the wheel-shaped net sinkers were intended. They were probably well suited for both forms of net, and it is not possible to argue for a functional definition. The Finnish sompa sinkers were used for gillnets as well as seine and hauling nets (Sirelius 1908: 147, 155; Valonen 1952, see also Fig. 3). The traditional fishing gear used by indigenous groups on the northwest-coast of North America includes similar wood-hoop sinkers used for gillnet fishing (Stewart 1977: 86). The necessary number of sinkers per net depended on the length of the net, but 30–40 sinkers per net is not unthinkable (Ropeid 1958; see Stewart 1977: 86, for an ethnographic example).

The way from Karelia to central Scandinavia

Finally, we further suggest that these fishing nets with wheel shaped sinkers were introduced to the region as part of an agricultural expansion in the Viking Age. The farming communities in the interior areas of central Scandinavia have always relied on various outfield resources in addition to crops and husbandry (Holm et al. 2005). In the interior regions, farming was established late compared to the rest of Europe, in some areas as late as AD 400–800 (Hougen 1947: 122; Bergstøl 2008; Pedersen & Widgren 2011: 322–3; Stene 2014). The outfield resources, including elk and reindeer hunting/trapping and iron production were important supplements to farming during the Viking period and Middle Ages, and a considerable means of income and prosperity (Loftsgarden 2020). The role of fishing is generally difficult to study due to the availability of source material; fishing leaves few material traces and sites compared to iron production and trapping. However, the written sources of early modern times tell of repeated conflicts in relation to fishing-rights. There are also early written sources, like the "Tesse

Figure 8. Seine net fishing in lake Sølensjøen, Rendalen municipality, Innlandet County, Norway, c. 1965. Seven people and three boats seem to be involved. Two men, who had probably gotten to this place with the help of the empty rowing boat at the far right of the picture, stand on a small rock ledge and pull the net towards them. (Photo: Tore Fossum, Anno Norsk skogmuseum (CC BY-NC-ND 4.0).)

Document", a charter made sometime between AD 1202–1220 (Ugulen 2016), which indicates that fish were an important outfield/mountain resource – so important, that even medieval kings were involved in assigning fishing rights.

The archaeological record, in particular grave inventories from burials, suggests contact between farming societies in Central Norway and the Gulf of Bothnia during the Late Iron Age, probably made possible by transport via Swedish river systems (e.g., Martens 1969: 70–2; Røstad 2020). There was also lively communication across the Baltic Sea (e.g., Mägi 2018), and thereby multiple ways for the tradition of fishing with plaited wheel-shaped sinkers to find their way from Karelia to central Scandinavia. There is no evidence of a large-scale migration westwards in the Late Iron Age resembling the one that took place by Finnish settlers around AD 1600. Hence, we consider it as more likely that the sinkers followed the east-westwards networks as a part of an idea, technique, and a particular practice of lake fishing. When the farming societies expanded during the Late Iron Age to areas where resources from the outfields had to play a significant role in the subsistence, people also needed to employ a viable form of lake fishing in the boreal forests. We believe this situation facilitated the adaptation of one specific eastern fishing tradition, which was already well adapted to a boreal environment and included plaited wheel-shaped net sinkers.

CONCLUSION

The experimental approach has provided novel information on the properties of birch plant fibres, crafting techniques and practical and aesthetic aspects of the plaited wheel-shaped sinkers. Based on the geographical distribution and the distinctive technique of plaiting strips of birch bark, we conclude that wheel-shaped net sinkers make up a particular technological and aesthetic craft tradition originating further east, in Karelia and Estonia. The wheel-shaped sinkers were presumably fastened on a type of gillnet or seine net (Ropeid 1958), and the practice of making wheel-shaped sinkers is therefore also entangled with a particular fishing tradition (cf. Hodder 2012). The fact that the wheel principle, the birch bark crafting technique as well as the aesthetics were embraced, strengthen such a perspective. Therefore, we propose that the net sinkers occurring in the region c. 800 BC also involved a novel method of net fishing. This novel package of fishing technology was introduced to the region as part of an agricultural expansion from east to west at the onset of the Viking Age.

CONTRIBUTIONS

E. W. proposed the idea for the study. E. M. N. and E.W. interviewed Torstein Bjørgen. E. M. N. performed the technological studies. A. Ma., A. Mj., E. M. N. and E. W. wrote the paper. A. Mj. and A. Ma. coordinated the work.

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REFERENCES

Bang-Andersen, S. 2009. Evig eies kun det tapte – med alle sine hemmeligheter. Refleksjoner rundt en gjenstand av kleberstein funnet ved Håelva på Jæren. In M. Nitter & E. S. Pedersen (eds.) *Tverrfaglige perspektiver*: 75–86. Stavanger: Arkeologisk museum.

Bayliss, A., Plicht, J., Ramsey, C., et al. 2011. Towards generational time-scales: The quantitative interpretation of archaeological chronologies. In A. Whittle, F. Healy & A. Bayliss (eds) *Gathering Time: Dating the Early Neolithic Enclosures of Southern Britain and Ireland* 1: 17–59. Oxbow Books.

Bergstøl, J. 2008. Samer i Østerdalen? En studie av etnisitet i jernalderen og middelalderen i det nordøstre Hedmark. Unpublished dissertation, Kulturhistorisk museum. Oslo: Universitetet i Oslo. < https://www.duo.uio.no/handle/10852/33240?locale-attribute=en>

Bergsvik, K. A. 2002. *Arkeologiske undersøkelser ved Skatestraumen,* B. 1, Bergen: Universitetet i Bergen.

Bergsvik, K. A. 2017. Mesolithic soapstone line-sinkers in Western Norway. Chronology, acquisition, distribution, function and decoration. In G. Hansen & P. Storemyr (eds.) *Soapstone in the North. Quarries, Products and People 7000 BC–AD 1700*: 73–92. Bergen: Universitetet i Bergen.

Bērziņš, V. 2008. *Sārnate: Living by a Coastal Lake during the East Baltic Neolithic*. Oulu: Faculty of Humanities, University of Oulu.

Bjørkli, B., Friis, E. K., Wammer, E. U., et al. 2016. Tesse – et arkeologisk eldorado og en innfallsport til fjellfisket som et tverrfaglig tema. In A. Mjærum & E. U. Wammer (eds.) *Fjellfiske i fortiden*: 15–35. Kristiansand: Portal forlag.

Björkquist, L. 1932. Ur accessionskatalogen 1932. *Jämten* 1932: 93–8.

Björkquist, L. 1938. Trä-och näverskor i Jämtland. *RIG* 21: 15–36.

Bjørshol, N. A. S. 1979. *Finnekulturen i Sør Norge – karakteristiske trekk. Instituttet for folkelivsgranskning*. Oslo: Universitetet i Oslo.

Bourdieu, P. 1977. *Outline of a Theory of Practice.* Cambridge: Cambridge University Press.

Broadbent, N. D. 1979. *Coastal Resources and Settlement Stability. A Critical Study of a Mesolithic Site Complex in Northern Sweden*. Uppsala: The Institute.

Brochmann, G. & Kjeldstadli, K. 2008. *A History of Immigration: The Case of Norway 900–2000*. Oslo: Universitetsforlaget.

Bronk Ramsey, C. 2009. Bayesian analysis of radiocarbon dates. *Radiocarbon* 51: 337–60.

Buck, C. E., Litton, C. D. & Smith, A. F. M. 1992. Calibration of radiocarbon results pertaining to related archaeological events. *Journal of Archaeological Science* 19: 497–512.

Carpelan, C. 2008. On the history and recent studies of the 'Antrea Net Find'. In M. Lavento (ed.) *Karelian Isthmus. Stone Age Studies in 1998s–2003*: 88–127. Helsinki: Finnish Antiquarian Society.

Dahlqvist, E. 2019. *Näver: fläta, tampa, vik*a. Stockholm: Natur & Kultur.

Eknæs, Å. 1975. Trinseformede garnsøkker og deres alder. *Årbok for Norsk skogbruksmuseum* 1973–1975: 172–7.

Evert, R. F. 2006. *Periderm. Esau's Plant Anatomy*: 427–45. John Wiley & Sons, Inc.

Finna.fi., 2022a. Cultural and scientific treasures from one address. <https://www.finna.fi/Record/museovirasto.4ED0F8B554EE31456B814709C7AD86C0?lng=en-gb> Read 11 September 2022. Finna.fi.

Finna.fi, 2022b. Cultural and scientific treasures from one address. <https://www.finna.fi/Record/museovirasto.C0D1EA79C8CF262F028B45C04DCAECFA> Read 11 September 2022.

Granlund, J. 1940. *Träkärl i svepteknik*. Stockholm: Museet.

Granlund, J, Luukko, A., Rasmussen, H., et al. 1967. Notfiske. In F. Hødnebø (ed.) *Kulturhistorisk leksikon for nordisk middelalder fra vikingtid til reformasjonstid*: 367–72. Oslo: Gyldendal Norsk Forlag.

Guldberg, S. S. 2014. The Smith on the Edge of Worlds. New perspectives on technology and ideology in the Late Norwegian Iron Age. Unpublished dissertation, Department of Archaeology, Conservation and History. Oslo: University of Oslo.

Hagen, A. 1959. Funn fra fjellvann. *Viking Tidsskrift for norrøn arkeologi Bind* XXIII: 35–41.

Hermundstad, K. 1964. Fisket. In K. Hermundstad (ed.) *Valdres Bygdebok V. Fyrste Del. Villdyr og veiding, fiske, turistferdsel, handverk og handverkarar*: 147–225. Leira: Valdres Bygdeboks Forlag.

Harris, S. 2014. Introduction. Leather in archaeology: between material properties, materiality and technological choices. In S. Harris & A. J. Veldmeije (eds.) *Why Leather? The Material and Cultural Dimensions of Leather*: 9–21. Leiden: Sidestone Press.

Hesthagen, T. & Kleiven, E. 2016. Fiskemåtar i fjellet i eldre tid. In A. Mjærum & E. U. Wammer (eds.) *Fjellfiske i fortiden*: 93–109. Kristiansand: Portal forlag.

Hodder, I. 2012. *Entangled. An Archaeology of the Relationships Between Humans andThings*. Chichester: Wiley-Blackwell.

Holm, I., Innselset, S. M., & Øye, I. (eds.) 2005. *'Utmark': The Outfield as Industry and Ideology in the Iron Age and the Middle Ages.* Bergen: University of Bergen.

Hougen, B. 1947. *Fra seter til gård. Studier i norsk bosetningshistorie.* Oslo: Norsk arkeologisk selskap.

Huitfeldt-Kaas, H. 1918. *Ferskvandsfiskenes utbredelse og indvandring i Norge. Med et tillæg om krebsen.* Kristiania: Centraltrykkeriet.

Hurcombe, L. 2007. A sense of materials and sensory perception in concepts of materiality. *World Archaeology* 39: 532–45.

Hurcombe, L. 2008. Organics from inorganics: using experimental archaeology as a research tool for studying perishable material culture. *World Archaeology* 40: 83–115.

Hurcombe, L. 2014. *Perishable Material Culture in Prehistory. Investigating the Missing Majority.* London: Routledge.

Indreko, R. 1956. *Steingeräte mit Rille*, Stockholm: Almqvist & Wiksell International.

Ingold, T. 2010. The textility of making. *Cambridge Journal of Economics* 34: 91–102.

Itkonen, T. 1957. *Suomen kielen suksisanastoa*. Helsinki: Suomalaisen kirjallisuuden seura.

Klepp, A. 1980. Tradisjon og kultur. Norveg. *Tidsskrift for etnologi og folkloristikk* 23: 195–224.

Klügl, J. & Di Pietro, G. 2021. The interaction of water with archaeological and ethnographic birch bark and its effects on swelling, shrinkage and deformations. *Heritage Science* 9: 3. https://doi.org/10.1186/s40494-020-00476-y.

Kristoffersen, E. S. & Stoltz, R. forthcoming. Textile and metal. A case of cross-crafting. In F.-A. Stylegar (ed.) *Snartemodugnaðr*.

Lannerbro, R. 1997. *Det södra fångstlandet. Katalog, Del 3,* Övre Österdalälven, Stockholm: Institutionen.

Lemonnier, P. 1986. The study of material culture today. Toward an anthropology of technical systems. *Journal of Anthropological Archaeology* 5: 147–86.

Lemonnier, P. 2012. *Mundane Objects, Materiality and Non-verbal Communication.* Walnut Creek: Left Coast Press.

Lemonnier, P. 2013. *Technological Choices: Transformation in Material Cultures since the Neolithic*. London and New York: Routledge.

Leroi-Gourhan, A. 1993. *Gesture and Speech.* Massachusetts: October.

Lindholm, K. 2017. Nävertäkt [Harvesting birch bark]. Regiongavleborg.se. <https://vimeo.com/248433906?embedded=true&source=video_title&owner=20905940> Visited 6 October 2022.

Loftsgarden, K. 2020. Mass production and mountain marketplaces in Norway in the Viking and Middle Ages. *Medieval Archaeology* 64(1): 94–115.

Martens, I. 1969. *Gravfeltet på By i Løten, Hedmark.* Universitetets Oldsaksamling Årbok 1965–66.

Mauss, M. 1979. Technique of the body. *Sociology and Psychology: Essays by Marcel Mauss*: 97–123. London: Routledge & Kegan Paul.

Miettinen, A., Sarmaja-Korjonen, K., Sonninen, E., et al. 2008. The palaeoenvironment of the 'Antrea Net Find'. In M. Lavento (ed.) *Karelian Isthmus – Stone Age Studies in 1998–2003*, 71–87. Helsinki: Finnish Antiquarian Society.

Moen, A. 1999. *National Atlas of Norway: Vegetation*. Hønefoss: Norwegian Mapping Authority.

Molander, B. 2018. Creativity and knowledge. In J. Sofaer (ed.) *Considering Creativity: Creativity, Knowledge and Practice in Bronze Age Europe*: 5–18. Oxford: Archaeopress.

Mägi, M. 2018. *In Austrvegr. The Role of the Eastern Baltic in Viking Age Communication across the Baltic Sea.* Leiden: Brill.

Nielsen. E. M. & Wammer, E. U. 2018. Trinsesøkker. Garnsøkker med trinseform. På besøk hos Torstein Bjørgen, juni 2018. Unpublished report.

Nordby. C. C. 2012. Gjemt og glemt? Harpikstetninger fra eldre jernalder – en forskningshistorisk gjennomgang i lys av tingenes hierarki. *Viking* LXXV: 75–92.

O'Neill, B. & O'Sullivan, A. 2019. Experimental archaeology and (re)-experiencing the senses of the medieval world. In R. Skeates & J. Day (eds.) *The Routledge Handbook of Sensory Archaeology.* Routledge.

Outram, A. K. 2008. Introduction to experimental archaeology. *World Archaeology* 40(1): 1–6.

Pedersen, A. & Widgren, M. 2011. Agriculture in Sweden. 800 BC–AD 1000. In J. Myrdal & M. Morell (eds.) *The Agrarian History of Sweden. 4000 BC to AD 2000*: 46–71. Lund: Nordic Academic Press.

Piličiauskas, G., Matiukas A., Peseckas. K, et al. 2020. Fishing history of the East Baltic during the Holocene according to underwater multiperiod riverine site Kaltanėnai, northeastern Lithuania. *Archaeological and Anthropological Sciences* 12: 1–26.

Piličiauskas, G., Vaikutiene, G., Kisieliene, D., et al. 2019. A closer look at Šventoji 2/4 – a stratified Stone Age fishing site in coastal Lithuania, 3200–2600 cal BC. *Lietuvos archeologija* 45: 105–43.

Pilø, L., Barrett, J., Eiken, T., et al. 2021. Interpreting archaeological site-formation processes at a mountain ice patch: A case study from Langfonne, Norway. *Holocene* 31(3): 469–82.

Pilø, L., Finstad, E., Ramsey. C. B., et al. 2018. The chronology of reindeer hunting on Norway`s highest ice patches. R*oyal Society Open Science* 5 171738171738. http://doi.org/10.1098/rsos.171738.

Pilø, L., Finstad, E., Wammer, E. U., et al. 2022. On a mountain high: Finding and documenting glacial archaeological sites during the

Anthropocene. *Journal of Field Archaeology* 47: 149–63.
Reimer, P. J., Austin W. E. N., Bard E., et al. 2020. The IntCal20 Northern Hemisphere Radiocarbon Age Calibration Curve (0–55 cal kBP). *Radiocarbon* 62: 725–57.
Ropeid, A. 1958. Nett- og notfiske i Trysilelva. *By og Bygd. Norsk Folkemuseums årbok* 1956–57: 113–20.
Rybina, E. A. 2007. Fishing and hunting. In M. Brisbane & J. Hather (eds.) *Wood Use in Medieval Novgrod,* 124–35. Oxford: Oxbow books.
Røstad, I. M. 2020. The Åker assemblage – Fit for a king? A new account and discussion of a collection of treasure of the Norwegian Merovingian Period. *Medieval Archaeology* 64: 1–30.
Schietzel, K. 2014. *Spurensuche Haithabu. Archäologische Spurensuche in der frühmittelalterlichen Ansiedlung Haithabu. Dokumentation und Chronik* 1963–2013. Neumünster: Wachholtz Verlag.
Severinsen, A. 2016. Sørsamenes fjellfiske. Ørret, sik og røye – svømmende matforråd. In A. Mjærum & E. U. Wammer (eds.) *Fjellfiske i fortiden*, 159–81. Kristiansand: Portal forlag.
Sirelius, U. T. 1908. *Suomalaisten kalastus, vol.* 3. Helsinki: Suomalaisen Kirjallisuuden Seura.
Sirelius, U. T. 1919. *Suomen kansanomaista kulttuuria*. Esineellisen kansatieteen tuloksia, vol. 1. Helsinki: Otava.
Sofaer, J. 2006. Pots, houses and metal: Technological relations at the Bronze Age Bronze Age tell of Százhalombatta, Hungary. *Oxford Journal of Archaeology* 25: 127–47.
Stene, K. 2014. *I randsonen av taigaen – bosetning og ressursutnyttelse i jernalder og middelalder i Østerdalen.* Kristiansand: Portal Forlag.
Stene, K., Persson, P., Damlien, H., et al. 2010. Lokaliteter fra steinbrukende tid ved Rena elv. In K. Stene (ed.) *Steinalderundersøkelser ved Rena elv. Gråfjellprosjektet. bind III*, 459–520. Oslo: Kulturhistorisk museum, Fornminneseksjonen.
Stewart, H. 1977. *Indian Fishing. Early Methods on the Nortwest Coast.* Vancouver: J. J. Douglas.
Stoklund, B., Hasslöf O., Virlonen E. A., et al. 1960. Garn og garnfiskeri. In F. Hødnebø (ed.) *Kulturhistorisk leksikon for nordisk middelalder fra vikingtid til reformasjonstid,* 195–206. Oslo: Gyldendal Norsk Forlag.
Ugulen, J. R. 2016. Tesse-dokumentet og fjellfisket i mellomalderen. In A. Mjærum & E. U. Wammer (eds.) *Fjellfiske i fortiden*, 127–35. Kristiansand: Portal forlag.
Valonen, N. 1952. *Geflechte und andere Arbeiten aus Birkenrindenstreifen unter besonderer Berücksichtigung finnischer Tradition.* Helsinki: Suomen muinaismuistoyhdistys.
Valonen, N. 1953. Om näverarbeten i Fenno-Skandien. In S. Erixon (ed.) *Från trä till stål.* Stockholm: Albert Bonniers forlag.
van Gijn, A. 2010. *Flint in Focus: Lithic Biographies in the Neolithic and Bronze Age*. Leiden.
Wammer, E. U. 2015. Maritimarkeologisk undersøkelse i forbindelse med fornyelse og revisjon av konsesjon (sektoravgift) i Tesse 2014. Saksnummer 2012363. Norsk Maritimt Museum. Oslo.
Wammer, E. U. 2016. Fjellfiske i grenselandet mellom fangstmark og jordbruksbygd i yngre jernalder og middelalder. In A. Mjærum & E. U. Wammer (eds.) *Fjellfiske i fortiden*: 183–205. Kristiansand: Portal forlag.
Wehberg, J., Thannheiser, D. & Meier, K.-D. 2005. Vegetation of the mountain birch forest in Northern Fennoscandia. In F. E. Wielgolaski (ed.) *Plant Ecology, Herbivory, and Human Impact in Nordic Mountain Birch Forests*, 34–52. Berlin - Heidelberg: Springer.
Welinder, S. 2002. *Skogsfinnarnas näverflätning*. Bingsjö.
Wollan, G. 2006. Håndverk som gestaltforståelse og skaperglede. En fenomenologisk studie. *Norsk antropologisk tidsskrift* 17: 63–76.
Yarish, V., Hoppe, F., & Widess, J. 2009. *Plaited Basketry with Birch Bark.* New York: Sterling Publishing Company.
Ågren, K., & Lundholm, K. 1970. *Näverslöjd*. Stockholm: ICA-Bokförlag.

NOTES

[1] The name *sompa* for the Finnish wheel-shaped net sinkers is a Sami loan word for the traditional ring - shaped device at the bottom end of a skiing pole (Itkonen 1957 : 157 – 9). In Norwegian, the same analogy is being used for the wheel-shaped sinkers: *trinse*-søkke.

[2] The idea of embodied, non-verbal body practices outlined by Marcel Mauss (1979) underlies Bourdieu's theory of practice (Bourdieu 1977).

[3] F.ex. Danish: Garn vs. Not. Swedish: garn/nät vs. Vad/not. (Stoklund et al. 1960: 193–206).

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DIETS IN THREE LATE MEDIEVAL TO EARLY MODERN COASTAL POPULATIONS IN FINLAND ACCORDING TO THE $\delta^{13}C$ AND $\delta^{15}N$ VALUES OF ARCHAEOLOGICAL BONE AND DENTIN COLLAGEN

Abstract

We explored the diets in three populations (Iin Hamina, Oulu, Rauma) dating between the late Middle Ages and mid-19th century. We compared diets of mid-childhood, adolescence, and adulthood based on the carbon and nitrogen stable isotope ratios in dentin (PM2, M3) and bone collagen. The $\delta^{13}C$ values were typical of terrestrial C_3 environments and to be expected by the brackish Baltic Sea. The ^{13}C content in the water decreases northwards, which was reflected in the results. The analyses displayed overall elevated $\delta^{15}N$ values, which is consistent with fish having been an important part of the nutrition of all the populations. The PM2 and bone collagen $\delta^{15}N$ values diverged in the Iin Hamina population, implying different diets of children and adults

Keywords: $\delta^{13}C$, $\delta^{15}N$, collagen, Finland, post-medieval, stable isotope, diet

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INTRODUCTION

This paper explores the carbon and nitrogen stable isotope ratios in collagen of human bones and teeth, collected from three archaeologically excavated former churchyard sites located in the western coastal region of the modern-day nation of Finland.[1] The studied selection of individuals represents the populations of the parishes and towns of Iin Hamina (c. 15th century to early 17th century), Oulu (late 17th to 18th century), and Rauma (late 18th to early 19th century) (Fig. 1).

The aim is to look at the past diets in the coastal region of Finland and to find out whether the diets consumed in these three populations chosen for analysis differ from each other. The skeletal remains of the studied individuals were sampled for bone collagen and permanent second premolar (PM2) and third molar (M3) dentin collagen. While the dentin collagen delta (δ) values represent the mid-childhood and adolescence diets, the bone collagen values represent the diet consumed in adulthood some years prior to death of the individual. This allows not only comparison of the diets in different site-specific populations but even assessment of these diets during different life-phases.

Use of nitrogen and carbon stable isotope ratios in dietary reconstructions

The ratios of stable isotopes of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) in tissues of organisms reflect the isotopic composition of their dietary input, facilitating their use in examining the diets of past human populations. The $\delta^{15}N$ value in tissues is related to the subject's trophic position. Fractionation causes enrichment of the heavier isotopes between the consumed diet and body tissues. This results in an increase in the $\delta^{15}N$ value by approximately 3.4 ±1.1‰ with each trophic step (Minagawa & Wada 1984), although variation occurs depending on the analysed tissue (O'Connell et al. 2012). The $\delta^{15}N$ value reveals the level of protein intake and/or the source of protein, as a greater amount of animal protein from species of high tropic position in diet leads to more elevated values (O'Connell & Hedges 1999).

The enrichment for carbon is smaller, often amounting to c. 0–2 ‰ per trophic level (Bocherens & Drucker 2003). The $\delta^{13}C$ values of consumer tissues are typically used to trace the influence of C_3 and C_4 plants in the diet. This is made possible by the very different $\delta^{13}C$ values of these plant types, caused by the different photosynthetic mechanisms they employ (Kohn 2010). C_4 plants, such as maize or millet, do not naturally grow in the Nordic region and by the relevant period, were probably not being imported into the area in notable quantities. Cane sugar from the New World, as an expensive luxury product, had reached the north at least by the period relevant to the Oulu population (Vilkama et al. 2016), while it was probably not consumed to an extent traceable in isotope values (Halila 1953: 201–2). On the other hand, by the period of the Rauma population in the early 19th century, sugar beet, which is a C_3 plant, was already a more common source of processed sugar in the region (Rousi 1997: 197–8).

Another common application of carbon isotope analysis is to evaluate the marine or terrestrial sources of the diet (Tauber 1981; Schoeninger & DeNiro 1984; Schulting 1998). The carbon in marine environments is mostly derived from

Figure 1. Map of the sites of the archaeological populations examined in the study. (Illustration: Tiina Väre.)

dissolved inorganic carbon (HCO_3), in which the ^{13}C concentration is much higher than in the atmospheric CO_2 from which the carbon in terrestrial organisms is derived. This distinction in the carbon source explains why the organisms in oceans typically present with less negative $\delta^{13}C$ values (Smith & Epstein 1971; Ambrose 1993). The water reserves in the target region of this study are brackish or fresh, both of which tend to draw the carbon values towards the lower terrestrial and C_3-end of the range (e.g., Katzenberg 1989; Angerbjörn et al. 2006; Enhus et al. 2011; Danielsson et al. 2015).

Each tissue or integument stores the stable isotope composition representing the conditions during their formation (DeNiro & Epstein 1978; 1981). The differences in their growth mechanisms and formation result in tissues representing varying periods in the individual's life. A bone sample of an adult individual typically represents the average diet of several years during which the bone tissue has been gradually remodelled (e.g., Parfitt 2002; Fahy et al. 2017). There can be quite significant variation between the turnover times depending on the skeletal element or factors such as the age and sex of the subject (Ambrose 1993; Hedges et al. 2007; Lee-Thorp 2008; Fahy et al. 2017).

Unlike bone, dentin grows incrementally according to a rather predictable pattern during childhood, although the schedules can differ slightly between populations and for example due to biological sex or whether the tooth is mandibular or maxillary (Hillson 1996: 123–4). Teeth grow from the top of the crown to the tip of the root, and the isotopic composition of the enamel and primary dentin will not change after their formation during childhood and youth (Hillson 1996: 182; Nanci 2013: 10–2). While some time-averaging may occur as a result of secondary and tertiary dentin formation (Eerkens et al. 2011; Henderson et al. 2014; Beaumont et al. 2015), primary dentin permanently stores isotopic data concerning the diet and health during its growth period, thus adult dentition can be used to trace childhood dietary patterns. The teeth used in this study were PM2 and M3 respectively developed during childhood and youth.

Churchyard sites

Iin Hamina

The remains of the individuals from the Iin Hamina churchyard site were excavated in 2009. The history of the local churches and churchyards surrounding them is poorly known, but during the 15th and 16th centuries, several of the parish's churches were burned in hostilities. The excavated churchyard was in use at least throughout the 15th and 16th centuries, but it is possible that the earliest burials date to the 14th century. In 1620, a new church was built in a different location and burials at the old churchyard were presumably discontinued (Kallio-Seppä 2011).

The biological samples analysed in this study were collected from a few separate contexts containing *in situ* burials but for the major part, from an ossuary forming an almost 2 m in diameter and 1 m deep bone pit in which disarticulated bones from disturbed old graves were collected. These bones were possibly put together as late as in the 1960s during infrastructure work at the site (Tranberg et al. 2020). Being excavated from such a context means that each subject consists of a cranium and in some cases only a mandible, which prevents most osteological interpretations – even the age and sex estimates remain tentative. For this reason, the biological sexes were not compared in this paper. For the same reason, estimating the social standing of the individuals is impossible, although the gravesite is usually a reflection of attributes related to rank and wealth (Talve 1989). However, the Iin Hamina population at the time was likely not strongly hierarchical. Yet, in the 16th century, regardless of its northern location and the repeated hostilities experienced in the area, the parish was one of the richest in Finland (Kallio-Seppä 2011; Tanska 2011).

Iin Hamina is located in the delta of the Iijoki River. Travelling by waterways, it was relatively easily approachable from Swedish towns in the south, the settlements in the northern areas, and by various travelling merchants from the east. This is one reason why, during the Middle Ages, it became a popular marketplace and quite a natural site of exchange, not only of goods but also of ideas and cultural influences. The main item exported from Iin Hamina at the time was fish, but the local people sold furs, seal skins, and blubber as well. In addition to marine and riverine resources, remote lakes yielded fish. Although agriculture had been practised since the 14th century alongside hunting and fishing, cultivation of crops remained rather marginal. In fact, the wealth gained by trading salmon probably hindered the development of time-consuming agriculture in the region by making it unnecessary. Participating in high-yielding fishing activities would often keep the men from labour-demanding agricultural duties, which in turn led to low produce from the fields. Catches of salmon in particular were abundant enough to function as the backbone of the local economy. Some essential products such as barley, wheat, and roots could be obtained from the local marketplace (Halila 1954: 183; Tanska 2011). Generally, animal husbandry was a more important source of livelihood in the region than cultivation (Vahtola 1997).

Oulu

The skeletal remains from Oulu originate from the town's churchyard excavated in 1996 and 2002 by the parish in connection to renovations in the area. The burials in the churchyard date to the 17th–18th centuries. The town churches had been located on the same plot presumably since the 1610s and people were buried there until 1780 when the cemetery was relocated outside the contemporary city borders. The individuals analysed in this study have been estimated to represent the period preceding 1777, when a new church was built on the same site. Although the oldest dates cannot be determined, it is likely that the repeated use of practically the same area for well over a century destroyed the earliest burials. As in Iin Hamina, some of the mandibulae from Oulu originate from ossuaries in which the bones from destroyed graves were deposited while building the new church in the 1770s (Kallio-Seppä & Tranberg 2021). Therefore, the osteological estimations, again, are tentative and the social standing of the subjects unknown.

During the latter part of the 17th and the first half of the 18th century, Oulu was a harbour town with borough rights and sea connections to larger Swedish towns. Its population included a large portion of rich merchants but also people with more modest incomes. Semi-urban life in the town was influenced by both the sea and the location by the mouth of the Oulujoki River (Halila 1953: 162, 333–5; Satokangas 1987). Marine, riverine, and lake fishing played an important role in Oulu at the time. Salmon was particularly important in Oulu as well as the rest of the northern coastal regions of Ostrobothnia – the above-mentioned Iin Hamina included. During the 17th and 18th centuries, the catches from the Oulujoki River and other nearby rivers were large enough for extensive exportation managed by the merchants of Oulu (Halila 1953: 450; Satokangas 1987). On the other hand, the game in the wilderness was well within reach and utilised by the townspeople. Even seals were still hunted on the coastal area during the 17th century, as their blubber was traded off (Halila 1954: 277–8; Vahtola 1987).

Cultivation was practised in Oulu – even inside the town borders, as the distinction between country and urban living was not very clear (Halila 1953: 440; Satokangas 1987; Vahtola 1987). The produce of the fields still remained meagre (Halila 1954: 179–81). Particularly during the 17th century, when the average temperatures dropped (Luoto 2013), harvest failures were common, and supplementary crops needed to be imported. The century ended with one of the worst hunger catastrophes in the whole country connected to the Great Famine ravaging the Baltic and Nordic regions. Animal husbandry provided much better results and butter was one of the most important local export products (Halila 1953: 200, 518; Vahtola 1987). The weather conditions and produce of agriculture slowly progressed during the 18th century, but the early part of it was not much different from the harsh previous century. What is more, the Great Northern War reached Oulu in 1714–21, leaving the town in ruins (Halila 1953: 13; Satokangas 1987; Vahtola 1987).

The population had slowly grown during the 17th century, but its precise size is unknown. In the latter part of the century, the population size has been estimated to have been slightly over 1000 inhabitants, while at the beginning of the 18th century, it may have significantly dropped consequent to the famine and hostilities (Halila 1953: 153). Nevertheless, the following decades were marked by an acceleration of economic and population growth. By the mid-18th century, the population had reached c. 2000 inhabitants, making Oulu the second-largest town in Finland after Turku, which at the time was the capital of Finland (Satokangas 1987; Vahtola 1987).

Rauma

The Holy Trinity churchyard in Rauma was excavated in 2015–6. The churchyard had been used from the late 14th century until 1853, apart from during 1790–1810 (Lähteenoja 1939: 342–6; Uotila & Lehto 2016: 4). The studied individuals were excavated from the northern side of the churchyard, where the most affordable burial plots were located. It has been estimated that these burials likely date to the earlier half of the 19th century and represent the poorer portion of the townsfolk (Uotila & Lehto 2016: 2, 4, 71).

Rauma, located on the south-western coast of Finland, was during the early 19th-century a small harbour town. Most of the town's inhabitants were self-sufficient, with few rich people. In 1832, a population of c. 1600 inhabited the town and by the time burying at the Holy Trinity churchyard was discontinued, the population had grown to nearly 2200 (Lähteenoja 1939: 276–8). Much like generally in Finland, the 19th century was defined by rapid population growth, a rising economy, and eventually, the emerging trend of urbanisation. In 19th-century southern Finland, cultivation of crops, increasingly potatoes, was already the base of the subsistence economy. Products from the surrounding countryside such as cheese, fish, crops, vegetables, and meat were obtained by the townspeople from local markets (Lähteenoja 1939: 242–3). Aquatic resources were still extensively used during the 19th century, although hunting no longer had significance as a source of livelihood in the town (Lähteenoja 1939: 267).

MATERIAL

Thirteen (13) Iin Hamina individuals were chosen for analysis; eight (8) were sampled for all skeletal elements, one for only M3 and bone, and for the remaining four (4) individuals, PM2 and bone were sampled. Ten (10) individuals from the Oulu population and thirteen (13) from Rauma were sampled for three skeletal elements. Required permissions for sampling were granted by the Finnish Heritage Agency and, in the case of the Oulu populations, the local parish authorities governing the burials and archaeological excavations at the site of the church.

The studied cortical bone samples were mainly from mandibulae of which more than 50% was preserved, or the maxillae or associated facial bones of complete or near-complete crania. For every individual from the Oulu population, the mandibula was the only bone available and in Rauma, all bones were collected from individual graves. In Iin Hamina, where the osteological samples were primarily collected from an ossuary, estimated to have contained a minimum number of approximately 160 individuals (Kallio-Seppä et al. 2009) and to prevent overrepresentation that may have followed using different skeletal elements, other bones than maxillae were from separate contexts and evaluated as unlikely to pair up with any of the sampled mandibulae. Some variation between the turnover times of these different bones is evident, but as the sample represents adults in various ages, this will not seriously decrease the representativity of the bone sample.

Dentin samples of c. 50–80 mg were drilled horizontally from the root, just below the cementoenamel junction of the subjects' PM2 and M3 after the surface had been cleaned using a drill bit. Developmentally, the crown of PM2 is complete by approximately 6 to 7 years of age and the first quarter of the root by 8.5 years, and the crown of M3 typically forms between the ages of approximately 9 and 21 years. It is usually completed by c. 13 years of age and the first quarter of the root by 15 to 16 years of age (Haavikko 1970: 127). Thus, the cuts from PM2 dentin represent conditions during the approximate ages between 6 and 8.5 years of age and those from M3 represent the teenage years (likely between 13 and 16 years). However, marked variation occurs in the M3 formation schedule (Hillson 1996: 123), which leads to the potential that the M3 samples used in this study represent quite a wide range of ages, although they can rather safely be narrowed down to have formed some time during adolescence.

METHODS

The bone samples (mandible) were cleaned by ultrasonication, 10 min in acetone bath and in ultrapure water 3 x 10 min, or until the rinsing water was clear. The collagen extraction from the clean bone sample, ground to powder using cryomilling, was performed according to Bocherens et al. (1997). The elemental content and isotopic composition of carbon and nitrogen were measured in an NC2500 elemental analyser coupled to a Thermo Scientific Delta V Plus isotope ratio mass spectrometer (IRMS) at the Laboratory of Chronology, Finnish Museum of Natural History in 2018. All analyses in Helsinki were performed in duplicate on each sample to ensure quality: the results represented here are averages of these double analyses.

The dentin samples were prepared for analysis at the Archaeological Research Laboratory, Stockholm University in the years 2019–20. Collagen extraction was performed on the ground samples including ultra-filtering according to a modified Longin method introduced by Brown et al. (1988). The stable isotope analyses of nitrogen and carbon were conducted at the Nuclear Research Department, Centre for Physical Sciences and Technology, Vilnius, Lithuania in 2020. Samples were weighed into tin capsules and combusted using a Flash EA 1112 series Elemental analyser connected to a Delta V Advantage Isotope Ratio Mass Spectrometer (IRMS) via a ConFlo III interface (all Thermo, Bremen, Germany). During the analysis, N% and C% were determined using the Elemental analyser and the gases were passed to the IRMS for stable isotope ratio measurement.

Isotope ratios were calculated according to the equation: $\delta X = [(R_{sample}/R_{standard})-1] \times 1000$ and the values presented with the δ notation as parts per thousand (‰).[2] The delta values were calibrated relative to the international standards for carbon (VPDB) or nitrogen (AIR). In Helsinki, we normalised the isotope data with a two-point calibration using international reference materials with known isotopic compositions (USGS-40, USGS-41). The mean measured $\delta^{13}C$ and $\delta^{15}N$ values, respectively, for the calibration references were -26.7‰ and -4.6‰ for USGS-40, and 36.3‰ and 46.6‰ for USGS-41, with R^2>0.99 between measured vs. expected values. The external precision, evaluated from lab reference bone material extracted and analysed alongside the unknowns, was ≤ 0.1‰ for both $\delta^{13}C$ and $\delta^{15}N$. In Vilnius, the used standards were Caffeine IAEA-600 ($\delta^{15}N$ = +1‰; $\delta^{13}C$ = –27.77‰), USGS24 ($\delta^{13}C$ = –16.05‰) and IAEA-NO-3 ($\delta^{15}N$ = +4.7‰). The analytical precision was 0.1‰ for both $\delta^{15}N$ and $\delta^{13}C$.

The obtained results were analysed using standard statistical tools provided by the program IBM SPSS Statistics version 27. When divided according to tissue, the data failed the Kolmogorov-Smirnov and Shapiro-Wilk tests of normality and when divided according to the site-specific populations, the data was heteroscedastic, which are both objections against usage of parametric testing. Thus, the site-specific populations (Iin Hamina, Oulu, Rauma) and different skeletal elements (PM2, M3, bone) were compared using rank-based non-parametric Kruskal-Wallis H tests with a confidence level of 95%.

RESULTS

Collagen quality control

Stable carbon and nitrogen isotope analyses were successfully performed on the 36 bone samples and 28 PM2 and 30 M3 tooth samples (Appendix 1, Table 1). The collagen quality of the samples was monitored by calculating the atomic C:N ratios, and those within the range of 2.9–3.6 were considered to represent adequate collagen quality. According to the amino acid composition of collagen, this is the acceptable range (DeNiro 1985), although in a recent study, more refined and species-specific ranges have been suggested (Guiry & Szpak 2021). Furthermore, samples within the carbon and nitrogen weight-% range of 34.3–45.5 for C% and 12.6–16.6 for N% indicating sufficient collagen quality were included in the analyses (Ambrose 1990; van Klinken 1999; Jørkov et al. 2009).

One PM2 sample from Rauma was excluded due to its exceedingly abnormal C% and N% values. Moreover, four PM2 dentin samples from Oulu and two M3 samples from Iin Hamina had atomic C:N ratios outside the acceptable range and were excluded from further discussion. The collagen yield for samples included in the analyses was within the range of 1.2–20.2%, indicating good preservation (Schoeninger et al. 1989; Ambrose & Norr 1993; van Klinken 1999). One PM2 sample from the Rauma population was discarded due to a too-low collagen yield. The obtained δ^{15}N and δ^{13}C results, group averages, and minimum and maximum values of dentin and bone collagen are presented in Table 1.

Statistical analyses

As the data failed the requirements for using parametric statistical tools, Kruskal-Wallis H tests (significance level of $p<0.050$) were employed to compare both the skeletal elements and the populations. According to the comparison of the δ values measured in PM2 and M3 dentin and bone collagen, the δ^{15}N values are different (p=0.001) between the elements but the δ^{13}C are not (p=0.691). Pairwise comparisons revealed that the δ^{15}N values in PM2 and bone collagen are particularly different (p=0.001), the latter representing a higher level, while the δ^{15}N values in M3 are similar to both PM2 and the bone values, with p=0.249 and p=0.200, respectively. In further testing, the difference in the δ^{15}N values between PM2 and bone collagen was observed only in Iin Hamina (p=0.004) (Table 1; Fig. 2). This suggests that the diets during mid-childhood and adulthood may have been different in Iin Hamina, but not in the Oulu and Rauma populations.

Despite the difference between the isotope values of the skeletal elements, their values were combined for comparison between populations. As the tissues formed at different ages, combining values enabled the diets in the populations to be observed on a holistic level. The site-specific populations differed according to both the δ^{13}C (p=0.000) and δ^{15}N (p=0.028) values. In a pairwise comparison of the populations, no differences were observed in the δ^{13}C values between the Iin Hamina and Oulu populations (p=0.192), but in the Rauma population the values were

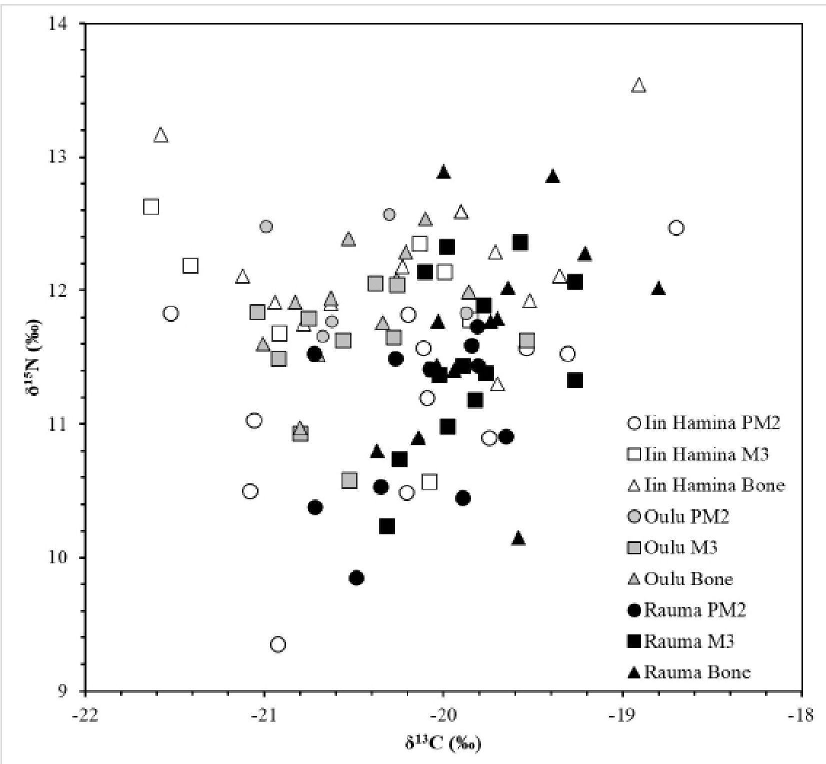

Figure 2. The δ^{13}C and δ^{15}N values measured in PM2 (circles), M3 (squares), and bone collagen (triangles) in Iin Hamina (white), Oulu (grey), and Rauma (black).

Table 1. Population minimum, maximum, and average δ¹⁵N and δ¹³C values of bone and PM2 and M3 dentin samples.

		N	Minimum (‰)		Maximum (‰)		Average (‰)		SD	
			$\delta^{13}C$	$\delta^{15}N$	$\delta^{13}C$	$\delta^{15}N$	$\delta^{13}C$	$\delta^{15}N$	$\delta^{13}C$	$\delta^{15}N$
Iin Hamina	PM2	12	-21,5	9,4	-18,7	12,5	-20,2	11,2	0,83	0,82
	M3	7	-21,6	10,6	-19,9	12,6	-20,6	11,9	0,74	0,67
	Bone	13	-21,6	11,3	-18,9	13,5	-20,2	12,2	0,78	0,59
	All	32	-21,6	9,4	-18,7	13,5	-20,3	11,8	0,78	0,82
Oulu	PM2	5	-21,0	11,7	-19,9	12,6	-20,5	12,1	0,42	0,43
	M3	10	-21,0	10,6	-19,5	12,1	-20,5	11,6	0,43	0,47
	Bone	10	-21,0	11,0	-19,9	12,5	-20,5	11,9	0,36	0,46
	All	25	-21,0	10,6	-19,5	12,6	-20,5	11,8	0,39	0,48
Rauma	PM2	11	-20,7	9,9	-19,7	11,7	-20,1	11,0	0,38	0,63
	M3	13	-20,3	10,2	-19,3	12,4	-19,9	11,5	0,33	0,64
	Bone	13	-20,4	10,2	-18,8	12,9	-19,7	11,7	0,42	0,78
	All	37	-20,7	9,9	-18,8	12,9	-19,9	11,4	0,41	0,73
Children		28	-21,5	9,4	-18,7	12,6	-20,2	11,3	0,61	0,77
Adolescents		30	-21,6	10,2	-19,3	12,6	-20,2	11,6	0,58	0,60
Adults		36	-21,6	10,2	-18,8	13,5	-20,1	11,9	0,63	0,66
All		94	-21,6	9,4	-18,7	13,5	-20,2	11,6	0,60	0,72

higher than both Iin Hamina (p=0.028) and Oulu (p=0.000). However, for the $\delta^{15}N$ values, a pairwise comparison could not indicate any significant differences between the populations (Iin Hamina vs. Oulu p=1.000, Iin Hamina vs. Rauma p=0.060, Oulu vs. Rauma p=0.086) which is probably an artefact caused by the small sample sizes (Table 1; Fig. 2).

DISCUSSION

Commonalities in dietary practices between the site-specific populations

The obtained $\delta^{13}C$ values (Table 1; Appendix 1), which can be used to trace the marine or terrestrial origin of the diets, are consistent with values typical of human collagen in terrestrial C_3 environments. According to Kohn (2010), the maximum $\delta^{13}C$ value for C_3 plants is -23‰. Considering that the fractionation of carbon between diet and collagen is approximately +5‰ (Krueger & Sullivan 1984; Lee-Thorpe et al. 1989), collagen $\delta^{13}C$ values of c. -18‰ or lower should be expected in present-day C_3 environments. However, due to the c. 1.5–2.0‰ drop in the $\delta^{13}C$ value of atmospheric CO_2 during the industrial era, mainly due to the utilisation of ^{13}C depleted fossil fuels (McCarroll & Loader 2004; Keeling et al. 2017), the corresponding expected collagen $\delta^{13}C$ values for C_3 environments translate to -16.5‰ or lower. In this study, none of the values exceed -18.8‰, and thus do not necessarily suggest any other influences than those from terrestrial C_3 environments or brackish water reservoirs.

In the light of the high $\delta^{15}N$ values throughout the populations, which might indicate marked animal protein consumption and a high tropic position, utilisation of aquatic resources – probably from both the nearby sea and the various freshwater sources local to each population – was likely. Typically, the food chains in water are long and complex, elevating the $\delta^{15}N$ values further than those in terrestrial environments (Ambrose 1993; Enhus et al. 2011; O'Brien 2015). From historical sources, we already know that during the relevant periods, fish – in the north, salmon, in particular – was an important part of the nutrition of all the populations (Lähteenoja 1939: 267; Halila 1953: 450; Satokangas 1987; Tanska 2011). In addition to salmon, species such as herring, pike, bream, ide, and whitefish were commonly caught (Halila 1954: 255–78). Even in 19th-century Rauma, fishing still played an important economic role, and catches of herring, salmon, whitefish, European perch, and pike were particularly significant (Lähteenoja 1939: 267–8).

Different sources of dietary animal protein in the site-specific populations

No significant differences in $\delta^{15}N$ values, commonly used in the reconstruction of plant versus animal protein intake, could be pinpointed in pairwise comparisons of the populations, although the initial testing had indicated differences ($p=0.028$). The $\delta^{15}N$ values, however, were higher in Iin Hamina and Oulu (in both, mean 11.8‰) than in Rauma (11.4‰). At least in Iin Hamina, and perhaps also in Oulu, some consumption of seal meat would not have been surprising. Locally in both populations, seals were indeed hunted for blubber and skins, which could be used as versatile raw materials for clothing and various household uses (Halila 1954: 277–8; Tanska 2011; Metsähallitus 2014). Their meat was also consumed in many coastal communities (Luukko 1954: 437–45; Ylimaunu 2000: 332). Even blubber could be used in cooking. The fact that the medieval Catholic Church considered seal as a species of fish is relevant particularly in relation to seal consumption in Iin Hamina. Until the mid-16th century, the parishes of Finland (then Sweden) were Catholic, and while meat consumption during Lent was forbidden, that of fish and thus, seal, was not, which made seal meat an important product (Metsähallitus 2014). Still in the 1770s, on the Swedish side of the Bay, seal was hunted (Halila 1954: 255), and as late as in the beginning of the 20th century, in the archipelago of Qvarken (FI Merenkurkku), seal meat was a seasonal spring delicacy – pups, in particular (Metsähallitus 2014).

However, as can be deduced by the rather high bone collagen $\delta^{15}N$ values, for example averaging 15.7±0.7‰ in the Västerbjers population from the island of Gotland in the Baltic Sea with a seal-based diet (Eriksson 2004), the values obtained in our study clearly cannot indicate a diet containing similarly large portions of fish or aquatic mammals. Although similarly anachronistic when used as a reference in this study, the same is obvious from the bone collagen $\delta^{15}N$ values of 14.5±0.5‰ of ringed seals (N=12; of which 11 from the Baltic Sea) and 16.6±0.9‰ in grey seals (N=15, 14 from the Baltic Sea) measured in seals dating to 1840 and onwards (Enhus et al. 2011).

The diets of the studied populations must have contained varying amounts of foodstuffs of lower ^{15}N content. The low $\delta^{15}N$ isotopic values may represent products from livestock such as cattle and sheep/goat or game lower in the trophic chain, but their proportions may have differed depending on the population. The mean values of certain local species are represented in Figure 3. Unfortunately, the soils in major parts of Finland are highly acidic because of silicon dioxide-based bedrocks which dissolve the remains of skeletal tissues quite effectively (Gordon & Buikstra 1981; Tattari & Rekolainen 2006: 27; Spellman 2009: 50), which is why osteoarcheaological materials are rarely preserved. This poses a challenge for finding suitable reference materials for stable isotope studies, but also highlights the importance of producing isotopic data from the region.

In the northern parts of Ostrobothnia, where both Iin Hamina and Oulu are located, the natural meadows gave excellent opportunities for cattle to graze while the conditions, including liability to frost, swampy soils, or short growing periods, did not favour cultivation of crops (Halila 1954: 179–81). Thus, for a long time, cattle, and particularly dairy products, which yield $\delta^{15}N$ values at the same level as meat (O'Connell & Hedges 1999), were more important for livelihoods than cultivation (Halila 1954: 210–1; Vahtola 1997; Tanska 2011). Meat production in the north at the time was likely less profitable, as the short growing periods often hindered not only the production of crops but that of winter fodder as well, even despite the extensive meadows (Halila 1954: 210–1; Lahtinen & Salmi 2019).

Still in the 18th century, in northern parts of Ostrobothnia, where both Iin Hamina and Oulu are located, traditional sources of livelihood such as hunting, and perhaps even fowling, were important (Halila 1954: 179–81). The significance of game animals is even evident in the large amount of their bones in northern archaeological sites (Puputti 2010: 37; Salmi 2011). In archaeological investigations of Northern Ostrobothnian settlements dating mainly to early modernity, large quantities of non-domesticated animal bones have been uncovered (Lahtinen & Salmi 2019). Ungulates such as elk consuming were popular game animals hunted for their meat in both Iin Hamina and Oulu, and their $\delta^{15}N$ values are rather low (Fig. 3; Lahtinen & Salmi 2019). These species must have contributed to the local diets in Iin Hamina and to some extent in Oulu, particularly among the common townspeople (Halila 1953: 440, 450; Satokangas 1987; Vahtola 1987; Puputti 2010: 37; Tanska 2011). Hunting of predators, such as wolves, was practised to prevent cattle losses, and generally furbearing species were hunted for the fur trade and not for their meat (Halila 1953: 441; 1954: 217; Luukko 1954: 383–97). Around the turn of the 19th century, in Rauma, hunting was no longer more than a form of leisure for the townspeople (Lähteenoja 1939: 267–8).

The unusual stable isotope patterns of certain species may be relevant in terms of interpreting the values. For instance, pigs and poultry being omnivorous usually present with more elevated $\delta^{15}N$ values than other domestic animals, but as the reference data implies, their values can be varied (Fig. 3). Pigs, however, probably had little economic significance in any of the studied populations during the relevant periods (Lähteenmäki 1939: 274; Halila 1953: 442; 1954: 216; Salmi 2011). Reindeer that are grazing on lichen usually have higher $\delta^{13}C$ values than the corresponding values of grass-grazing species from the same ecosystem (e.g., Fizet et al. 1995). Unlike species from aquatic environments, the $\delta^{15}N$ values of both the lichen-grazing and grass-grazing species remain at a lower level (Fjellström et al. 2020; Salmi et al. 2020). Still during the 18th century, reindeer were kept in the northern parts of Ostrobothnia, even at the latitude of Oulu, although their popularity was already fading (Halila 1954: 219). Nevertheless, locally the lack of proper winter fodder is known to have prompted cattle's diets to be supplemented with lichen (Halila 1954: 211), which could elevate the $\delta^{13}C$ values.

Significance of cultivated nutritional plants in the light of the $\delta^{15}N$ values

Cultivation was practised in Iin Hamina and Oulu, but its significance to the diet was marginal, and the produce of fields remained labile throughout the observation periods (Halila 1953: 200, 518; 1954: 179–81; Vahtola 1987; Tanska 2011). Overall, in the north, the short growing season, lack of field labour, skill, technology, and even willingness, hindered development of cultivation, which only began to gain significance as a source of livelihood during the late 18th century (Halila 1954: 183–5). This happened as a result of advances in agricultural technology and the adoption of new, hardier plant varieties (Helistö 2001: 230). Indeed, dental studies of the Iin Hamina individuals revealed a low incidence of caries, which implies low-carbohydrate diets, that are still believed to have contained some sweet berries as well as bread and porridge (Vilkama 2011; Lahtinen et al. 2013). Furthermore, our findings are in line with the findings of a previous stable isotope study of the Iin Hamina population by Lahtinen and Salmi (2019) concerning restricted reliance on domesticated crops as opposed to aquatic resources and terrestrial animal meat and dairy products.

According to a comparison of dental health in the Oulu and Iin Hamina populations, the diets in Iin Hamina seem to have been less cariogenic than those in Oulu (Vilkama et al. 2016). This difference, however, is not reflected in the isotope values obtained in this study, pointing towards the similarity of the two populations. The dating of the Oulu population coincides with a particularly cold period (Luoto 2013). As indicated by repeated harvest failures of the period in the region in general (Halila 1953: 728–9; 1954: 195–6; Satokangas 1987; Vahtola 1987), the produce of cultivation could still not be relied on. Crops were imported into Oulu but could be expensive (Halila 1953: 200–1).

For the Rauma population, which not only inhabited the southernmost site in this study but is also the most modern, cultivation of crops was already much more productive and its significance for the subsistence economy markedly greater (Lähteenoja 1939: 242–3; Vuorela 1999). Its population could rely on the produce of the surrounding countryside including crops of rye and barley in particular, but also the increasingly popular potatoes (Lähteenmäki 1939: 270–3). This could be significant considering the slight but not statistically significant differences observed in the $\delta^{15}N$ values between Iin Hamina and Rauma ($p=0.060$) and even Oulu and Rauma ($p=0.086$).

While the Rauma population may have relied on the carbohydrate-rich produce of fields, generally lower in $\delta^{15}N$, to a much greater degree

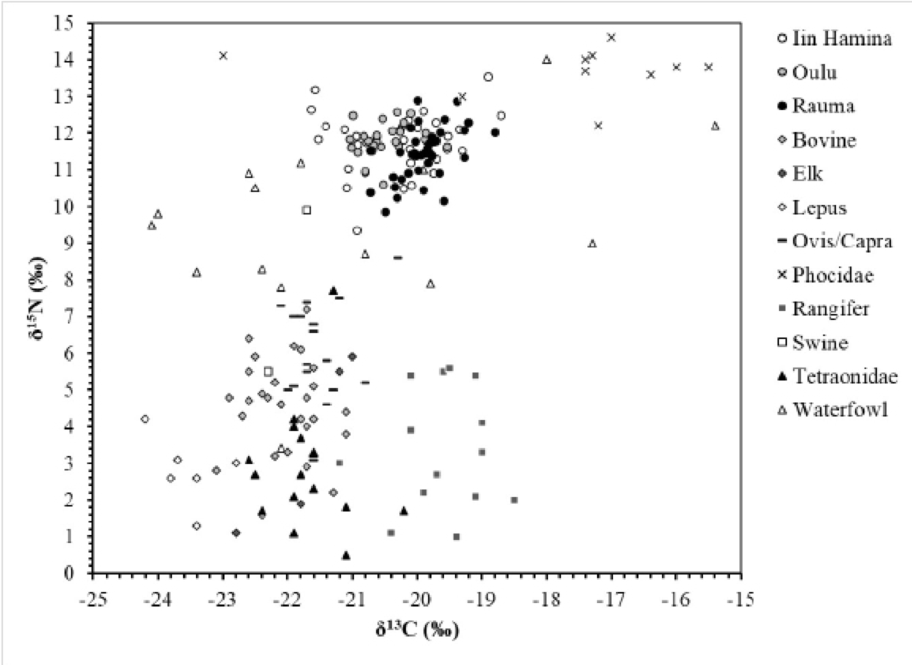

Figure 3. Bone δ^{13}C and δ^{15}N values of some animal species (for fish, see Table 2) likely utilised for food by the target populations, plotted with the human isotope data. The utilised faunal isotope data is Finnish and date between the medieval period and 1950 AD, after which a major depletion in atmospheric ^{13}C abundance due to fossil fuel emission has occurred (e.g., McCarroll & Loader 2004). The data were collected from the dIANA database (Bläuer et al. 2016; Lahtinen & Salmi 2018; Etu-Sihvola et al. 2019; Salmi & Heino 2019; Oinonen et al. 2020; Salmi et al. 2020).

than the other populations during their respective observed periods, the measured δ^{15}N values were high. The development of cultivation technologies and practices may have influenced the values in Rauma. Manuring with animal dung elevates the δ^{15}N values of crops, thus obscuring the patterns of plant- versus animal-based protein intake (Bogaard et al. 2007; Treasure et al. 2013). In the regions of Oulu and Iin Hamina, despite the importance of animal husbandry, the number of cows would for a long time not have been significant enough to have produced the dung needed to adequately manure the fields (Halila 1954: 183, 189). In addition, the traditional burn-beating technique requiring vast areas of old forests was used occasionally up until the 18th century in the coastal region in the north, although its significance diminished over time as the permanent settlements grew (Halila 1954: 182). This cultivation technique would not require the use of animal dung for fertilisation (Skrubbeltrang 1964). Moreover, based on the low δ^{15}N values measured in local contemporary cow remains, manuring is suspected not to have been practised in the natural meadows grazed by Ostrobothnian cattle (Lahtinen & Salmi 2019). In contrast, in Rauma, even the cultivation of fodder involved manuring (Lähteenoja 1939: 271), which would have led to higher δ^{15}N values in the animal products utilised as nutrition.

Effect of brackish reservoirs and marked consumption of aquatic species

In the coastal area of the Baltic Sea, δ^{13}C values pointing towards a terrestrial C_3 environment are to be expected. Despite its name, the Baltic Sea is not isotopically equivalent to a marine environment, as it is a brackish water reservoir. The δ^{13}C values of organisms living in connection to brackish bodies of water resemble those encountered in terrestrial C_3 plant environments (Katzenberg 1989). The ocean water from the North Sea is distributed into the Baltic Sea in

Brackish water pool	Bothnian Bay					Bothnian Sea					Northern Baltic Proper				
Kiljunen et al, 2020	δ^{13}C‰	SD	δ^{15}N‰	SD	N	δ^{13}C‰	SD	δ^{15}N‰	SD	N	δ^{13}C‰	SD	δ^{15}N‰	SD	N
Herring (*C, harengus*)	-23,4	0,85	9,7	0,63	85	-20,3	0,60	10,9	0,63	136	-20,4	0,92	11,8		45
Salmon (*S, salar*)	-19,7	0,83	12,7	0,64	73	-19,5	0,60	12,9	0,52	14	-18,6	0,24	12,4	0,47	10
Venduce (*C, Albula*)	-24,3	1,14	10,8	0,73	30										
Smelt (*O, eperlanus*)	-22,4	0,94	10,8	0,73	25										
Sprat (*S, sprattus*)						-20,2	0,43	9,6	0,51	40	-19,3	0,74	11,8	1,16	21
Gray seal (*H, grypus*)	-20,4	0,96	13,7	0,73		-19,3		14,6	0,77	18	-19,7		14,0		9

Table 2. Modern δ^{13}C and δ^{15}N values of species of fish and seal living in different parts of the brackish Baltic Sea measured in muscle (according to Kiljunen et al. 2020). When compared to the archaeological values, both the SUESS effect decreasing the modern carbon isotope values and the possible difference between the values yielded by the analyses of different tissues should be considered (e.g., McCarroll & Loader 2004; Leuenberger 2007; Bownes et al. 2017). Nevertheless, as these values are presented only as a demonstration of the gradient in δ^{13}C values, such modifications were not necessary.

limited pulses via the narrow Danish straits and its fraction decreases northwards. A dilution of the ocean water is caused by the large rivers descending into the Bothnian Bay, carrying organic material containing terrestrial carbon with low δ^{13}C values. Due to this, the isotopic composition of water near the northernmost corners of the Baltic Sea, known as the Bothnian Bay (Fig. 1), closely corresponds to that of fresh water. The slightly higher fraction of ocean water with a higher δ^{13}C value in front of Rauma may explain the relatively elevated values measured in the population of Rauma in comparison to the populations of both Oulu ($p=0.000$) and Iin Hamina ($p=0.028$).

A similar gradient has been observed in an isoscape study of the stable isotopes values of dissolved inorganic carbon (δ^{13}CDIC) in the water of the Baltic Sea (Torniainen et al. 2017). This gradient is evident in the δ^{13}C values measured in muscle tissues of fish and seals caught from different major basins of the Baltic Sea (Kiljunen et al. 2020). As seen in Table 2, the stable carbon isotopes values rather systematically elevate from the northernmost basin, the Bothnian Bay, towards the Baltic proper in the south. Only the values of grey seal (*H. grypus*) diverged slightly from the trend (Kiljunen et al. 2020), but perhaps their low number may have affected the representativity of the results. Furthermore, grey seals are known to move extensive distances, particularly in their youth (Ronald & Gots 2003; Reeves 2014), and thus, contain isotopic influences from many different areas (cf. Ben-David et al. 1997a; 1997b).

The δ^{13}C values in the Baltic Sea are clearly lower than those encountered in marine environments, but, particularly in the southern parts of the sea, in most cases they are still higher than those measured in freshwater organisms. For instance, Auttila et al. (2015) measured average δ^{13}C values between nearly -28‰ and -25‰ (and average δ^{15}N values between c. 8 and 14) in Lake Saimaa, Eastern Finland depending on the region, and the type of fish (benthic, pelagic, littoral). In Jyväsjärvi, Central Finland, the periphyton utilised as the nutrition of many fish species had δ^{13}C values ranging between -32.0‰ and -22.3‰ (and δ^{15}N values between 3.6‰ to 8.0‰) (Syväranta et al. 2006). Nevertheless, notable variation in the δ^{13}C values of the species as well as the composition and size of the Baltic Sea has been observed to occur over time (Ukkonen et al. 2014; Etu-Sihvola et al. 2019; Lahtinen & Salmi 2019), which makes comparisons over large temporal gaps difficult.

Children, adolescents, and adults

The statistical testing indicated different $\delta^{15}N$ values in PM2 dentin collagen and bone collagen in the Iin Hamina population, with higher values obtained from the bone collagen samples ($p=0.004$). This implies that the adults and children in 15th to early 17th-century Iin Hamina may have had different diets. Aquatic environments are typically elevated in $\delta^{15}N$ (e.g., Minagawa & Wada 1984; Schoeninger & DeNiro 1984; Ambrose 1993; Schulting 1998; Enhus et al. 2011; O'Brien 2015). As already discussed, aquatic predatory species, such as salmon, probably played an important role in the diets of the study subjects. The detected difference may reflect an increasing abundance of animal protein or a greater proportion of protein with high trophic levels, perhaps fish, in diets towards adulthood. Children in Iin Hamina may have eaten more food items such as bread, roots, berries, or porridge.

On the other hand, the effect of growth on the $\delta^{15}N$ values is worth considering. It has been suggested that the metabolic differences in growing versus adult individuals consuming similar diets lead to different $\delta^{15}N$ values (Millard 2000). This has been demonstrated in pregnant women growing new tissues and presenting with lower $\delta^{15}N$ values (e.g., Fuller et al. 2004). Many authors, nevertheless, lean towards a presumption that if such an effect can be measured in growing individuals, the decline caused by it remains minor (e.g., Ponsard & Averbuch 1999; Waters-Rist & Katzenberg 2010; Nitsch et al. 2011).

Another explanation for the difference may even simply reflect the fact that the analyses of bone (adult) and dentin (childhood/adolescent) samples were performed in different laboratories (Helsinki and Vilnius). Differences in sample preparation and analytical conventions (e.g., instrumentation, working standards, and normalisation protocols) can result in offsets in stable isotope data levels between laboratories. Considering the findings of typical interlaboratory differences of 0.4‰ for collagen $\delta^{15}N$ data (Pestle et al. 2014), it is entirely possible that some of the difference in $\delta^{15}N$ mean values between the adolescents and adults detected as significant by the statistical analysis is an artefact stemming from analytical causes.

Other factors to consider

Serious epidemics, famines, and wars have affected all the studied populations. In Iin Hamina, this period was disrupted several times by attacks from Novgorod (Kallio-Seppä 2011; Tanska 2011). Living in Oulu was complicated by the difficult climate conditions brought about by the particularly harsh climatic spell and even the Great Northern War and other hostilities during the 18th century (Satokangas 1987; Vahtola 1987; Luoto 2013). The Finnish War in 1808–9 likely coincided with the lifetime of some of the individuals in the Rauma sample. This may be worth consideration, as the influence of such stressors as nutrition and health concerns on stable isotope values have a better chance of being stored in rapidly and incrementally growing tissues (dentin, hair, nail). Under stress, a negative nitrogen balance necessitates the release of protein, already enriched with heavier nitrogen isotopes in relation to the diet, from muscles to enable new protein synthesis, which leads to an elevation in $\delta^{15}N$ values. Starvation may lead to the body utilising stored adipose tissues low in heavier carbon isotopes as an energy source, which is observable as a depletion of $\delta^{13}C$ values (DeNiro & Epstein 1977; Lee-Thorpe et al. 1989; Ambrose 1993; Katzenberg & Lovell 1999; Fuller et al. 2005; Beretta et al. 2010; Reitsema 2013; D'Ortenzio et al. 2015; Webb et al. 2015; Doi et al. 2017). However, it is unclear how these episodes of stress affect the stable isotope composition of bone tissues that present average conditions over an extended period of several years. Especially in the absence of anything resembling anamnesis, it is impossible to conclusively tell whether such conditions could have influenced the signals measured in the sample.

All individuals included in this analysis had an erupted M3 according to which they could be interpreted as adults. While the group of adolescents is age-wise quite constant because of the relatively systematic time window of PM2 and even M3 formation, the range of ages at death, however, is much wider, as the sample includes individuals from young to mature adults. Due to this, the biological ages their bone collagen samples represent vary greatly. In fact, the bone samples of the youngest may still contain some isotope signals formed during adolescence, which may bring the average values of the age-specific groups closer to each other. What is more, there may have been differences between the diets of younger and older adults which were obscured due to the makeup of the sample.

CONCLUSION

The $\delta^{13}C$ values yielded by the analyses are consistent with the values typical of terrestrial C_3 environments and to be expected in the coastal area of the brackish Baltic Sea. A larger fraction of ocean water (Atlantic/North Sea) with a higher $\delta^{13}C$ value outside the coast of Rauma compared to the two more northerly sites likely explains why the $\delta^{13}C$ values measured in the Rauma population are significantly elevated in comparison to the populations of both Oulu and Iin Hamina.

Elevated levels of $\delta^{15}N$ values are observed throughout the populations, implying continuous utilisation of aquatic resources as a common part of diets. The historical information concerning the populations suggests that both the nearby sea and the various freshwater sources local to each population were used. Particularly salmon, high in the food chain, presenting with elevated $\delta^{15}N$ values, has been plentifully consumed especially in Iin Hamina and Oulu, but to some extent in Rauma as well. In Iin Hamina and even in Oulu, some consumption of seal meat may well have been possible, and although the difference was not significant, it may explain the slightly higher $\delta^{15}N$ values in these populations in comparison to the Rauma population.

The diets of the studied populations still contained varying amounts of foodstuffs of lower ^{15}N content. Depending on the population, they may be products of livestock or game. During the relevant period, in the northern parts of Ostrobothnia, where both Iin Hamina and Oulu are located, animal husbandry was an important part of livelihoods and hunting contributed to local diets. The significance of the cultivation of crops, however, was not as great in late medieval to early modern Iin Hamina or even in early modern Oulu as it was in the south-western 19th-century Rauma. Nevertheless, despite the greater reliance on crops and potatoes lower in protein than aquatic resources, the $\delta^{15}N$ values in Rauma are high. They may have been influenced by the adoption of more advanced agricultural technologies, including extensive manuring with animal dung of both meadows growing winter fodder and fields growing crops.

The samples divided into groups according to tissue types representing childhood, adolescence and adulthood differ from each other – in Iin Hamina, the $\delta^{15}N$ values measured in dentin collagen of PM2 representing childhood diets and in bone collagen representing adulthood diets were significantly different. This may be due to the larger amount of aquatic foodstuffs in the diets of adults in Iin Hamina. Children may also have eaten more foods such as bread, porridge, berries, and roots.

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REFERENCES

Unpublished sources

Uotila, K. & Lehto, H. 2016. Rauma, Vanhankirkonkatu. Historiallisen ajan hautakaivaus 16.5.–25.7.2016. Excavation report, Muuritutkimus Oy/ the Finnish Heritage Agency, Archives, Helsinki.

Literature

Ambrose, S. H. 1990. Preparation and characterization of bone and tooth collagen for isotopic analysis. *Journal of Archaeological Science* 17: 431–51.

Ambrose, S. H. 1993. Isotopic analysis of paleodiets: Methodological and interpretive considerations in investigations of ancient human tissues. In M. K. Sandford (ed.) *Chemical Analyses* *in Anthropology*: 59–130. Greensboro, NC: University of North Carolina of Greensboro.

Ambrose, S. H. & Norr, L. 1993. Experimental evidence for the relationship of the carbon isotope ratios of whole diet and dietary protein to those of bone collagen and carbonate. In J. B. Lambert & G. Grupe (eds.) *Prehistoric Human Bone*: 1–37. Berlin, Heidelberg: Springer.

Angerbjörn, A., Börjesson, P. & Brandberg, K. 2006. Stable isotope analysis of harbour porpoises and their prey from the Baltic and Kattegat/Skagerrak Seas. *Marine Biology Research* 2: 411–9.

Auttila, M., Sinisalo, T., Valtonen, M., Niemi, M., Viljanen, M., Kurkilahti, M. & Kunnasranta, M. 2015. Diet composition and seasonal feeding patterns of a freshwater ringed seal (Pusa hispida saimensis). *Marine Mammal Science* 31(1): 45–6.

Beaumont. J., Montgomery, J., Buckberry, J. & Jay, M. 2015. Infant mortality and isotopic complexity: New approaches to stress, maternal health, and weaning. *American Journal of Physical Anthropology* 157: 441–57.

Ben-David, M., Flynn, R. W. & Schell, D. M. 1997a. Annual and seasonal changes in diets of martens: Evidence from stable isotope analysis. *Oecologia* 111: 280–91.

Ben-David, M., Hanley, T. A., Klein, D. R. & Schell, D. M. 1997b. Seasonal changes in diets of coastal and riverine mink: The role of spawning Pacific salmon. *Canadian Journal of Zoology* 75: 803–11

Beretta, L., Rocchetti, S. & Braga, M. 2010. What's new in emergencies, trauma, and shock? Nitrogen balance in critical patients on enteral nutrition. *Journal of Emergencies, Trauma, and Shock* 3(2): 105–8.

Bläuer, A., Arppe, L., Niemi, M., Oinonen, M., Lidén, K., Taavitsainen, J.-P. & Kantanen, J. 2016. Inferring prehistorical and historical feeding practices from δ^{15}N and δ^{13}C isotope analysis on Finnish archaeological domesticated ruminant bones and teeth. *Fennoscandia Archaeologica* XXXIII: 171–88.

Bocherens, H., Billiou, D., Patou-Mathis, M., Bonjean, D., Otte, M. & Mariotti, A. 1997. Paleobiological implications of the isotopic signatures (^{13}C, ^{15}N) of fossil mammal collagen in Scladina Cave (Sclayn, Belgium). *Quaternary Research* 48: 370–80.

Bocherens, H. & Drucker, D. 2003. Trophic level isotopic enrichment of carbon and nitrogen in bone collagen: Case studies from recent and ancient terrestrial ecosystems. *International Journal of Osteoarchaeology* 13: 46–53.

Bogaard, A., Heaton, T. H. E., Poulton, P. & Merbach, I. 2007. The impact of manuring on nitrogen isotope ratios in cereals: Archaeological implications for reconstruction of diet and crop management practices. *Journal of Archaeological Science* 34(3): 335–43.

Bownes, J., Ascough, P., Cook, G., Murray, I. & Bonsall, C. 2017. Using stable isotopes and a Bayesian mixing model (FRUITS) to investigate diet at the Early Neolithic Site of Carding Mill Bay, Scotland. *Radiocarbon* 59(5): 1275–94.

Brown, T., Nelson, D., Vogel, J. & Southon, J. 1988. Improved collagen extraction by modified Longin method. *Radiocarbon* 30(2): 171–7.

Danielsson, S., Faxneld, S., Bignert, A., Dahlgren, H., Kylberg, E., Jones, D. & Sundbom, M. 2015. *Carbon and nitrogen stable isotopes within the Swedish national monitoring of contaminants in marine biota*. Swedish Museum of Natural History, Report 9.

DeNiro, M. J. 1985. Postmortem preservation and alteration of in vivo bone collagen isotope ratios in relation to palaeodietary reconstruction. *Nature* 317: 806–9.

DeNiro, M. J. & Epstein, S. 1977. Mechanism of carbon isotope fractionation associated with lipid synthesis. Science 197(4300): 261–3.

DeNiro, M. J. & Epstein, S. 1978. Influence of diet on the distribution of carbon isotopes in animals. *Geochimica et Cosmochimica Acta* 42: 495–506.

DeNiro, M. J. & Epstein, S. 1981. Influence of diet on the distribution of nitrogen isotopes in animals. *Geochimica et Cosmochimica Acta* 45: 341–51.

Doi, H., Akamatsu, F. & González, A. L. 2017. Starvation effects on nitrogen and carbon stable isotopes of animals: An insight from meta-analysis of fasting experiments. *Royal Society Open Science* 4170633.

D'Ortenzio, L., Brickley, M., Schwarcz, H. & Prowse, T. 2015. You are not what you eat during physiological stress: Isotopic evaluation of human hair. *American Journal of Physical Anthropology* 157(3): 374–88.

Eerkens, J. W., Berget, A.G. & Bartelink, E. J. 2011. Estimating weaning and early childhood diet from serial micro-samples of dentin collagen. *Journal of Archaeological Science* 38(11): 3101–11.

Enhus, C., Boalt, E. & Bignert, A. 2011. *A retrospective study of metals and stable isotopes in seals from Swedish waters*. Swedish Museum of Natural History, Report 5.

Eriksson, G. 2004. Part-time farmers or hard-core sealers? Västerbjers studied by means of stable isotope analysis. *Journal of Anthropological Archaeology* 23(2): 135–62.

Etu-Sihvola, H., Bocherens, H., Drucker, D., Junno, A., Mannermaa, K., Oinonen, M., Uusitalo, J. & Arppe, L. 2019. The dIANA database – Resource for isotopic paleodietary research in the Baltic Sea area. *Journal of Archaeological Science: Reports* 24: 1003–13.

Fahy, G. E., Deter, C., Pitfield, R., Miszkiewicz, J. J. & Mahoney, P. 2017. Bone deep: Variation in stable isotope ratios and histomorphometric measurements of bone remodeling within adult humans. *Journal of Archaeological Science* 87: 10–6.

Fizet, M., Mariotti, A., Bocherens, H., Lange-Badré, B., Vandermeersch, B., Borel, J.-P., Bellon, G. 1995. Effect of diet, physiology and climate on carbon and nitrogen isotopes of collagen in a late Pleistocene anthropic paleoecosystem (France, Charente, Marillac). *Journal of Archaeological Science* 22: 67–79.

Fjellström, M., Eriksson, G., Angerbjörn, A. & Lidén, K. 2020. Approaching historic reindeer herding in Northern Sweden by stable isotope analysis. *Journal of Nordic Archaeological Science* 19: 63–75.

Fuller, B. T., Fuller, J. L., Sage, N. E., Harris, D. A., O'Connell, T. C. & Hedges, R. E. M. 2004. Nitrogen balance and $\delta^{15}N$: Why you're not what you eat during pregnancy. *Rapid Communications in Mass Spectrometry* 18: 2889–96.

Fuller, B. T., Fuller, J. L., Sage, N. E., Harris, D. A., O'Connell, T. C. & Hedges, R. E. M. 2005. Nitrogen balance and $\delta^{15}N$: Why you're not what you eat during nutritional stress. *Rapid Communications in Mass Spectrometry* 19: 2497–506.

Gordon, C. C. & Buikstra, J. E. 1981. Soil pH, bone preservation, and sampling bias at mortuary sites. *American Antiquity* 46: 566–71.

Guiry, E. J. & Szpak, P. 2021. Improved quality control criteria for stable carbon and nitrogen isotope measurements of ancient bone collagen. *Journal of Archaeological Science* 132: 105416.

Haavikko, K. 1970. The formation and the alveolar and clinical eruption of the permanent teeth: An orthopantomographic study. *Suomen Hammaslääkäriseuran Toimituksia* 66: 103–70.

Halila, A. 1953. *Oulun kaupungin historia 2, 1721–1809.* Oulu: City of Oulu.

Halila, A. 1954. *Pohjois-Pohjanmaan ja Lapin historia V. Pohjois-Pohjanmaa ja Lappi 1721–1775.* Oulu: Pohjois-Pohjanmaan maakuntaliiton ja Lapin maakuntaliiton yhteinen historiatoimikunta.

Hedges, R. E., Clement, J. G., Thomas, C. D. & O'Connell, T. C. 2007. Collagen turnover in the adult femoral mid-shaft: Modeled from anthropogenic radiocarbon tracer measurements. *American Journal of Physical Anthropology* 133(2): 808–16.

Helistö, M. 2001. *Kemin asutuksen historiaa.* Kemi: Kemin kotiseutu- ja museoyhdistys.

Henderson, R. C., Lee-Thorp, J. & Loe, L. 2014. Early life histories of the London poor using $\delta^{13}C$ and $\delta^{15}N$ stable isotope incremental dentine sampling. *American Journal of Physical Anthropology* 154: 585–93.

Hillson, S. 1996. *Dental Anthropology.* Cambridge: Cambridge University Press.

Jørkov, M. L. S., Heinemeier, J. & Lynnerup, N. 2009. The petrous bone: A new sampling site for identifying early dietary patterns in stable isotopic studies. *American Journal of Physical Anthropology* 138: 199–209.

Kallio-Seppä, T. 2011. Tietoja Iin kirkosta ja kirkkomaista kirjallisten ja arkeologisten lähteiden perusteella. In T. Kallio-Seppä, J. Ikäheimo & K. Paavola (eds.) *Iin Vanhan Haminan kirkko ja hautausmaa: arkeologisia tutkimuksia*: 34–43. Oulu: Oulun yliopisto.

Kallio-Seppä, T., Junno, J.-A., Niinimäki, S., Korpi, H.-K., Tanska, T., Heikkilä, T. & Kamula, K. 2009. Excavations at Ii Hamina discontinued cemetery – Some preliminary results and implications. *Fennoscandia Archaeologica* XXVI: 172–6.

Kallio-Seppä, T. & Tranberg, A. 2021. The materiality of odors: Experiencing church burials and the urban environment in Early Modern

Northern Sweden. Historical Archaeology 55(1): 65–81.
Katzenberg, M. A. 1989. Stable isotope analysis of archaeological faunal remains from southern Ontario. *Journal of Archaeological Science* 16: 319–29.
Katzenberg, M. A. & Lovell, N. C. 1999. Stable isotope variation in pathological bone. *International Journal of Osteoarchaeology* 9: 316–24.
Keeling, R. F., Graven, H. D., Welp, L. R., Resplandy, L., Bi, J., Piper, S. C., Sun, Y., Bollenbacher, A. & Meijer, H. 2017. Atmospheric evidence for a global secular increase in carbon isotopic discrimination of land photosynthesis. *Proceedings of the National Academy of Sciences of the United States of America* 114(39): 10361–6.
Kiljunen, M., Peltonen, H., Lehtiniemi, M., Uusitalo, L., Sinisalo, T., Norkko, J., Kunnasranta, M., Torniainen, J., Rissanen, A. J. & Karjalainen, J. 2020. Benthic-pelagic coupling and trophic relationships in northern Baltic Sea food webs. *Limnology and Oceanography* 65: 1706–22.
van Klinken, G. J. 1999. Bone collagen quality indicators for palaeodietary and radiocarbon measurements. *Journal of Archaeological Science* 26(6): 687–95.
Kohn, M. J. 2010. Carbon isotope compositions of terrestrial C3 plants as indicators of (paleo)ecology and (paleo)climate. *Proceedings of National Academy of Science of the United States of America* 107(46): 19691–5.
Krueger, H. W. & Sullivan, C. H. 1984. Models for carbon isotope fractionation between diet and bone. In J. R. Turnlund & P. E. Johnson (eds.) *Stable Isotopes in Nutrition.* American Chemical Society Symposium Series 258: 205–20.
Lähteenoja, A. 1939. *Rauman kaupunginhistoria IV. Rauma 1809–1917.* Rauma: Länsi-Suomen Kirjapaino.
Lahtinen, M. & Salmi, A.-K. 2018. Farming in the extreme: Animal management in late medieval and early modern Northern Finland. *Arctic Anthropology* 55(3): 76–96
Lahtinen, M. & Salmi, A.-K. 2019. Mixed livelihood society in Iin Hamina: A case study of medieval diet in the Northern Ostrobothnia, Finland. *Environmental Archaeology* 24(1): 1–14.
Lahtinen, M., Salmi, A.-K. & Vilkama, R. 2013. Ruoanjätteitä, kariesta ja kemiaa: Miten arkeologiset ja luonnontieteelliset menetelmät kertovat ruokapöydän antimista 1400–1700-luvulla. *Historiallinen Aikakauskirja* 4: 409–21.
Lee-Thorp, J. A. 2008. On isotopes and old bones. *Archaeometry* 50(6): 925–50.
Lee-Thorp, J. A., Sealy, J. C. & van der Merwe, N. J. 1989. Stable carbon isotope ratio differences between bone collagen and bone apatite, and their relationship to diet. *Journal of Archaeological Science* 16: 585–99.
Leuenberger, M. 2007. To what extent can ice core data contribute to the understanding of plant ecological developments of the past? *Terrestrial Ecology* 1: 211–33.
Luoto, T. P. 2013. How cold was the Little Ice Age? A proxy-based reconstruction from Finland applying modern analogues of fossil midge assemblages. *Environmental Earth Sciences* 68: 1321–9.
Luukko, A. 1954. *Pohjois-Pohjanmaan ja Lapin historia II. Pohjois-Pohjanmaan ja Lapin keskiaika sekä 1500-luku.* Oulu: Pohjois-Pohjanmaan Maakuntaliiton ja Lapin Maakuntaliiton yhteinen historiatoimikunta.
McCarroll, D. & Loader, N. J. 2004. Stable isotopes in tree rings. *Quaternary Science Reviews* 23(7–8): 771–801.
Metsähallitus. 2014. *Merenkurkun saaristo - Hylkeen liha, rasva, traani ja nahka.* Vantaa: Metsähallitus.
Millard, A. R. 2000. A model for the effect of weaning on nitrogen isotope ratios in humans. In G. A. Goodfriend, M. Collins, M. Fogel, S. Macko & J. F. Wehmill (eds.) *Perspectives in Amino Acids and Protein Geochemistry*: 51–9. Oxford: Oxford University Press.
Minagawa, M. & Wada, E. 1984. Stepwise enrichment of ^{15}N along food chains: Further evidence and the relation between $\delta^{15}N$ and animal age. *Geochimica et Cosmochimica Acta* 48: 1135–40.
Nanci, A. 2013. *Ten Cate's Oral Histology Development, Structure and Function.* St. Louis: Elsevier.
Nitsch, E. K., Humphrey, L. T. & Hedges, R. E. 2011. Using stable isotope analysis to examine the effect of economic change on breastfeeding practices in Spitalfields, London, UK.

American Journal of Physical Anthropology 146(4): 619–28.
O'Brien, D. M. 2015. Stable isotope ratios as biomarkers of diet for health research. *Annual Review of Nutrition* 35: 565–94.
O'Connell, T. C & Hedges, R. E. 1999. Investigations into the effect of diet on modern human hair isotopic values. *American Journal of Physical Anthropology* 108(4): 409–25.
O'Connell, T. C., Kneale, C. J., Tasevska, N. & Kuhnle, G. G. C. 2012. The diet-body offset in human nitrogen isotopic values: A controlled dietary study. *American Journal of Physical Anthropology* 149(3): 426–34.
Oinonen, M., Alenius, T., Arppe, L., Bocherens, H., Etu-Sihvola, H., Helama, S., Huhtamaa, H., Lahtinen, M., Mannermaa, K., Onkamo, P., Palo, J., Sajantila, A., Salo, K., Sundell, T., Vanhanen, S. & Wessman, A. 2020. Buried in water, burdened by nature: Resilience carried the Iron Age people through Fimbulvinter. *PloS One* 15(4): e0231787.
Parfitt, A. M. 2002. Misconceptions (2): Turnover is always higher in cancellous than in cortical bone. *Bone* 30(6): 807–809.
Pestle, W. J., Crowley, B. E. & Weirauch, M. T. 2014. Quantifying inter-laboratory variability in stable isotope analysis of ancient skeletal remains. *PLoS One* 9(7): e102844.
Ponsard, S. & Averbuch, P. 1999. Should growing and adult animals fed on the same diet show different $\delta^{15}N$ values? *Rapid Communications in Mass Spectrometry* 13: 1305–10.
Puputti, A.-K. 2010. *Living with Animals: a Zooarchaeological study of Urban Human-Animal Relationships in Early Modern Tornio, 1621–1800*. BAR International Series 2100.
Reeves, R. 2014. Distribution, abundance and biology of ringed seals (Phoca hispida): An overview. *Nammco Scientific Publications* 1: 9–45.
Reitsema, L. J. 2013. Beyond diet reconstruction: Stable isotope applications to human physiology, health, and nutrition. *American Journal of Human Biology* 25: 445–56.
Ronald, K. & Gots, B. L. 2003. Seal (Phocidae, Otariidae, and Odobenidae). In G. A. Feldhamer, B. C. Thompson & J. A. Chapman (eds.) *Wild Mammals of North America: Biology, Management, and Conservation: 789–854.* Baltimore: Johns Hopkins University Press.
Rousi, A. 1997. *Auringonkukasta viiniköynnökseen, viljelyskasvit ihmisen palveluksessa.* Porvoo, Helsinki, Juva, WSOY.
Salmi, A.-K. 2011. Riistaa, kalaa ja konttiluita – Pohjois-Suomen maaseudun ruokakulttuurista n. 1400–1700 AD. In J. Ikäheimo, R. Nurmi & R. Satokangas (eds.) *Harmaata näkyvissä. Kirsti Paavolan juhlakirja:* 221–36. Vaasa: Waasa Graphics.
Salmi, A.-K., Äikäs, T., Fjellström, M., Spangen, M., Núñez, M. & Lidén, K. 2020. Zooarchaeological and stable isotope evidence of Sámi reindeer offerings. *Journal of Archaeological Science: Reports* 29: 102–29.
Salmi, A.-K. & Heino, M. T. 2019. Tangled worlds: The Swedish, the Sámi, and the reindeer. *International Journal of Historical Archaeology* 23: 260–82.
Satokangas, R. 1987. Oulu ja meri (1721–1809). In K. Julku (ed.) *Valkean kaupungin vaiheet. Oulun historiaa*: 101–21. Jyväskylä: Gummerus.
Schoeninger, M. J. & DeNiro, M. J. 1984. Nitrogen and carbon isotopic composition of bone collagen from marine and terrestrial animals. *Geochimica et Cosmochimica Acta* 48: 625–39.
Schoeninger, M. J., Moore, K. M., Murray, M. L. & Kingston, J. D. 1989. Detection of bone preservation in archaeological and fossil samples. *Applied Geochemistry* 4: 281–92.
Schulting, R. J. 1998. Slighting the sea: The transition to farming in northwest Europe. *Documenta Praehistorica* 25: 203–18.
Skrubbeltrang, F. 1964. The history of the Finnish peasant. *Scandinavian Economic History Review* 12(2): 165–80.
Smith, B. N. & Epstein, S. 1971. Two categories of c/c ratios for higher plants. *Plant Physiology* 47(3): 380–4.
Spellman, F. R. 2009. *Geology for Nongeologists.* Lanham: Government Institutes Press.
Syväranta, J., Hämäläinen, H. & Jones, R. I. 2006. Within-lake variability in carbon and nitrogen stable isotope signatures. *Freshwater Biology* 51: 1090–102.
Talve, I. 1989. Kalmisto – hautausmaa – kirkkotarha. In M. Taipale & E. Vanhalukkarla (eds.) *Elämän merkit. Vuosikirja* 38: 55–75. Turun arkkihiippakunta. Loimaa: Loimaan kirjapaino.

Tanska, T. 2011. Asutusta ja kaupankäyntiä Iijoella. In T. Kallio-Seppä, J. Ikäheimo & K. Paavola (eds.) *Iin Vanhan Haminan kirkko ja hautausmaa: arkeologisia tutkimuksia:* 25–31. Oulu: Oulun yliopisto.

Tattari S. & Rekolainen S. 2006. Finland. In J. Boardman & J. Poesen J (eds.) *Soil Erosion in Europe*: 27–34. Chichester: John Wiley & Sons, Ltd.

Tauber, H. 1981. 13C evidence for dietary habits of prehistoric man in Denmark. *Nature* 292: 332–3.

Torniainen, J., Lensu, A., Vuorinen, P. J., Sonninen, E., Keinänen, M., Jones, R. I., Patterson, W. P. & Kiljunen, M. 2017. Oxygen and carbon isoscapes for the Baltic Sea: Testing their applicability in fish migration studies. *Ecology and Evolution* 7: 2255–67.

Tranberg, A., Alenius, T. H., Kallio-Seppä, T., Philip, B., Mullins, P. R. & Ylimaunu, T. 2020. The late medieval church and graveyard at Ii Hamina, Northern Ostrobothnia, Finland – Pollen and macro remains from graves. *Journal of Nordic Archaeological Science* 19: 49–61.

Treasure, E. R., Church, M. J. & Gröcke, D. R. 2016. The influence of manuring on stable isotopes ($\delta^{13}C$ and $\delta^{15}N$) in Celtic bean (Vicia faba L.): Archaeobotanical and palaeodietary implications. *Archaeological and Anthropological Sciences* 8: 555–62.

Ukkonen, P., Aaris-Sørensen, K., Arppe, L., Daugnora, L., Halkka, A., Lõugas, L., Oinonen, M. J., Pilot, M. & Storå, J. 2014. An arctic seal in temperate waters: History of the ringed seal (Pusa hispida) in the Baltic Sea and its adaptation to the changing environment. *Holocene* 24: 1694–706.

Vahtola, J. 1987. Oulun historia kaupungin perustamisesta Isoonvihaan. In K. Julku (ed.) *Valkean kaupungin vaiheet. Oulun historiaa:* 79–99. Jyväskylä: Gummerus.

Vahtola, J. 1997. Vaikea vuosisata (1601–1721). In R. Satokangas (ed.) *Keminmaan historia:* 86–177. Jyväskylä: Gummerus.

Vilkama, R. 2011. Iin vanhan Haminan vainajien hammassairaudet pohjoisen ruokavalion kuvastajina n. 1400–1600 AD. In J. Ikäheimo, R. Nurmi & R. Satokangas (eds.) *Harmaata näkyvissä. Kirsti Paavolan juhlakirja*: 251–64. Vaasa: Waasa Graphics.

Vilkama, R., Kylli, R. & Salmi, A-K. 2016. Sugar consumption, dental health and foodways in late medieval Iin Hamina and early modern Oulu, Northern Finland. *Scandinavian Journal of History* 41(1): 2–31.

Vuorela, I. 1999. Viljelytoiminnan alku Suomessa paleoekologisen tutkimuksen kohteena. In P. Fogelberg (ed.) *Pohjan poluilla. Suomalaisten juuret nykytutkimuksen mukaan, Bidrag till kännedom av Finlands natur och folk* 153: 143–51.

Waters-Rist, A. L. & Katzenberg, M. A. 2010. The effect of growth on stable nitrogen isotope ratios in subadult bone collagen. *International Journal of Osteoarchaeology* 20: 172–91.

Webb, E. C., White, C. D., Van Uum, S. & Longstaffe, F. J. 2015. Integrating cortisol and isotopic analyses of archaeological hair: Reconstructing individual experiences of health and stress. *American Journal of Physical Anthropology* 156(4): 577–94.

Ylimaunu, J. 2000. *Itämeren hylkeenpyyntikulttuurit ja ihminen-hyljesuhde -suhde*. Helsinki: Suomalaisen Kirjallisuuden Seura.

NOTES

[1] During the period relevant to this study, the area of modern-day nation of Finland was first part of the Kingdom of Sweden known as Österland and from 1809 onward, autonomous Grand Duchy of Finland in the Russian Empire. Later in this paper, we will refer this entity as Finland, although its geographical area has not remained unchanged during all historical periods.

[2] X= Isotope ratio of interest ($^{13}C/^{12}C$ or $^{15}N/^{14}N$), R= Isotope ratio of the sample or a standard.

APPENDIX

*Appendix 1. Results of the δ^{13}C and δ^{15}N analyses of the PM2 and M3 dentin and bone collagen from archaeological populations of Iin Hamina, Oulu, and Rauma. * Poor collagen quality **Skeletal element: 1=mandible 2=maxilla*

Sample	Individual	Skeletal element**	δ^{13}C (‰)	δ^{15}N (‰)	N%	C%	C/N atom	Yield %
PM2 dentin collagen								
Iin Hamina (IHA)	CH15_100/56 _I	1	-20,1	11,2	14,94	39,57	3,1	1,5
	CH15 XX	2	-20,9	9,4	14,80	38,47	3,0	2,7
	SH1_5	1	-19,7	10,9	14,85	38,27	3,0	6,1
	CR1_24A	1	-21,1	10,5	14,14	36,48	3,0	5,5
	CR1_36A	1	-21,1	11,0	14,30	37,16	3,0	3,1
	CR1_59	2	-20,1	11,6	13,69	36,64	3,1	2,1
	CR1_102/54_165	2	-19,5	11,6	13,87	36,28	3,1	4,1
	CR1_102/54_251	2	-21,5	11,8	14,77	38,80	3,1	6,9
	CR1_288	2						
	CR1_57	2	-18,7	12,5	14,12	37,20	3,1	5,8
	CR1_71	2	-19,3	11,5	12,56	34,27	3,2	1,2
	CR1_102/54_166	2	-20,2	10,5	14,92	38,43	3,0	2,6
	CR1_102/54_177	2	-20,2	11,8	13,88	37,27	3,1	4,4
Oulu (OTK)	42P18*	1	-22,5	11,4	9,79	36,49	4,4	11,1
	H29	1	-19,9	11,8	14,24	39,33	3,2	5,6
	4860	1	-21,0	12,5	13,81	37,99	3,2	3,7
	049750*	1	-23,3	11,8	9,61	38,45	4,7	10,1
	208178*	1	-22,0	12,1	10,72	37,43	4,1	7,4
	4710	1	-20,3	12,6	14,25	39,07	3,2	7,4
	2201625	1	-20,6	11,8	13,41	37,06	3,2	2,0
	20042	1	-20,7	11,7	13,36	36,73	3,2	5,6
	20439*	1	-22,7	10,5	11,02	38,52	4,1	7,0
	203G20*	1	-22,9	12,3	10,17	38,93	4,5	9,5
Rauma (RAU)	12	1	-20,1	11,4	14,34	38,26	3,1	3,5
	122	1	-20,3	11,5	14,27	38,76	3,2	5,5
	123	1	-19,7	10,9	14,53	38,36	3,1	5,9
	124	1	-19,8	11,4	13,95	38,06	3,2	3,3
	150	1	-19,8	11,7	13,84	37,87	3,2	4,7
	151	1	-20,4	10,5	14,32	38,99	3,2	4,2
	166	1	-19,8	11,6	14,62	39,95	3,2	7,5
	193*	1	-20,2	7,1	14,30	35,83	2,9	0,9
	196	1	-20,5	9,9	14,46	37,59	3,0	5,7
	197	1	-20,7	11,5	14,59	39,94	3,2	6,7
	200	1	-20,7	10,4	13,94	38,49	3,2	7,0
	202*	1	-20,7	11,0	9,82	29,90	3,6	5,7
	208	1	-19,9	10,5	14,93	36,83	2,9	4,9

Sample	Individual	Skeletal element**	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	N%	C%	C/N atom	Yield %
M3 dentin collagen								
Iin Hamina (IHA)	CH15_100/56 _I	1	-20,0	12,1	13,98	40,13	3,3	6,4
	CH15 XX	2	-20,1	10,6	13,91	38,77	3,3	3,4
	SH1_5	1	-19,9	11,8	14,19	39,24	3,2	5,3
	CR1_24A*	1	-21,7	11,6	11,61	36,68	3,7	3,2
	CR1_36A	1	-21,4	12,2	13,73	38,20	3,2	4,2
	CR1_59*	2	-21,6	11,5	11,40	37,29	3,8	3,3
	CR1_102/54_165	2	-20,1	12,4	12,65	37,65	3,5	4,2
	CR1_102/54_251	2	-21,6	12,6	14,01	39,88	3,3	6,2
	CR1_288	2	-20,9	11,7	13,13	36,79	3,3	1,5
	CR1_57	2						
	CR1_71	2						
	CR1_102/54_166	2						
	CR1_102/54_177	2						
Oulu (OTK)	P18	1	-20,3	11,7	14,49	39,84	3,2	6,8
	H29	1	-20,8	10,9	14,59	40,26	3,2	5,6
	4860	1	-21,0	11,8	14,27	39,35	3,2	6,7
	049750	1	-20,9	11,5	14,93	41,01	3,2	6,8
	208178	1	-19,5	11,6	14,54	39,97	3,2	3,9
	4710	1	-20,3	12,0	14,42	39,51	3,2	5,1
	2201625	1	-20,8	11,8	14,42	39,57	3,2	5,1
	20042	1	-20,6	11,6	14,43	38,80	3,1	7,5
	20439	1	-20,5	10,6	14,73	39,42	3,1	8,1
	203G20	1	-20,4	12,1	14,50	38,88	3,1	6,6
Rauma (RAU)	12	1	-20,0	12,3	14,03	39,21	3,3	2,0
	122	1	-19,6	12,4	14,14	38,30	3,2	4,7
	123	1	-19,9	11,4	13,68	37,36	3,2	6,2
	124	1	-19,3	12,1	14,75	40,49	3,2	6,7
	150	1	-20,0	11,4	14,35	39,05	3,2	7,9
	151	1	-19,8	11,4	14,46	39,61	3,2	7,5
	166	1	-19,8	11,9	14,16	38,36	3,2	7,2
	193	1	-19,3	11,3	14,34	38,55	3,1	5,8
	196	1	-20,0	11,0	14,50	38,70	3,1	7,0
	197	1	-20,1	12,1	14,25	38,38	3,1	6,0
	200	1	-20,3	10,2	14,93	39,37	3,1	4,5
	202	1	-20,2	10,7	14,50	39,76	3,2	7,2
	208	1	-19,8	11,2	14,14	38,06	3,1	6,3

Sample	Individual	Skeletal element**	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	N%	C%	C/N atom	Yield %
Bone collagen								
Iin Hamina (IHA)	CH15_100/56 _I	1	-19,4	12,1	16,15	44,35	3,2	12,7
	CH15 XX	2	-19,7	11,3	14,76	40,65	3,2	15,1
	SH1_5	1	-19,7	12,3	15,45	42,90	3,2	17,0
	CR1_24A	1	-20,6	11,9	16,60	45,45	3,2	16,5
	CR1_36A	1	-21,1	12,1	16,10	44,40	3,2	15,4
	CR1_59	2	-20,2	12,2	16,25	44,45	3,3	17,8
	CR1_102/54_165	2	-19,9	12,6	16,25	44,50	3,2	18,5
	CR1_102/54_251	2	-21,6	13,2	16,30	44,85	3,2	18,7
	CR1_288	2	-20,9	11,9	15,18	41,90	3,2	16,2
	CR1_57	2	-18,9	13,5	15,20	42,45	3,3	18,2
	CR1_71	2	-19,5	11,9	15,30	42,05	3,2	18,5
	CR1_102/54_166	2	-20,8	11,8	15,70	42,80	3,2	18,8
	CR1_102/54_177	2	-20,3	12,1	15,03	40,50	3,1	3.8
Oulu (OTK)	P18	1	-20,2	12,3	16,20	44,05	3,2	18,7
	H29	1	-20,7	11,5	15,02	41,60	3,2	18,7
	4860	1	-21,0	11,6	15,75	43,05	3,2	18,0
	049750	1	-20,8	11,0	14,94	41,05	3,2	17,8
	208178	1	-19,9	12,0	14,20	38,90	3,2	17,6
	4710	1	-20,1	12,5	16,05	44,15	3,2	17,2
	2201625	1	-20,8	11,9	15,55	43,10	3,2	15,9
	20042	1	-20,6	11,9	14,88	40,70	3,2	17,3
	20439	1	-20,3	11,8	15,45	42,45	3,2	20,2
	203G20	1	-20,5	12,4	15,35	41,75	3,2	17,4
Rauma (RAU)	12	1	-19,6	12,0	15,65	42,75	3,2	16,1
	122	1	-19,4	12,9	15,10	40,85	3,2	7,9
	123	1	-20,0	11,8	15,07	41,20	3,2	3,5
	124	1	-19,2	12,3	14,64	40,35	3,2	5,2
	150	1	-18,8	12,0	15,85	43,30	3,2	11,7
	151	1	-19,7	11,8	15,50	42,30	3,2	12,1
	166	1	-19,7	11,8	16,00	43,40	3,2	12,4
	193	1	-19,6	10,2	15,80	43,40	3,2	19,4
	196	1	-20,0	11,4	16,15	43,80	3,2	17,8
	197	1	-20,0	12,9	15,85	43,30	3,2	18,5
	200	1	-20,4	10,8	14,84	41,40	3,3	5,6
	202	1	-20,1	10,9	15,95	43,85	3,2	14,4
	208	1	-19,9	11,4	15,50	42,40	3,2	13,3

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THE CONSTRUCTION DATE OF THE DOMINICAN CONVENT OF ST OLAF IN TURKU, FINLAND – A RE-EVALUATION

Abstract

The foundation of the medieval Dominican Convent of St Olaf in Turku, South-West Finland, marked the connection of the country to an international network of contacts with the Latin West, and the establishment of taught education in Finland. However, the chronology of its construction has been a subject of scholarly debate since the early 20th century. The archaeological material from the convent is scant, and the only properly datable finds are a sample of timber from the structures and a collection of bricks recovered from the site. In this article we present the results of a wiggle-match dating of the timber, and OSL dating of eight bricks. The bricks were also analysed by pXRF. The building phase of brick masonry seems to date to the second half of the 14th century or around 1400AD.

Keywords: Chronology, Dominicans, Finland, medieval archaeology, monastic architecture, Turku

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INTRODUCTION

The Dominican Convent of St Olaf in Turku, South-West Finland, had a special importance among the medieval monastic institutions in Finland, which had been integrated into the medieval Kingdom of Sweden by the mid-13th century. The convent left a major impression on the cultural and liturgical makeup of the Diocese of Turku, comprising the area of present-day Finland (e.g., Malin 1925: 184; Bonniwell 1945: 205–6; Lehmijoki-Gardner 2004: 240). Moreover, according to Markus Hiekkanen (2002; 2003a; 2003b: 90–1), Dominicans played a crucial role in the foundation of the town of Turku itself, and throughout the Middle Ages they had a considerable impact on its urban life.

Yet, despite the significance of the convent, its physical remains are no longer visible in the urban landscape of Turku, and scholars have failed to determine the exact age of the ruins laying underground. This is partly because of the patchy history of research at the site. The location of the convent was identified at the turn of the 19th and 20th centuries, and since then, the site was explored in a series of poorly documented excavations. In addition, the documented architectural features and archaeological finds saved in museum collections are not easy to date, making the chronology of the convent's ruins difficult to establish.

To break away from the current deadlock, this study will present the results of the scientific analysis of eight bricks and a sample of timber obtained from the convent site. These provide an indication of the age of the brick structures and the possible origins of the building material. The article will also provide a summary of the complex research history of the site and meagre archaeological material available, and set this research in context within the architectural development of the medieval town of Turku, especially regarding the use of brick for urban constructions.

Although the new dates obtained by this study are not unambiguous with regard to their context, they can nevertheless be compared with published scholarly hypotheses on the architectural chronologies of the convent and of the town, in order to assess the likely accuracy of the latter. The findings suggest that the brick structures were erected in the latter part of the 14th century or around 1400, at a time of intensive masonry construction within the urban area.

THE FALL AND REDISCOVERY OF ST OLAF'S CONVENT

The Dominican Convent of St Olaf has been of particular interest to Finnish scholars because so few monastic foundations are known to have existed in the country during the Middle Ages. While 200 monasteries or convents were founded in Scandinavia during the Middle Ages (on the Nordic terminology, see Lovén 2001), only six are known from the Diocese of Turku (Hiekkanen 1993: 123). In addition to the Dominican Convent, which hosted a community of monks, the remainder of these were friaries – modest buildings that served as a base for itinerant preaching by friars. Another Dominican convent, as well as a Franciscan convent, were also established in Viipuri, an important urban centre controlling Sweden's eastern frontier with the Novgorod Republic (Immonen 2019). Two Franciscan friaries also existed in the town of Rauma, on Finland's western coast, and on the island of Kökar, in the Åland Islands. The only actual monastery in the diocese was in Naantali, located c. 15 km north-west from Turku. This belonged to the Bridgettine Order and accommodated both nuns and monks.

The monastic houses of Turku were closed in 1536 as a consequence of the Reformation, with brothers dispersing across the diocese to serve as ordinary parish priests. In 1537, the Convent and the town were damaged by fire, and the friary along with its lands were taken over by the Crown (Leinberg 1890: 79; Ruuth 1909: 108, 122; Nikula 1987: 99; Salminen 2003: 39–40; Gardberg 2005: 67–9). Townspeople began to exploit the Convent's ruins as a source of building materials, and in 1543 King Gustavus Vasa ordered some of the bricks and other architectural elements of the convent to be used in the renovations of the castles of Kastelholm and Turku (Ruuth 1909: 108; Nikula 1987: 99; Hiekkanen 2018: 183).

During the same period, some of the plots of land belonging to the Convent were rented to burghers and ended up in private ownership. These plots were situated on Kaskenmäki Hill, about 100 meters from the present-day bank of the River Aurajoki in a dell formed by the steep slopes of Vartiovuori Hill and Samppalinna Hill. During the Middle Ages, the river served as a major waterway for the region, flowing through the town to meet the Baltic Sea. Due to the landscape's challenging topography, height differences across the site of the Dominican Convent are quite significant (Rinne 1908: 107–8). Nonetheless, following its destruction, the site began to be occupied by new buildings, although the Convent's church and cemetery were initially excluded from construction activities. By 1609, this area had become an herb garden (Ruuth 1909: 116–8; Brusila 2001: 107; Laaksonen & Lahtinen 2011: 26), and the exact location of the Convent was forgotten.

The Great Fire of 1827 destroyed most of the City of Turku. In the following year, a completely renewed urban plan was introduced. During the subsequent years, as the remains of old buildings were torn down and foundations for new ones were excavated, ancient brick walls and graves were found around the city (von Bonsdorff 1894: 43). When human bones and brick structures were discovered on Kaskenkatu Street, at the site of the Dominican Convent, these were assumed to be the remains of the monastic cemetery, although no direct evidence of this was apparent (Brusila 2001: 81, 84; Gardberg 2005: 74).

Despite ancient remains being regularly found and destroyed, building activities during the 19th century and in previous eras was relatively light and did not drastically disturb buried archaeological remains (Ruuth 1909: 122; Gardberg 2005: 72). The situation changed at the turn of the 20th century with the introduction of modern building techniques and the boom of erecting multi-storey buildings. In 1901, excavations for a new stone building at 1 Kaskenkatu Street revealed the ruins of the Dominican Convent. The first archaeologist to investigate was Hjalmar Appelgren (1902). The structures he observed were built exclusively of brick, reaching a height of three meters in the best-preserved areas.

Based on these early observations, archaeologist Juhani Rinne (1908) presented the first reconstruction of the convent's plan in 1908 (see also Ahl 2007). He identified an almost triangular garth and surrounding cloistered ambulatory and proposed the space on the north and north-west side of the north range as the site of the Convent's church (Rinne 1928: 91; 1952: 199–201). During subsequent decades, as more stone buildings were erected in this area, archaeologists and architects documented as much as they could and deposited some of the revealed finds in museum collections, but soil removed during these works was not sifted. In 1909, architect Alex Nyström made a few rough notes and sketches of the brick structures and graves that were uncovered during the construction of a large building at 2 Kaskenkatu Street and in 1927–1928, Rinne monitored the discovery of further ancient structures that emerged when another major building was constructed on the site of 1 Kaskenkatu. This led him to publish a revised reconstruction of the Convent's lay-out in 1928 (Rinne 1928; 1952: 201).

It was not until the 1960s, however, that the first modern archaeological excavations were undertaken at the site of the Convent. These took place mostly on Kaskenkatu Street, the modern road that divides the site into two parts. Even this fieldwork was problematic, however, since no excavation reports were filed. The aim of the excavations seems to have been to reveal and document merely the existence of architectural features. As a result, the fieldwork stopped when the uppermost floor level was uncovered (Kolehmainen 2008: 67–9).

The 1960s excavations nevertheless revealed that Rinne's reconstruction and interpretations needed updating, and a new plan was published in 1986 (Pihlman 1986). Hiekkanen (1993; 2003a; 2003b) would later argue that, based on other medieval Finnish church sites, the Convent's church would have been in the eastern-north-eastern corner of the complex. In the 2010s, a group of archaeologists compiled a new critical plan of the site and presented a revised interpretation of its spatial use (Fig. 1) (Immonen et al. 2014a; 2014b; Immonen 2015; Harjula et al. 2016). Based on the revised architectural plan and on the distribution of fragments of mortar painted with typical ecclesiastical murals, the group concluded that Hiekkanen's idea of the church's location was very likely, whereas the location identified by Rinne for the church does not seem to have been occupied by a roofed building at all: the walls surrounding it are too irregular to have been a covered space, and no signs of flooring have been documented there. In addition, the group concluded that the vaulted room with two pillars underneath Kaskenkatu Street seemed to have been the chapterhouse. The plan of the convent complex could therefore be reconstructed satisfactorily, but the age of the buildings still remained an unresolved issue.

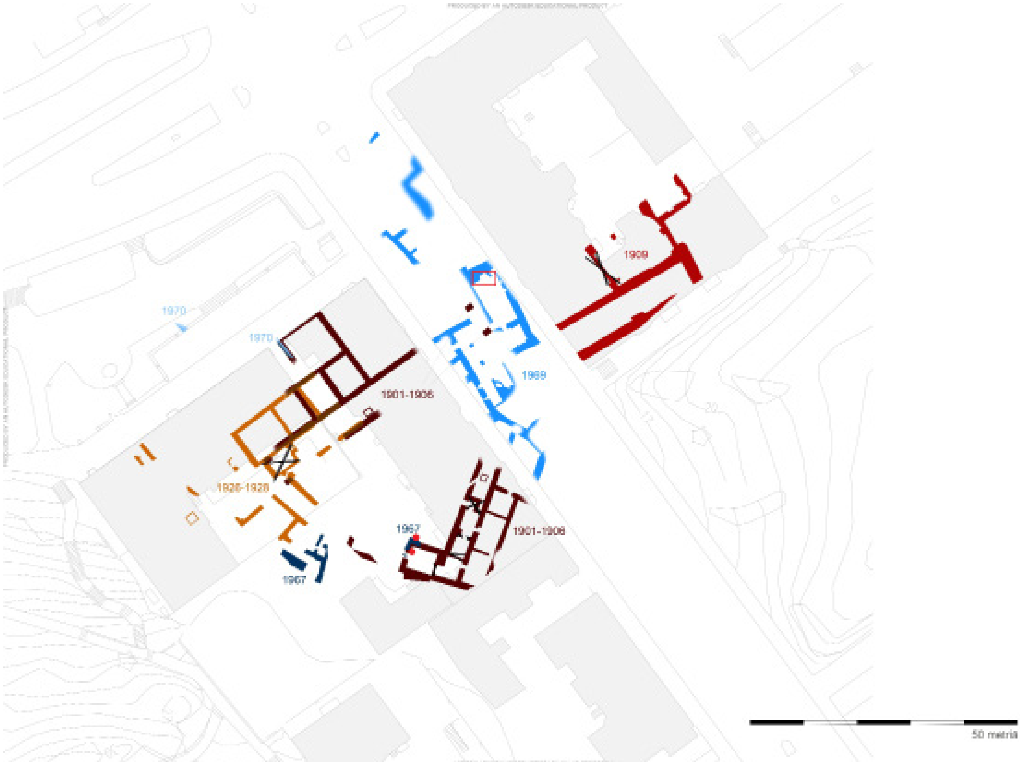


Figure 1. Plan of the Dominican Convent of St. Olaf based on archaeological documentation. Red dots indicate the location of bricks ID 1–2. The rest of the ceramic objects sampled were found underneath Kaskenkatu Street in 1969. Rectangular red box in the street area indicates the location of the dated timber. Plan by Panu Savolainen, modified by Tanja Ratilainen.

THE PROBLEM OF AGE

According to the Annals of the Dominican convent of Sigtuna, the Dominicans arrived in Finland in 1249 (DF 98; Maliniemi 1947: 87–8). This passage has been used to support the equation of the first Dominican convent with the structures identified archaeologically on Kaskenmäki Hill (Salminen 2003: 38). Based on archaeological excavations made during the last three decades, however, it has become apparent that, in the latter part of the 13th century, the site of the later medieval town was rural in character, with Turku itself not founded until around 1300 (Hiekkanen 2001: 627; 2002: 157–8; 2003a: 42–8; Pihlman 2007; Seppänen 2009: 242–3; Pihlman 2010; Seppänen 2011; 2012: 941; Pihlman et al. 2022). When the convent was established in 1249, therefore, the town of Turku did not yet exist. This is problematic considering that Dominicans usually founded their convents in urban areas. Perhaps the first convent lay somewhere other than in the location later identified as its site.

The most likely site for the foundation of the first convent is the fortified site of Koroinen, situated two kilometres up the River Aura from the site of the later Dominican Convent of Turku. Archaeology has confirmed that Koroinen was once the site of a 13th-century cathedral and two secular buildings that formed the bishop's residence (Harjula et al. 2018). In around 1300, the cathedral was moved to its present location within Turku. Problematically, however, no structures or finds from Koroinen indicate the existence of a Dominican convent there.

In addition to the possible transfer of the Dominican convent from elsewhere to its present location, another issue that has puzzled scholars is the dating of the architectural features on

Kaskenmäki Hill. The structures excavated there are made of brick, but earlier buildings at the site may have been constructed of other materials. The surviving literary sources do not record the material of the friary's first buildings (DF 259; 466), and it may well be that these were constructed of wood and only later rebuilt using more durable materials (Hiekkanen 2003b: 92; Gardberg 2005: 48, 52). However, there is a written record that the town along with the Convent burned down in 1429, and in 1431 the master mason Simon of Tallinn directed some construction work at the Convent (DF 1901, 1902, 1910, 1917, 1977, 2005; Ruuth 1909: 107–8; Kuujo 1981: 180). Hiekkanen (1993: 128; 2003b: 92; 2018: 182) suggests that the architectural features documented during the 20th century are probably from this period, while Liisa Seppänen (2012: 647–9, 668) argues that they may be even earlier, since the first masonry structures appear in Turku in the first half of the 14th century (Ratilainen 2010; 2020).

To date, four separate hypotheses have been proposed regarding the age of the remains of the Dominican Convent on Kaskenmäki Hill:

1. The first convent was constructed of wood at the same site, and later rebuilt in brick.

2. The brick structures found at the site were erected before Turku was founded around 1300.

3. The brick structures were erected after 1300 but before Convent's destruction by fire in 1429.

4. The brick structures were constructed after the 1429 fire.

These four hypotheses do not entirely exclude one another, and do not represent the only scenarios possible. However, they provide a framework against which to evaluate archaeological and written sources and the results of scientific analyses. These hypotheses will now be assessed, in light of (1) a brief examination of other archaeological evidence from the site, and (2) the results of the modern scientific analyses.

Hypothesis 1 (as listed above) is quite difficult to evaluate, but there are indeed faint signs of a building phase prior to the masonry structures on Kaskenmäki Hill. Firstly, a deposit of burned wood was discovered near a pillar inside the building identified as the Convent's church in 1909 (Kolehmainen 2008: 52). This deposit rests directly on the bedrock but beneath a demolition layer containing pieces of bricks. Secondly, in the excavations of 1967 across Kaskenmäki Street, in the western or north-western corner of the cloister ambulatory, a layer of clay coloured by organic matter was discovered in two places. The layer was 2–8 cm in thickness and sandwiched between natural clay and a demolition layer with brick fragments (Kolehmainen 2008: 62, 66). No calendar date has yet been obtained for this organic layer and that will not be possible before new excavations in future, but it remains a feasible, though insecure, indication of an initial phase of building that used wood.

The Convent's brick architecture is also rather challenging to date stylistically, partly because the features documented are quite generic and partly because some post-medieval building activities took place even after the Convent was dissolved (Appelgren 1902: 57; Rinne 1908: 110, 122–34; 1928: 91; Hiekkanen 2003b: 92 note 28). The use of Monk bond in the brickwork (consisting of a consecutive pattern of brick header and two stretchers) is a medieval feature (Rinne 1908; Gardberg 1957: 33, 63; Brusila 2001: 100–1; Hiekkanen 1994: 214–5; Kolehmainen 2008), while the use of dovetail notches in some of the documented timber structures could be dated to the 15th century at the earliest (Rinne 1908: 126, Figs. 14, 131; Seppänen 2012: 636).

Any further architectural dating remains dubious, while archaeological finds are of limited use given the small number of datable objects recovered. Two coin hoards have been discovered at the site, with the *terminus post quem* date of one being 1558 (Brusila 2001: 91), and of the other being the 1450s (Talvio 2011: 161). In addition to the miniature stoneware jug in which the latter hoard was deposited, only two pieces of medieval pottery are known from the site (Pihlman 1995: 348; pers.comm. 2012). A few other late medieval and early modern finds survive (Immonen et al. 2014b: 14–6), but nothing appears older than the 15th century. This challenging age profile is probably due to coarse fieldwork practices and to the buildings' long history of use after the convent ceased to function. A more accurate dating of the architecture would require either new archaeological finds or the application of modern scientific analyses to extract information from the existing material (see, e.g., Atlıhan et al. 2018; Gueli et al. 2018). The latter option involves the dating and analysis of bricks and wood from the site.

In the following, we will first describe the sampling and analysis of brick samples and a timber post from the Convent site. After that we will proceed to the optically stimulated luminescence dating of the samples, and the wiggle-match dating of a timber post. Combining the datings of the bricks and the timber provide a basis to argue that hypothesis 3 is the most likely chronology for the masonry structures at the Convent site.

THE MATERIALS AND THEIR TREATMENT

The most abundantly available material for scientific dating from the Convent site is comprised by bricks. Eight pieces of masonry out of 113 (TMC 16768) collected from the convent site were selected for further dating and material analysis. The selection criteria were as follows:

1. The bricks were already broken so that it was not necessary to sample intact objects;

2. The shape of the bricks, and thus their function, had to be easily identifiable;

3. The bricks sampled were not block-shaped, but moulded, and thus more likely to have belonged to the medieval Convent than the more easily recyclable, block-shaped wall bricks.

Following these criteria, we selected six bricks (ID 1–6), a floor tile (ID 7) and a curved roof tile with a notch (ID 8). Three of the bricks were rib bricks used in vaulting (ID 1–2, 5), three were round-moulded bricks (ID 3–4) and one was a concave moulded brick usually applied in window jambs and portals (ID 6). All these were found in the late 1960s excavations and deposited in the collections of the Turku Museum Centre. Some of their find locations were roughly documented, but no precise context information was recorded for any of them. Since no excavation reports are available, we had to resort to the information provided by the find catalogues, which gave the find location of two bricks with some accuracy. Although the context data is highly problematic, there is still more information on these items than on the material excavated earlier.

The first of the bricks (ID 1) was discovered in 1967 within a building waste layer inside a test pit dug north of a wall in the inner courtyard of the building at 1 Kaskenkatu Street. The brick was recovered at a depth of 50 cm from the top of a medieval wall. The second brick (ID 2) was found on the other side of the same wall, inside a room, within a 70-cm thick archaeological layer. The brick was found 20 cm above the clay layer lying beneath this. The rest of the ceramic objects sampled were found underneath Kaskenkatu Street in 1969. Despite the limited information available, it seems very likely that also these bricks and tiles were discovered loose in layers of building waste, and not extracted from standing structures. Moreover, the type of floor (evidenced by ID 7) and roof tiles (evidenced by ID 8) found are typical of the medieval period (cf. Antell 1986: 29; Seppänen 2012: 698–9), supporting the conclusion that these formed part of structures belonging to the Dominican Convent.

Samples for OSL dating were extracted from the bricks and tiles in accordance with the instructions by the Laboratory of Chronology at the Finnish Museum of Natural History. To avoid contamination from exposure to light, the original surfaces were scraped away. Before sampling, the bricks and tiles were also photographed. Samples were removed using a water-colled diamond blade and separated with a hammer and chisel. The preferred size for samples was 4 cm x 4 cm x 4 cm. After samples for OSL dating had been removed from the selected ceramic objects, a study of their composition was undertaken. For each ceramic, a freshly cut and cleaned surface was examined under a stereo microscope (Table 1).

In tiles ID 1–7, temper was found to be composed mainly of light coloured and sharp-edged mineral fragments and few rock fragments under 1 mm in diameter size. The amount of the temper

Table 1. The features of the sampled ceramics and the results of stereo microscope examination. Hbl = hornblende, Mca = mica, Or = orthoclase/potash feldspar, Pl = plagioclase, Qz = quartz (Siivola & Schmid 2007).

Id	Sample (TMC inv. no.)	Description	Measured brick size (cm)	Brick colour	Temper particle form	Temper minerals/rocks
1	16768:29	vault rib brick	(21) x 15 x 7.5–8	dark red	sharp crushed fragm. + rounded sand	Pl, Qtz, Or, Mca, carbon inclusions
2	16768:30	vault rib brick	(20.5) x (14.5) x 8	orange	sharp crushed fragm. + rounded sand	Qtz, Pl, Or
3	16920:62	profiled brick	thickness 13.5, round part ø 6.5	orange	sharp crushed fragm. + rounded sand	Qtz, Pl
4	16920:64	profiled brick	thickness 13.5, round part ø 6.5	orange	sharp crushed fragm.	Qtz, Pl
5	16920:78	vault rib brick	(14.5) x 11.5 x (6.0)	orange	sharp crushed fragm.	Qtz, Pl, Mca, rock frag. granodiorite
6	16920:92	moulded brick	(18) x 12 x 8.5	orange	sharp crushed fragm.	Qtz, Or, Mca, Hbl
7	16920:131	floor brick	21.5 x 21.5 x 7	orange	sharp crushed fragm.	Qtz, Pl, Mca, rock frag. granite
8	16920:132	roof brick/tile	12.5 x 11.5 x 6.6, tile thickness 2–3	orange	sharp crushed fragm. + rounded sand	tiny Qtz and Pl, tiny carbon inclusions

was estimated to be 10–15%. The main mineral fragments were quartz and plagioclase, with the remainder composed of potassium feldspar and dark mafic minerals, mostly mica and hornblende. The rock fragments, meanwhile, consisted of all the above minerals in approximately equal proportions, and can thus be identified as leucocratic granite or granodiorite. This, in addition to the results of a pXRF-analysis strongly suggested that temper consisted of crushed granite or granodiorite (see Appendix 1). This type of rock exists in Finland, Sweden, and parts of southern Norway. To a minor extent, rounded sand grains, mainly quartz, were also observed in bricks ID 1, 2, 3, and 8. There were no sharp granitic mineral fragments in the roof tile (ID 8). Instead, traces of organic material were detected as dark carbon inclusions.

A macroscopic inspection of the bricks and tiles revealed mortar remains on all their original surfaces, except for one rib brick (ID 2). The colour of their firing was mostly a reddish orange, but in one case was dark red (ID 1). The mixture of the bricks' ceramic material appeared to be well-fired, and the consistency appeared solid and compound, except for the fragile floor tile (ID 7). No additives, such as fragments of burnt bone or charcoal, were present, but traces of an iron spike, used to attach a cutting board to the surface of the brick, were detected on two round-moulded bricks (ID 3–4) and one of the rib bricks (ID 5). Consequently, we concluded that two kinds of techniques, based on a cutting board and moulds, were used in shaping the bricks. No traces of glazing or severe fire were detected.

In addition, a wood sample for radiocarbon dating was obtained from the area of the Convent. This was extracted from a timber 'located next to a stone basis of a room adjacent to 2 Kaskenkatu Street, facing the Aura River' in 1969 (TMC 16920:150). The room, situated between the church and the chapterhouse, had a large window in its north-east wall (see Fig. 1). It has been identified either as a passage between the church and the convent area (Immonen et al. 2014) or as a kitchen and washing room (Stenlund 2010: 64). However, since no hearth was found, the interpretation of the room as a passage seems more plausible.

Material from this wood sample was sent to two separate dendrochronological laboratories, and they both independently concluded that the wood was too deformed for a proper dendrochronological analysis (Zetterberg 2015; Daly 2017). Consequently, the only possibility for dating the timber was a Carbon-14 wiggle-match dating (WMD) based on a series of radiocarbon dates. This analysis was conducted at the Laboratory of Chronology, University of Helsinki (following a procedure described in Uusitalo et al. 2018; see also Oinonen et al. 2013).

Optically stimulated luminescence dating of the sampled bricks

Samples from the eight ceramics in this study were dated by OSL at the Laboratory of Chronology at the Finnish Museum of Natural History, University of Helsinki (Oinonen & Eskola 2016). The analyses were made on coarse (150–300μm) quartz grains using the SAR protocol (Murray & Wintle 2000) with 260°C preheat temperature. Outer layers of the quartz grains were etched with hydrofluoric and hydrochloric acid treatments to consider the alpha radiation component to be unessential (cf. Liritzis et al. 2013). Beta radiation dose rates were measured with a Risø GM-25-5 beta multicounter from crushed brick samples. The beta count rates were converted to beta dose rates based on a linear relationship obtained from beta count rate measurements of known activities. Since it was not possible to measure gamma radiation dose rate at site, the rate was estimated based on measurements of dose rate ratios of beta and gamma radiation on reference samples collected by the laboratory and following the approach of Ankjærgaard and Murray (2007). For all the samples a luminescence light distribution was measured and thus a paleodose could be defined (Fig. 2). Eventually, OSL ages were deduced as a ratio of paleodose to total dose rate (Table 2). The uncertainties of the dose rate determinations, including reference measurement-based beta and gamma dose-rate ratio, and paleodose measurements were included in OSL ages through law of error propagation. Eventually, the uncertainties on a 1σ level were ranging from 13–18% thus being fairly conservative largely due to estimated c. 10–12% uncertainties within dose rate determinations.

Moisture content (Zimmermann 1971; Aitken 1985) is an essential feature in determining the OSL age uncertainty (Bailiff 2007) due to absorption of radiation by water. Based on site location 100m uphill from the River Aura, the assumed history of brick samples consisted of their presence in the Convent's structure and an over 100-year storage time after excavations, and thus the average water content of bricks was estimated to be small. Particularly, we adopted a saturation water content W=0.12 of a wet masonry wall (Hoła et al. 2017) and fractional water uptake F=0.25 to characterize fairly dry conditions with c. 3% mass moisture content. Potential increase of water content decreases the dose rate due to absorption and thus increases the age estimates. As a sensitivity analysis, change of F ranging from 0.25 to 0.8 (neglecting water absorption during >100 years of storage time) yielded to a c. 50-year increase in age, still within the conservative uncertainty estimates.

Sample	Laboratory Code	Palaeodose (Gy)	Age a, round	(+/-) a, round	1σ (calAD)	2σ (calAD)
Turku 2015 16768:29	Hel-TL04303	3.18±0.30	650	100	1293–1476	1205–1565
Turku 2015 16768:30	Hel-TL04304	3.00±0.13	560	70	1403–1546	1335–1615
Turku 2015 16920:62	Hel-TL04305	3.48±0.39	620	100	1313–1517	1215–1615
Turku 2015 16920:64	Hel-TL04306	3.47±0.25	690	90	1263–1446	1175–1535
Turku 2015 16920:78	Hel-TL04307	3.37±0.15	620	80	1333–1496	1255–1575
Turku 2015 16920:92	Hel-TL04308	3.60±0.33	670	100	1263–1467	1165–1586
Turku 2015 16920:131	Hel-TL04309	3.29±0.20	690	100	1253–1436	1165–1525
Turku 2015 16920:132	Hel-TL04310	2.35±0.32	450	90	1493–1656	1415–1735

Table 2. The eight OSL dates from the Dominican Convent in Turku.

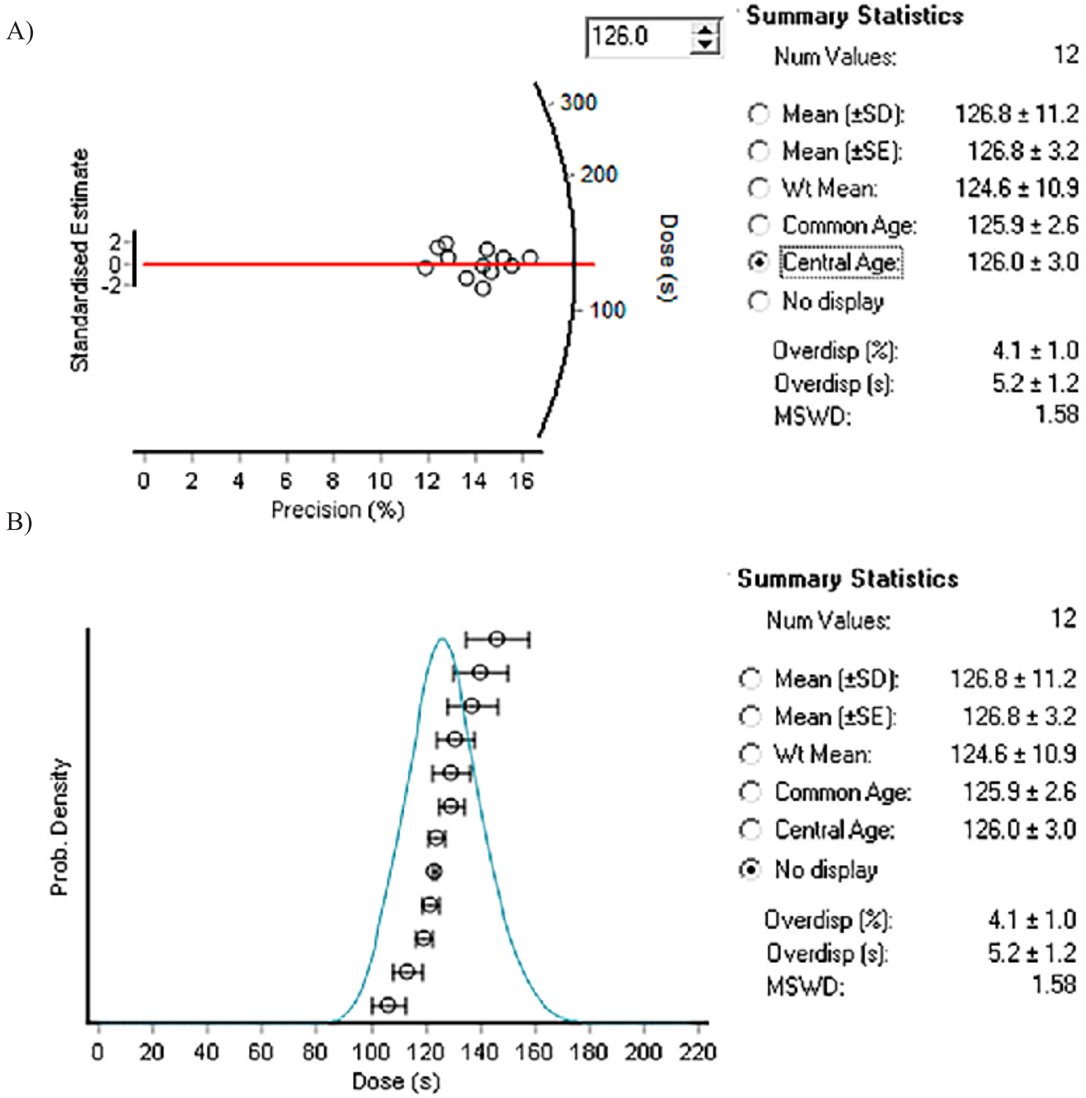


Figure 2. An example of a a) growth curve and b) equivalent dose determination for an OSL measurement (sample 16920:92, Hel-TL04308). The figures are an output of the analysis with the Analyst software (Duller 2007).

Moreover, since SAR protocol was adopted for the OSL measurements, it intrinsically involved quality criteria for recycling ratio limit (<10%), maximum test dose error (<10%) and maximum palaeodose error (<20%). For instance, results for ID 2 and ID 8 include only four successful measurements of aliquots, since half of them were rejected due to exceeding of the recycling error limit of 10%, meaning that the first and last test doses were differing more than 10%. The small number of aliquots is intrinsically taken into account within the statistical uncertainty estimate.

Although the OxCal software (Bronk Ramsey 2021) is typically used for radiocarbon date calibrations, we adopted it to present OSL dates consistently as calendar years. Results for the eight sampled ceramics, with probability ranges of 68.2% and 95.4%, are presented in Table 2. We also made a combined modelling of the dating results with OxCal. Since the OSL results of the samples ID 2 and ID 8 were based only on four light measurements and clearly younger than other results, they were excluded from the model. In OxCal, the *terminus post quem* date was set to 1249, when the Dominican Order arrived in Finland (DF 98), which can be considered as the earliest possible time for building the convent. The *terminus ante quem* date was set to the Great Fire of 1827. The combined model of the five bricks and the floor tile resulted in a probability range of 1329–1404 AD.

The evaluation of the OSL dating results is complicated for four main reasons. Firstly, the original samples were not taken directly from the brick structures identified with the Dominican Convent (Fig. 3), and only for two ceramics has a precise find location recorded. Secondly, if masonry elements, such as bricks, are found in building waste within an urban area, these do not necessarily derive from the closest standing structure to them but may originate from elsewhere. Thirdly, the wide margins of the calibrated OSL dates obtained from the ceramics analysed in this study are problematic. This is particularly significant in the case of Turku's Dominican Convent, because radiation data could not be obtained on site. However, this difficulty can be addressed to some degree through the combined modelling of the dating results, acknowledging the limitations imposed by imprecise contextual data. Fourthly, we must take into account that the dating results might indicate either the time of the firing of the bricks, or some later fire to which the bricks were subjected.

This fourth problem can be resolved by extracting further information from the bricks and the dating procedure. There were no indications of severe damage by fire on the surfaces of the sampled bricks. Moreover, the OSL light distribution curves for several measurements were narrow, and deviations from these results were estimated to be caused mainly by contamination from the brick surface or local variations in the background radiation. Consequently, the dating results seem to indicate the time when the bricks were produced, not some later fire.

When considering individual dating results, the curved roof tile (ID 8) appears to be clearly younger than all the other objects sampled. It was produced in the late medieval period, or, more likely, in the early modern period. This finding is interesting, considering the production and use of curved roof tiles. Traditionally these are expected to date to the Middle Ages, or at least to the period before the 17th century (e.g., Antell 1986: 10–1, 29; Andersson & Hildebrand 2002: 198). The dating result is based on only four measurements of light, but, on the other hand, they provide a high-quality luminescence signal. Except for this sample, all the other samples seem to date to the Middle Ages with the probability of 68.2%.

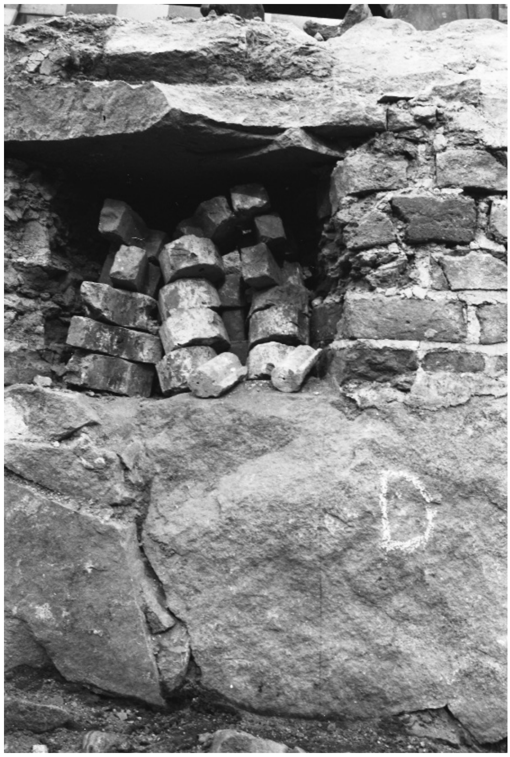


Figure 3. Bricks stacked in a niche revealed underneath Kaskenkatu Street in 1969. (Photo by Per-Olof Welin/Turku Museum Centre.)

If we assume that the two similar rib bricks (ID 1–2) and two similar round-moulded bricks (ID 3–4) originated from the same structures, the former pair from the vaults, and the latter pair from a portal, for instance, their dating results should be similar, if they came from the same production batch. However, this does not seem to be the case as their dating results differ

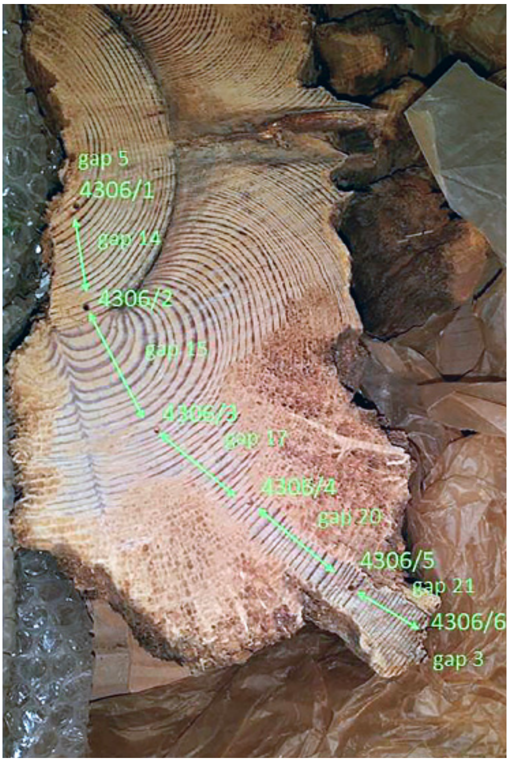


Figure 4. Altogether six wood samples were extracted from the timber post and radiocarbon dated. (Photo by Markku Oinonen.)

considerably: ID 1 is much older than ID 2, and ID 4 is older than ID 3. These conclusions are supported by the pXRF analysis results.

The OSL datings of the ceramics in this study are best summarised using by a combined model that groups the five bricks and a floor tile, resulting in a probable date range of 1329–1404 AD. This suggests that construction of the masonry remains of Turku's Dominican Convent began during the last three quarters of the 14th century. In contrast, the two youngest samples from the rib brick (ID 2) and roof tile (ID 8) may relate to post-medieval building activities in the area.

Wiggle-match dating of the wooden post from the foundations of a brick wall

Altogether six wood samples were extracted from the timber post and radiocarbon dated (Fig. 4, Table 3). The wiggle-match was initiated with these six dates and an agreement index (A-index) values provided by OxCal (Bronk Ramsey 2017), after which the most unlikely dates were removed until three radiocarbon dates were left. The A-index value describes the differences between individual dates and the results given by the model. The higher the A-index value, the larger is the overlap and thus the better the model, since it does not change the original dating result too much.

The model based on six radiocarbon dates gives an A-index value smaller than the required threshold value (A=18.5% vs. An=28.9%), which is unsatisfactory. The reason is the deviation of dates 2 and 3 from the model. Although A-index-based limitations do not affect results considerably, we adopted a model with 5 dates that provided a high-enough A-index value (A=38.5% vs. An=31.6%) by excluding date 2 (Hela-4306/2). Eventually, based on the data at hand, the model with 5 dates provides a result of 1310±10calAD, which is the date of the youngest annual ring on the sample.

The WMD was based on a dendrochronological measuring line (A) with c. 95±10 annual rings of reddish heartwood, but another measuring line (B) provides c. 135 annual rings plus two destroyed rings (Pentti Zetterberg, pers. comm. 2019). Consequently, there has been at least 42+2 annual rings in the sapwood, and thus the actual youngest annual ring dates to c. 1350AD, which is the *terminus post quem* for the wood. This suggests that the timber was laid in the foundations in the latter part of the 14th century, which overlaps with the OSL datings of the sampled bricks.

DISCUSSION ON THE CONVENT'S CONSTRUCTION CHRONOLOGY

Because the archaeological documentation and finds from the Convent are scanty and problematic, using the material to create a chronology for the discovered structures is a rather complex and demanding exercise. The interpretation of these new scientific dates is therefore a balancing act between different probabilities. The significance of the dating results will now be summarized in relation to the four hypotheses presented earlier, followed by the presentation of an approximate dating of the Convent's masonry structures, which will be compared with

Table 3. The six AMS dates of the timber sample (TMC16920:150) from the Dominican Convent in Turku.

Lab. Code	Sample	Radiocarbon date (BP)
Hela-4306/1	Annual ring 5	761±28
Hela-4306/2	Annual ring 19	721±36
Hela-4306/3	Annual ring 34	877±42
Hela-4306/4	Annual ring 51	754±45
Hela-4306/5	Annual ring 71	704±48
Hela-4306/6	Annual ring 92	702±46

the current chronology of urban architecture in Turku, based on existing evidence.

Hypothesis 1 conjectured that the Convent was initially built of wood, with brick only used in later phases of construction. At this stage, this hypothesis cannot be rejected or accepted. As a result, it is not possible to evaluate hypotheses regarding the existence and dating of the first building phase. Instead, one must focus exclusively on the dating of the brick structures surviving from the site.

OSL analysis of eight ceramic masonry elements from the 1960s excavations produces a wide range of dates. However, the modelling of these suggests that the majority belongs to the probability range of 1329–1404 AD. The chronology suggested by OSL dating is supported by the WMD of the timber sample to the *terminus post quem* of c. 1350 AD. It seems that the Convent's brick walls were constructed in the latter part of the 14th century or around 1400 AD. Since the sampled bricks and the timber are from different parts of the Convent, we can assume that the new chronology is relevant for the whole complex. This conclusion is supported by the pXRF analyses which reveal that, except for one roof tile, the sampled ceramics originated from the same local or Swedish source. The brick material is quite homogenous.

In the Turku region, the earliest masonry architecture is from Koroinen, where the first structures of brick and stone were erected in the second half of the 13th century or early 14th century (Ratilainen 2016; Ratilainen et al. 2017; 2021). As Ratilainen (2018: 90–121; 2020) points out, these are among the first masonry structures in mainland Finland. The oldest known evidence of masonry architecture in Turku date to the 14th century. Bricks used in the door jambs of the sacristy of Turku Cathedral date to the first half of the 14th century. Construction of the cathedral in stone began probably in the latter part of the 14th century, and the cathedral was completed in brick by 1425 (Drake 2003a: 137–8; 2003b: 86–8; 2005: 483–4; 2006: 242–3).

In urban secular buildings, hearths and ovens were made of brick in the earlier part of the 14th century (Ratilainen 2014), and a possible gate house was built of brick near the cathedral after the mid-14th century (Ratilainen 2010: 41–3). The Town Hall of Turku was built in the early 14th century, but brick was not used until its second building phase, which is dated to 1350–1430 (Uotila 1991: 132–8; 2002: 8–10; 2003: 125). The oldest town houses with proper brick features, like vaults and niches, date to the last decade of the 14th century (Saloranta & Seppänen 2002; Uotila 2003: 128; 2006: 352–3; 2007: 25; Ratilainen 2010: 43–4). In sum, the use of brick in Turku began in the earlier part of the 14th century, but architectural features of brick became common in public buildings only after the mid-14th century, and in private buildings only at the very end of the 14th century.

CONCLUSIONS

In all, of the four hypotheses outlined above, the hypothesis that the Dominican Convent's brick masonry predates the town of Turku and the hypothesis that it dates to after the 1429 fire both appear to be false, whereas the hypothesis that the Convent complex was built between 1300 and 1429 seems correct. In fact, scientific dating suggests that the structures were erected in the latter part of the 14th century or around 1400 AD. This chronology corresponds well with the development of brick architecture in Turku since it is known that masonry structures were constructed intensively in the town during the same period.

Since the available archaeological finds from the Convent have been searched thoroughly for datable material, and the documentation of previous fieldworks remains scant, the material that survives will probably not provide any surprises in future. Dating more bricks scientifically might help narrow and stabilise the results acquired so far but making further analyses from this problematic material is not economical in terms of its input-output ratio. Therefore, the most effective line of inquiry is to gather new archaeological material from the site. The excavations in the 1960s along the Kaskenkatu Street were halted when the first structures were revealed after which they were covered over and left under the street surface. In addition, some parts of the Convent might still be intact in the easternmost corner of the complex up on the hill, or in the strip of land between the known structures and the River Aura. These three areas are the most likely to reveal material relevant for dating the convent's buildings. In the meantime, however, the present study provides best chronological framework available.

REFERENCES

Personal communications

Pihlman, A., archaeologist, personal communication to Tanja Ratilainen, 4 September 2012.

Zetterberg, P., dendrochronologist, e-mail to Visa Immonen, 18 March 2019.

Unpublished sources

Daly, A. 2017. Dendrochronological analysis of a timber from the Dominican convent in Turku, Finland. Dendro.dk Report 69: 2017.

Kolehmainen, H.-L. 2008. Turun Pyhän Olavin dominikaanikonventti: Asiakirja-aineisto ja arkeologiset lähteet. Unpublished MA dissertation, Department of Archaeology, University of Turku.

Oinonen, M. & Eskola, K. O. 2016. Pyhän Olavin Konventti 2016: Ajoitustuloksia/ Luminesenssi. Dating report, Finnish Museum of Natural History, Helsinki.

Pihlman, A. 1995. Keskiaikaiset savi- ja puuastiat Turun kaupungissa ja Turun linnassa. Unpublished Licentiate thesis, Archaeology, University of Turku.

Saloranta, E. & Seppänen, L. 2002. Kaupunkiarkeologiset kaivaukset, Turku, Rettiginrinne, Hämeenkatu 24–26. Excavation report, Turku Museum Centre, Turku.

Stenlund, P. 2010. Dominikankonventets byggnader i Åbo under medeltiden. Unpublished MA dissertation, Church History, Åbo Akademi University.

TMC. The Inventory of Archaeological Finds. Turku Museum Center.

Uotila, K. 1991. Turun raatihuoneen rakennushistoria keskiajalta vuoteen 1734. Unpublished Licentiate thesis, Finnish history, University of Turku.

Zetterberg, P. 2015. Turun dominikaanikonventin puulöydön TMM 16920 dendrokronologinen tutkimus, näytteet F1T2201A ja F1T2201B. Itä-Suomen yliopisto Joensuu, Luonnontieteiden ja Metsätieteiden tiedekunta, Metsätieteiden osasto, Dendrokronologian laboratorion ajoitusseloste 413: 1–3.

Literature

Ahl, E. 2007. Kloster och konvent i Finland under medeltiden: Dominikanerna. *Arkeologia NYT!* 1/2007: 5–10.

Aitken, M. J. 1985. *Thermoluminescence dating.* London: Academic Press.

Atlıhan, M. A., Koralay, T. & Sahiner, E. 2018. Luminescence dating and mineralogical investigations of bricks from Erikli basilica in Stratonikeia ancient city (SW Turkey). *Mediterranean Archaeology and Archaeometry* 18(1): 77–91. 10.5281/zenodo.1069527.

Andersson, K. & Hildebrand, K. 2002. *Byggnadsarkeologisk undersökning: Det murade huset.* 2nd edition. Stockholm: Riksantikvarieämbetet.

Ankjærgaard, C. & Murray, A. S. 2007. Total beta and gamma dose rates in trapped charge dating based on beta counting. *Radiation Measurement*s 42: 352–9.

Antell, O. 1986. *Taktegel – Tegeltak.* Stockholm: Byggforskningsrådet & Riksantikvarieämbetet.

Appelgren, H. 1902. Det underjordiska Åbo. *Finskt Museum* 1901: 49–65.

Autere, E. 1976. Tutkimus Suomessa käytettävistä kvartsihiekoista. Helsinki: Geologian tutkimuskeskus. <https://tupa.gtk.fi/raportti/arkisto/p13_5_2_014.pdf> Accessed 29 July 2020.

Bailiff, I. K. 2007. Methodological developments in the luminescence dating of brick from English Late-Medieval and Post-Medieval buildings. *Archaeometry* 49: 827–51.

Bezur, A., Lee, L., Loubser, M. & Trentelman, K. 2020. *Handheld XRF in Cultural Heritage:*

A Practical Workbook for Conservators. Los Angeles: The Getty Conservation Institute.
Bonniwell, W. R. 1945. *A History of the Dominican Liturgy 1215–1945.* 2nd edition. Joseph F. Wagner: New York.
von Bonsdorff, C. 1894. *Åbo stads historia under sjuttonde seklet:* Första bandet. Åbo: Åbo stad.
Borgström, L. H. 1924. Suomen kvartsihiekka. Helsinki: Suomen geologinen komissioni. <https://tupa.gtk.fi/julkaisu/geoteknillinen/gt_s_023.pdf> Accessed 29 July 2020.
Bronk Ramsey, C. 2017. Methods for summarizing radiocarbon datasets. *Radiocarbon* 59(2): 1809–1833.
Bronk Ramsey C. 2021. Oxcal v4.4.4. <https://c14.arch.ox.ac.uk/oxcal/OxCal.html> Accessed 3 April 2022.
Brusila, H. 2001. Pyhän Olavin dominikaaniluostarin raunioista. In H. Soiri-Snellman & H. Brusila (eds.) *Kaskenlinna: Asunto Oy Kaskenlinnan rakennushistoria ja Pyhän Olavin luostarin raunio*t: 79–111. Turku: Turun maakuntamuseo.
Cuomo di Caprio, N. 2017. C*eramics in Archaeology: From Prehistoric to Medieval Times in Europe and the Mediterranean: Ancient Craftsmanship and Modern Laboratory Techniques*. Rome: L'Erma di Bretschneider.
DF. Diplomatarium Fennicum. <http://df.narc.fi/> Accessed 17 March 2020.
Drake, K. 2003a. Åbo domkyrka och byggnadsarkeologin. In L. Seppänen (ed.) *Kaupunkia pintaa syvemmältä: Arkeologisia näkökulmia Turun historiaan*: 135–52. Turku: TS-Yhtymä & Suomen keskiajan arkeologian seura.
Drake, K. 2003b. Åbo domkyrkas äldre byggnadshistoria. *Taidehistoriallisia tutkimuksia – Konsthistoriska studier* 27: 83–2.
Drake, K. 2005. Der Dom zu Turku/Åbo. *Kunsthistorische Arbeiter der Kulturstiftung der deutschen Vertriebenen*: Band 4: 480–90.
Drake, K. 2006. Åbo domkyrkas första murade sakristia. *Hikuin* 33: 239–48.
Duller, G. 2007. Assessing the error on equivalent dose estimates derived from single aliquot regenerative dose measurements. *Ancient TL* 25: 15–24.
Gardberg, C. J. 1957. *Med murslev och timmerbila: Drag ur det finländska byggnadshantverkets historia.* Helsingfors: Svenska byggmästareföreningens i Helsingfors.
Gardberg, C. J. 2005. *Veritas – Sanningen! Dominikanerna i Åbo under medeltiden.* Esbo: Schildt.
Gueli, A., Garro, V., Pasquale, S. & Stella, G. 2018. Chronology of the crypt of Sant'Agata la Vetere in Catania obtained by thermoluminescence. *Mediterranean Archaeology and Archaeometry* 18(1): 27–35.
Harjula, J., Hukantaival, S., Immonen, V., Salonen, K. & Ratilainen, T. (eds.) 2018. *Koroinen: Suomen ensimmäinen kirkollinen keskus*. Turku: Turun Historiallinen Yhdistys.
Harjula, J., Immonen, V. & Savolainen, P. 2016. Voimatekijästä unohdetuksi raunioksi – Turun dominikaanikonventti. In M. Heinonen & M. Räsänen (eds.) *Pohjoinen reformaatio*: 281–98. Turku: TUCEMEMS.
Hiekkanen, M. 1993. De finska klostren under medeltiden: Arkeologiskt och byggnadshistoriskt perspektiv. *Hikuin* 20: 123–54.
Hiekkanen, M. 1994. *The Stone Churches of the Medieval Diocese of Turku: A Systematic Classification and Chronology.* Helsinki: Suomen Muinaismuistoyhdistys.
Hiekkanen, M. 2001. Domestic building remains in Turku, Finland. In M. Gläser (ed.) *Lübecker Kolloquium zur Stadtarchäologie im Hanseraum III: Der Hausbau*: 627–33. Lübeck: Schmidt-Römhild.
Hiekkanen, M. 2002. Die Gründung der Stadt Turku. In Ē. Mugurēvičs & I. Ose (eds.) *Civitas et castrum ad Mare Balticum: Baltijas arheoloģijas un vēstures problēmas dzelzs laikmetā un viduslaikos*: 156–77. Riga: Latvijas vēstures institūta apgāds.
Hiekkanen, M. 2003a. Turun kaupungin perustaminen – Tulkintayritys uusien arkeologisten tutkimusten perusteella. In L. Seppänen (ed.) *Kaupunkia pintaa syvemmältä: Arkeologisia näkökulmia Turun historiaan*: 42–52. Turku: TS-Yhtymä & Suomen keskiajan arkeologian seura.
Hiekkanen, M. 2003b. Turun Pyhän Olavin konventti ja sen rakennusmuistot. T*urun maakuntamuseo: Raportteja* 18: 89–104.
Hiekkanen, M. 2018. *Suomen keskiajan kivikirkot.* 4th edition. Suomalaisen Kirjallisuuden Seuran toimituksia 1117.
Hoła, A., Matkowski, Z. & Hoła, J. 2017. Analysis of the moisture content of masonry walls in historical buildings using the basement of a medieval town hall as an example. *Procedia Engineering* 172: 363–8.

Holmqvist, E. 2017. Handheld portable energy-dispersive X-ray fluorescence spectrometry (pXRF). In A. M. W. Hunt (ed.) *The Oxford Handbook of Archaeological Ceramic Analysis*: 363–81. Oxford: Oxford University Press.

Immonen, V. 2015. Buried in the archives: Medieval graves at the Dominican convent of St Olaf in Turku, Finland. *Mirator* 16 (1): 29–51. <http://www.glossa.fi/mirator/pdf/i-2015/buriedinthearchives.pdf> Accessed 17 March 2020.

Immonen, V. 2019. Monasticism in a border landscape: Religious orders in medieval Finland. In E. Bhreathnach, M. Krasnodębska-D'Aughton & K. Smith (eds.) *Monastic Europe: Medieval Communities, Landscapes, and Settlements*: 303–28. Turnhout: Brepols.

Immonen, V., Harjula, J., Kirjavainen, H. & Ratilainen, T. 2014a. The Dominican convent of St Olaf in Turku, Finland. In M. Gläser & M. Schneider (eds.) *Lübecker Kolloquium zur Stadtarchäologie im Hanseraum IX: Die Klöste*r: 545–58. Schmidt-Römhild: Lübeck.

Immonen, V., Harjula, J., Kirjavainen, H. & Ratilainen, T. 2014b. Turun Pyhän Olavin dominikaanikonventti: Aineksia tilankäytön tulkintaan. *SKAS* 3/2013: 3–23.

Kuujo, E. 1981. *Turun kaupungin historia 1366–1521.* Turku: Turun kaupunki.

Laaksonen, H. & Lahtinen, R. 2011. Bostadsaktiebolaget Asunto-osakeyhtiö Pantern 100 vuotta. In P. Toivanen & N. Ekholm (eds.) *Pantern: Talo luostarin raunioilla*: 15–134. Turku: Turun museokeskus.

Lehmijoki-Gardner, M. 2004. Mendikanttisääntökunnat, etuoikeutena köyhyys. In T. Heikkilä & M. Lehmijoki-Gardner (eds.) *Keskiajan kirkko: Uskonelämän muotoja läntisessä kristikunnassa*: 198–288. Helsinki: Suomalaisen Kirjallisuuden Seura.

Leinberg, K. G. 1890. *De finska klostrens historia.* Helsingfors: Svenska litteratursällskapet i Finland.

Liritzis, I., Stamoulis, K., Papachristodoulou, C. & Ioannides, K. 2013. A reevaluation of radiation dose rate conversion factors. *Mediterranean Archaeology & Archaeometry* 13(3): 1–15.

Lovén, C. 2001. Kloster, klosterliknande inrättningar och klostertraditioner. *Fornvännen* 96: 243–66.

Malin, A. 1925. *Der Heiligenkalender Finnlands: Seine Zusammensetzung und Entwicklung.* Helsinki: Suomen kirkkohistoriallinen seura.

Maliniemi, A. 1947. Grundandet av dominikankonventet i Åbo och dess förhållande till Sigtuna: Några kritiska randanmärkningar. In H. Arbman, W. Holmqvist & R. Hillman (eds.) *Sigtuna Mariakyrka 1247–1497*: 83–95. Sigtuna: Sigtuna Fornhems förlag.

Montana, G. 2017. Ceramic raw materials. In A. M. W. Hunt (ed.) *The Oxford Handbook of Archaeological Ceramic Analysis*: 87–100. Oxford: Oxford University Press.

Murray, A. & Wintle, A. 2000. Luminescence dating of quartz using an improved single-aliquot regenerative-dose protocol. *Radiation Measurements* 32: 57–73.

Nikula, O. 1987. *Åbo stads historia 1521–1600*. Åbo: Åbo stad.

Oinonen, M., Hilasvuori, E., Mehtonen, H., Uotila, K., & Zetterberg, P. 2013. On the eve of urbanization: Bayesian model dating for medieval Turku. *Radiocarbon* 55(2–3): 1265–77. <https://doi.org/10.2458/azu_js_rc.55.16244> Accessed 17 March 2020.

Pihlman, A. 1986. Materialsamling. In A. Pihlman & J. Kostet (eds.) *Åbo (fi. Turku): Medeltidsstaden* 3: 63–190. Åbo: Åbo landskapsmuseum.

Pihlman, A. 2007. Varhainen Turku -tutkimushanke: Uusia arkeologisia tulkintoja Turun kaupungin muodostumisesta. In K. Majantie & K. Motuste (eds.) *HIT – History in Turku: Tietoja, taitoja ja löytöjä: Näyttely Turun linnassa 15.6.–23.9.2007*: 10–15. Turku: Turun maakuntamuseo.

Pihlman, A. 2010. Turun kaupungin muodostuminen ja kaupunkiasutuksen laajeneminen 1300-luvulla. *Turun museokeskus: Raportteja* 22: 9–29.

Pihlman, A., Saloranta, E., Krappala, K. & Ratilainen, T. 2022. Turun kaupunkia vanhempi asutus ja kaupungin synty: Tulkinta varhaisen keramiikka-aineiston ja luonnontieteellisten ajoitustulosten perusteella. *SKAS* 2/2021 (2022): 2–37.

Ratilainen, T. 2010. Tiilen käytöstä 1300-luvun Turussa. *Turun museokeskus: Raportteja* 23: 31–55.

Ratilainen, T. 2014. Unfired bricks used for a medieval oven in Turku, Finland. *British Archaeological Reports: International Series* 2611: 93–101.

Ratilainen, T. 2016. At the dawn of masonry architecture: Church remains and associated brick structures at Koroinen, Turku. *Estonian Journal of Archaeology* 20(1): 54–80.

Ratilainen, T. 2018. Rakennukset ja rakenteet. In J. Harjula, S. Hukantaival, V. Immonen, T. Ratilainen & K. Salonen (eds.) *Koroinen: Suomen ensimmäinen kirkollinen keskus*: 85–16. Turku: Turun Historiallinen yhdistys.

Ratilainen, T. 2020. *Early Brick Use and Brick Building in Mainland Finland: Contribution of Koroinen, Early Phases of Turku project and Holy Cross Church of Hattula*. Turku: University of Turku. <https://www.utupub.fi/handle/10024/149739> Accessed 26 April 2021.

Ratilainen, T., Immonen, V., Salonen, K. & Harjula, J. 2017. The bishop's brick house: Remains of medieval buildings on the river bank of Koroinen. *Lund Archaeological Review* 23: 1–25.

Ratilainen T. & Kinnunen J. 2019. Identifying the origin of bricks and roof tiles with pXRF: A case study from medieval Turku, Finland. *Turun museokeskus: Raportteja* 23: 135–60.

Ratilainen, T., Oinonen, M., Lindroos, A., Harjula, J., Immonen, V. & Salonen, K. 2021. The Contribution of bricks and mortar in the chronology of the fortified site of Koroinen, Finland. *Castella Maris Baltici* XIV: 33–54.

Rinne, J. 1908. P. Olavin luostari ja rauniot Kaskenkadun ja Ison Hämeenkadun yhtymän tienoilla Turussa: Rakennushistoriallinen tutkimus. *Lännetär: Varsinaissuomalainen osakunta: Uusi jakso 1*: 106–68.

Rinne, J. 1928. Pyhän Olavin luostari Turussa. *Suomen Museo* 1928: 89–92.

Rinne, J. 1952. *Turun tuomiokirkko keskiaikana III: Turun tuomiokirkko hiippakunnan hallinnon elimenä.* Turku: Turun tuomiokirkon isännistö.

Ruuth, J.W. 1909. *Åbo stads historia under medeltiden och 1500-talet: Första häftet*. Bidrag till Åbo stads historia, Andra serien 9.

Salminen, T. 2003. Dominikaanit Tallinnassa, Viipurissa ja Turussa. *Turun maakuntamuseo: Raportteja* 18: 37–46.

Salminen, R., Kukkonen, M., Paukola, T. & Töllikkö, S. 1997. Chemical composition of clays in Southwestern Finland. *Geological Survey of Finland: Current Research* 23: 117–26.

Seppänen, L. 2009. Town in transition – Outlining the construction activities in medieval Turku. In H.-M. Pellinen (ed.) *Maasta, kivestä ja hengestä – Earth, Stone and Spirit: Markus Hiekkanen Festschrift:* 240–9. Turku & Helsinki: Arkeologia, Turun yliopisto; Taidehistoria, Helsingin yliopisto, Suomen kirkkohistoriallinen seura & Suomen keskiajan arkeologian seura.

Seppänen, L. 2011. Stadskulturens djuprotade rötter ligger vid Aura ås stränder. *Finsk Tidskrift* 10/2011: 475–87.

Seppänen, L. 2012. *Rakentaminen ja kaupunkikuvan muutokset keskiajan Turussa: Erityistarkastelussa Åbo Akademin päärakennuksen tontin arkeologinen aineisto*. Turku: Turun yliopisto. <https://www.utupub.fi/handle/10024/86116> Accessed 17 March 2020.

Siivola, J. & Schmid, R. 2007. Recommendations by the IUGS subcommission on the systematics of metamorphic rocks: Web version 01.02.07. Beijing: IUGS Commission on the Systematics in Petrology. <https://www.environmentalgeochemistry.org/scmr/products.html> Accessed 17 March 2020.

Talvio, T. 2011. A coin hoard from the Turku Dominican Convent (1901). In J. Harjula, M. Helamaa & J. Haarala (eds.) *Times, Things & Places: 36 Essays for Jussi-Pekka Taavitsainen*: 152–65. Turku: J.-P. Taavitsainen Festschrift Committee.

Uotila, K. 2002. Åbo medeltida rådhus: En stenbyggnad vid ett medeltida torg. *META* 4/2002: 3–18.

Uotila, K. 2003. Kivitaloja keskiajan Turussa. In L. Seppänen (ed.) *Kaupunkia pintaa syvemmältä: Arkeologisia näkökulmia Turun historiaan*: 121–34. Turku: TS-Yhtymä & Suomen keskiajan arkeologian seura.

Uotila, K. 2006. Muuratut talot keskiajan Turussa. In V. Immonen & M. Haimila (eds) *Mustaa valkoisella: Ystäväkirja arkeologian lehtori Kristiina Korkeakoski-Väisäselle*: 351–53. Turku: Turun yliopiston arkeologian oppiaine.

Uotila, K. 2007. Aboa Vetus -museon kivirakennusten tutkimukset v. 2002–2006. *SKAS* 2/2007: 18–27.

Uusitalo, J., Arppe, L., Hackman, T., Helama, S., Kovaltsov, G., Mielikäinen K., Mäkinen, H., Nöjd, P., Palonen, V., Usoskin, I. & Oinonen, M. 2018. Solar superstorm of AD 774 recorded subannually by Arctic tree rings. *Nature Communications* 9 (3495). <https://doi.org/10.1038/s41467-018-05883-1> Accessed 17 March 2020.

Zimmermann, D. W. 1971. Thermoluminescent dating using fine grains from pottery. *Archaeometry* 13: 29–52.

APPENDIX

Appendix 1. The pXRF analyses of the sampled bricks.

The sampled bricks were also examined with a portable XRF analyser. Analyses were conducted with a Thermo Scientific Niton XL3t-950 GOLDD+ (SN#:100535) pXRF at the Turku Museum Centre. The tube type of the analyser was 50kV Au anode with maximum 200µA electric current. The preset mode for the analyses was TestAll Geo, calibrated by the Finnish Niton importer, Holger Hartman Oy, on 8 November 2018 (Bezur et al. 2020: 160). The applied traceable calibration standards were defined by the National Institute of Standards & Technology (NIST) and Bureau of Analysed Samples Ltd (BAS). The number of the calibration certificate, stored in the pXRF instrument box, is 140-00072. It was issued in accordance with the specifications of the Thermo Fisher Scientific factory, and the measurements were found to be within specification limits at the time of the calibration. The total radiation time of one measurement was 120s, and the diameter of the beam window in the instrument was 3mm. The pXRF analyses were made on freshly cut and cleaned surfaces. The results of the analyses are presented in Appendix Table 1 (main elements) and Appendix Table 2 (trace elements).

Even though the factory calibration of TestAll Geo measurement mode passes to semiquantitative class, and the relative standard deviation (RSD) of results is nearly definitive (<±10%), the results of analyses presented here are intended to be used only for chemical comparison and classification of bricks, while the overall results are presented here 'as is'.

Overall, when studying analyses of ceramics (e.g., bricks and tiles), and fired and natural clay, some preliminary remarks should be presented:

1. Ceramics are fired which reduces the percentage of volatile elements in comparison with natural clay.

2. In ceramics, clay is tempered and mixed with fillers, and thus the composition of ceramic clay does not represent that of natural clay.

3. Different clays from different locations can be used within the same ceramic production batch, and thus the composition of its clay does not necessarily represent any natural clay. Geologically all clays in South-West Finland were stratified during the different sea-lake-phases of the Baltic Sea after the Ice Age. Dry land became exposed from the waters of the Baltic during thousands of years of seashore displacement. For these reasons, the composition of different clay types varies depending on its different sedimentation environments (deep–shallow, pelagic–littoral), different flora and fauna, and the changing salinity of the water.

4. When archaeological objects are exposed to natural substances in soil, it is possible for water-soluble elements to migrate from and into the porous ceramic and change its overall composition.

In general, clay and fired clay artefacts are one of the most suitable natural earthen materials for XRF analyses because of the substance's fine grain size and homogeneity. Yet the composition of even well-mixed clay has heterogeneities on a nano-micrometer scale, since the elements are chemically bonded to differently-sized and oriented mineral grains (Cuomo di Caprio 2017: 47–57; Montana 2017: 87–8, 90–5). Consequently, the XRF analysis of ceramics should be considered as a qualitative or semi-quantitative method (Cuomo di Caprio 2017: 588; Holmqvist 2017: 363). In the case of bricks, moreover, such tempering materials as sand, chamotte, chalk, graphite and slaked lime alter the final total composition of brick clay (Cuomo di Caprio 2017: 61–76; Holmqvist 2017: 365–7).

Regarding the results, it must be first pointed out that carbon (C), present as dark inclusions within several of the ceramics studied (see above), is not detectable by pXRF. Sodium (Na, Z=11) was also not possible to detect using the Niton pXRF. The percentages of light bulk elements magnesium (Mg, Z=12) and silicon (Si, Z=14) are usually over-represented in analyses and repeatability is poor. Consequently, their use in classification plots is unreliable. Aluminium (Al) and titanium (Ti) are usually the most stable elements in bedrock and soil samples, but the pXRF analysis of aluminium is also somewhat problematic and unreliable. Hence, the most useful major elements for interpreting pXRF analyses of rock or soil samples as well as clay products, like bricks and pottery, are iron (Fe), calcium (Ca) and potassium (K) (Holmqvist 2017: 368).

The sampled ceramics had been fired to a red colour, and thus it was expected that their iron content would be relatively high. The percentage of iron varied from c. 3.8% to 7.2%, and these readings are common both in local bricks and natural clay. In contrast, transported bricks were usually fired yellow, containing c. 2–4% iron (Salminen et al. 1997: 120; Ratilainen & Kinnunen 2019: 140).

The percentage of calcium in the sampled bricks varied from 0.16% to 1.22%, which is also common for local bricks (Ratilainen & Kinnunen 2019: 140). Many of the sampled ceramic objects are partly coated with mortar or plaster, in which calcium is normally an abundant element (c. 10–25%). Analysis of the freshly-exposed interiors of these ceramics showed very low calcium contents, which clearly indicates that calcium does not transport and absorb easily from the surface of these ceramics, not even by a few centimetres. In the sampled ceramics, the percentage of potassium varied from c. 2.3% to 3.2%, and these readings correspond approximately with the average Finnish potassium contents of natural clay, c. 3% (Salminen et al. 1997: 120).

Interestingly, high Z (>15) trace elements found in the samples are chlorine (Cl), sulphur (S), vanadium (V), nickel (Ni), copper (Cu), zinc (Zn) and heavy metals, including lead (Pb), cadmium (Cd), arsenic (As) and tin (Sn). The quantity of chlorine and sulphur is prone to post-depositional alterations, but the analyses were made on the freshly-exposed interiors of the ceramic objects studied (Holmqvist 2017: 368). The element contents of the ceramics analysed are presented in binary xy plots (Appendix Figs. 1 and 2). The variables and the order of the plots are the same as in the study of Ratilainen and Kinnunen (2019). Cluster fields in Appendix Figs. 1 and 2 demonstrate the general interpretation based on all data in its entirety.

The material of the roof tile (ID 8) is depleted of most analysed elements. This effect could be explained by the excessive use of the quartz sand, practically pure SiO2, in filler, which is also distinguishable in microscope. Generally, pure rounded natural quartz sand (SiO2) in Finland is rare (Borgström 1924: 3; Autere 1976: 36–43).

Overall, variations in the element compositions of the sampled ceramics are minor, and this is evident for each detected element. Silicon, aluminium, and magnesium are difficult elements for a pXRF detection, which can explain their slight variations. Other minor variations in the compositions of these ceramics can be a result of their internal structure, different firing temperatures and post-depositional processes. The analysis results of the moulded bricks (ID 1–6) form an evident cluster, indicating that these objects shared a similar origin. Meanwhile, the clay material of the floor tile (ID 7) is different and the roof tile (ID 8) significantly different from the others.

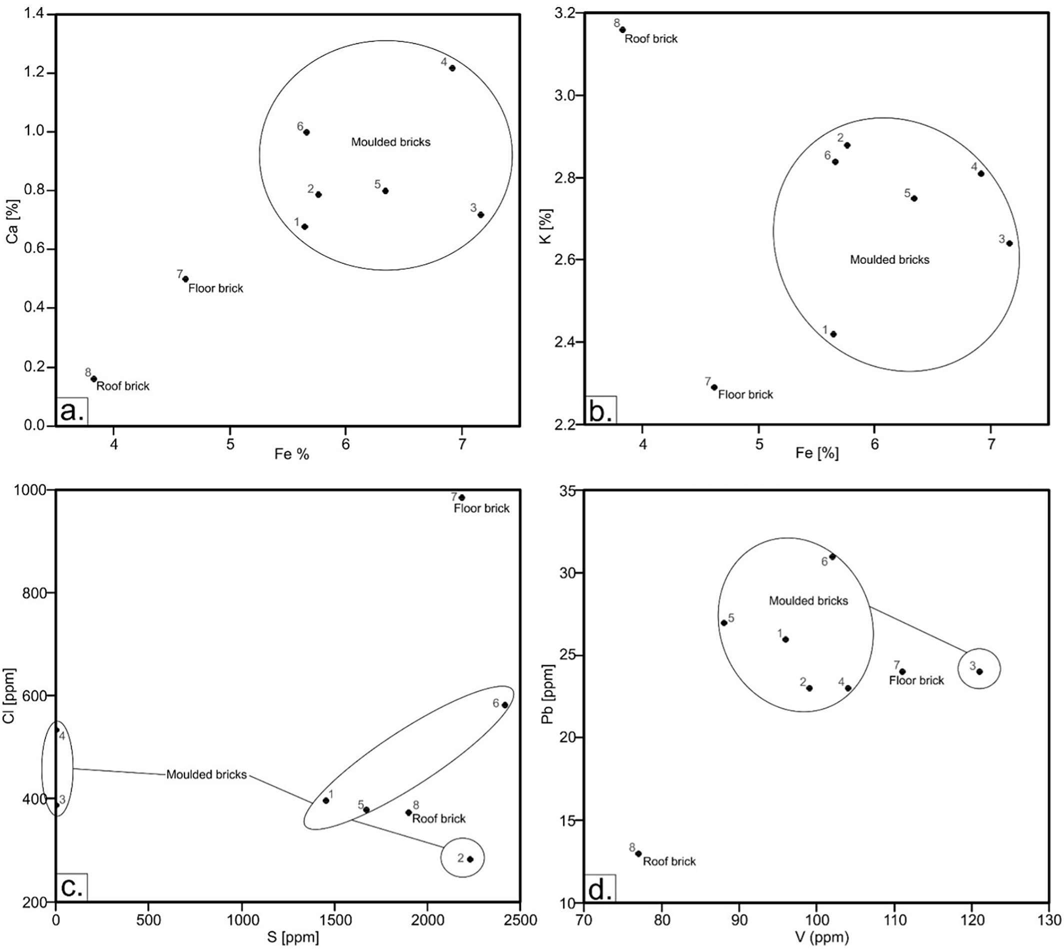
Based on the clustering of the pXRF element analyses and on the observation by microscopy of the sampled ceramics, these can be divided into three groups. Group 1 consists of the six round-moulded bricks (ID 1–6), while Groups 2 and 3 consist of one sample each: the floor tile (ID 7), and the roof tile (ID 8). The data suggests that the three groups were all made using the same clay recipe, and consequently may originate from the same source. Despite potential sources of error, also the results of the pXRF analyses, in addition to the identification of granitic temper, strongly suggest that the clay used in seven (ID 1–7) of the eight sampled items was acquired locally or in Sweden.

Appendix Table 1. The main element analyses of the sampled ceramic masonry elements from the Dominican Convent in Turku. All the values presented are in percentages. It should be kept in mind that the total sum of the element percentages in the same sample is not one hundred, since the pXRF instrument cannot detect all elements.

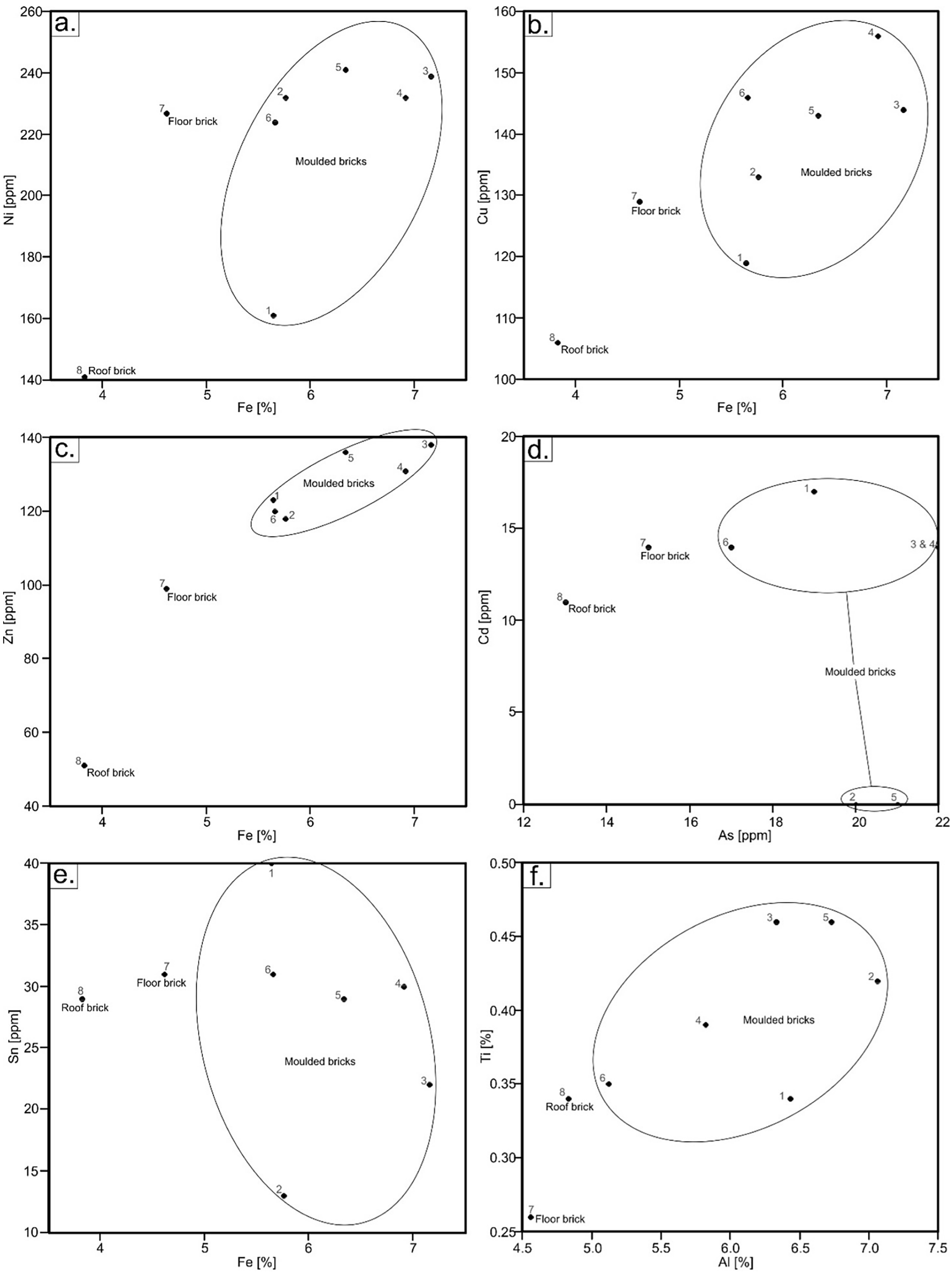
ID	Sample (TMC inv. no.)	Si %	Ti %	Al %	Fe %	Mn %	Mg %	Ca %	K %	P %
1	16768:29	25.89	0.34	6.43	5.64	0.08	1.58	0.68	2.42	0.14
2	16768:30	27.87	0.42	7.06	5.76	0.06	2.33	0.79	2.88	0.15
3	16920:62	24.92	0.46	6.33	7.16	0.07	1.90	0.72	2.64	0.15
4	16920:64	21.84	0.39	5.82	6.91	0.12	1.25	1.22	2.81	0.14
5	16920:78	25.25	0.46	6.73	6.34	0.07	2.13	0.80	2.75	0.13
6	16920:92	20.94	0.35	5.12	5.66	0.06	1.76	1.00	2.84	0.18
7	16920:131	21.46	0.26	4.56	4.61	0.04	1.01	0.50	2.29	0.19
8	16920:132	24.80	0.34	4.83	3.82	0.06	0.38	0.16	3.16	0.10

Appendix Table 2. Trace element analyses of the sampled bricks from the Dominican Convent in Turku. All the presented values are in ppm's (parts per million), and '<LOD' indicates that the result is under the pXRF instrument's limit of detection.

ID	1	2	3	4	5	6	7	8
Sample	16768:29	16768:30	16920:62	16920:64	16920:78	16920:92	16920:131	16920:132
V	96	99	121	104	88	102	111	77
Cr	197	213	242	262	301	206	194	178
Ni	161	232	239	232	241	224	227	141
Cu	119	133	144	156	143	146	129	106
Zn	123	118	138	131	136	120	99	51
As	19	20	22	22	21	17	15	13
S	1454	2228	<LOD	<LOD	1670	2416	2183	1897
Cl	397	283	388	534	379	582	986	374
Ba	776	657	673	700	708	692	709	540
Rb	99	100	103	101	101	104	89	75
Sr	163	134	130	138	130	134	141	48
Zr	184	160	172	142	167	148	123	247
Cs	168	117	145	144	143	142	150	142
Mo	6	4	<LOD	5	<LOD	5	5	6
Nb	18	19	19	20	21	16	15	18
Sn	40	13	22	30	29	31	31	29
Sb	47	21	34	42	30	27	30	42
Te	69	43	49	61	58	58	61	57
Pb	26	23	24	23	27	31	24	13
Bi	22	29	34	35	27	26	23	21
Th	11	12	17	18	13	14	10	11
Cd	17	<LOD	14	14	<LOD	14	14	11
Co	<LOD	<LOD	<LOD	<LOD	<LOD	108	<LOD	<LOD
Ag	10	7	<LOD	7	6	6	6	<LOD
W	169	199	207	228	209	214	223	203



Appendix Fig. 1. Results of pXRF analysis of eight ceramic masonry elements from the Dominican Convent in Turku: a) Iron (%) vs. calcium (%), b) iron (%) vs. potassium (%), c) sulphur (ppm) vs. chlorine (ppm) and d) vanadium vs. lead (ppm).



Appendix Fig. 2. Results of pXRF analysis of eight ceramic masonry elements from the Dominican Convent in Turku: a) Iron (%) vs. nickel (ppm), b) iron (%) vs. copper (ppm), c) iron (%) vs. zinc (ppm), d) arsenic (ppm) vs. cadmium (ppm), e) iron (%) vs. tin (ppm) and f) aluminium (%) vs. titanium (%).

IN MEMORIAM: ALEKSANDR IVANOVICH SAKSA (11 AUG 1951–14 AUG 2022)

A sad message arrived on August 15, the annual "Day of the Archaeologist" in Russia. Aleksandr Ivanovich Saksa had passed away. We truly miss the leading expert in the early history of Karelia and senior research fellow at the Institute for the History of Material Culture of the Russian Academy of Sciences in St Petersburg (ИИМК РАН).

Aleksandr Saksa – better known as Aleksanteri, Sasha, Santtu or Santeri among his friends in Finland – was born in Petrozavodsk. His Finnish-speaking family was from Ingermanland and belonged to the Ingrian Finns (more precisely, *savakot*). Their small farm, located in the village of Gorki (Korkka) in the municipality of Gubanitsy, was dear to Aleksandr Saksa throughout his adult life. The farm's old smoke sauna and peaceful garden gave a nice contrast to his busy life that never lacked surprises.

Aleksandr Saksa. Photo: Christian Carpelan.

Quoting Saksa's own words: "*My interest in archaeology started when we schoolboys from the village of Korkka in Kupanitsa, Ingermanland, during our summer vacation sometime in the mid-1960s, set out to excavate a kurgan or burial mound near the village, which according to the story belonged to a "Swedish warrior". Our aim was to find a real sword, because the usual World War II weapons obtained from battlefields in the forests were no longer enough for the boys. – – Nothing was found in the burial mound, but the matter itself continued to bother me.*" (Saksa 1998, 11.)

SAKSA'S EARLY CAREER

Aleksandr Saksa had his first lessons in archaeology in the Faculty of History at Leningrad State University in 1973. His most prominent teachers were Abram D. Stolyar, Gleb S. Lebedev and Anatoliy N. Kirpichnikov. As a student, Saksa participated in archaeological excavations led by Kirpichnikov inside Käkisalmi Fortress (Корела; Kexholm).

In 1978, Saksa was given the position of an aspirant at the Leningrad Branch of the Institute of Archaeology of the USSR Academy of Sciences (ЛОИА АН СССР, later ИИМК РАН). The bilingual and talented young researcher was welcomed to the Sector (now Department) of Slavic and Finnic archaeology.

The Soviet-Finnish working group in the field of archaeology had been established within the framework of the Committee for Cooperation in the Fields of Science and Technology between the USSR and Finland in 1969. Within a few years, a visiting research fellow exchange programme and cross-border symposia were launched. Aleksandr Saksa joined the network as a young scholar and as the fast-learning Russian–Finnish–Russian interpreter.

It was seemingly an easy choice for Saksa to direct his scholarly attention towards Karelia. Since 1945, there had not been but very minimal archaeological activity in the annexed Karelian parishes – and no access to non-Soviet citizens.

In the beginning, Saksa followed the footsteps of the Finnish "grand old man" Theodor Schvindt (1851–1917). He wished to revisit the Iron Age and Early Medieval sites that Finnish archaeologists had explored many decades ago. The relevant, valuable archive for him was in Helsinki: he needed the copies of the excavation reports by Finnish colleagues of the former generation and maps drawn by them in the field. Saksa received great help from the National Board of Antiquities (later named The Finnish Heritage Agency).

Saksa's first survey in 1978 was a success: a number of Iron Age and Early Medieval sites in Kaukola, Räisälä, Sakkola and the Käkisalmi rural municipality were found, recorded, photographed and marked on maps. After a promising start, Saksa extended his surveys to the coast of the Lake Ladoga in Hiitola and Kurkijoki, and to numerous other places in the Karelian Isthmus. He discovered previously unknown Crusade Period and Early Medieval settlement sites, sacrificial mounds, cup stones and other features of archeological interest. The early history of Karelia became the topic for Saksa's candidate dissertation that he completed in 1984 (corresponding to a licentiate academic degree in Finland).

THE KÄKISALMI EXPEDITION AND OTHER PROJECTS

The Priozersk (Käkisalmi) archaeological expedition was led by Aleksandr Saksa for two decades (1978–1997). The project carried out excavations at the Iron Age and Early Medieval settlements in Sakkola (site: Lapinlahti / Ольховка), Räisälä (site: Hovinsaari / Большой полуостров) and Kurkijoki (site: Kuuppala). In the last-mentioned case, even Early Metal Period and Stone Age layers were discovered. The Priozersk expedition also studied ancient hillforts, such as Lopotti, Hämeenlahti and Rantalinnamäki in the parish of Kurkijoki.

Political turbulences occurred and global disbalances changed, including glasnost, perestroika, the opening of the Iron Curtain. Finally, a door opened for Finnish archaeologists to join an archaeological excursion and take part in a short field work in the Karelian Isthmus in 1988. Aleksandr Saksa proudly guided the visitors at different legendary archaeological sites, the memory of which was not forgotten. On the other hand, many of the former Karelian villages were gone. But, as Saksa put it, "Finnish houses are strong even if in ruins".

In the following field seasons, a few excavations were carried out in bilateral Soviet-Finnish cooperation. The studies of the Käkisalmi Fortress (1989–1990, 1992–1993) and the burial ground of Suotniemi (Яркое) in Käkisalmi (1991) were conducted in the multidisciplinary fashion with Saksa as the director. The questions were set and analyses made from the viewpoints of archaeology, geology, paleoecology, botanical studies, dendrochronology and ^{14}C-dating. On the fortified island of Käkisalmi, the oldest wooden constructions were dated to the early 13th century and Viking Age and Merovingian Period artefacts were found. Correspondingly, a few finds at the Crusade Period cemetery site in Suotniemi dated to the earlier Iron Age periods.

After the collapse of the Soviet Union, Saksa completed his PhD studies at the University of Joensuu, Finland. He defended his doctoral thesis on the settlement history of Iron Age Karelia in 1998 (Saksa 1998). Later, he held the position of associate professor at the Department of History and Geography at the University of Eastern Finland (Joensuu). Preliminary plans for a teaching program in archaeology were also made, but due to financial reasons, they were not made reality there (yet).

The co-operation with Aleksandr Saksa was of crucial importance for the University of Helsinki for the planning of archaeological surveys in the Karelian Isthmus. Any project plans would not even have been realistic without his thorough knowledge of the area. The first field excursion took place in summer 1998 with Saksa as the guide.

Between 1999 and 2003, there was a team of archaeologists from the University of Helsinki in the field in the Karelian Isthmus every year. From the Russian side, new researchers joined the team. Surveys in the parishes of Räisälä, Kaukola, Kurkijoki, Johannes, Koivisto and Kuolemajärvi and a seminar excavation at the Mesolithic and Neolithic dwelling site of Juoksemajärvi in Räisälä were good training both for the Finnish students and their teachers. Moreover, mutual learning took place: the precise methods applied for field survey by the Finns were well worth considering by colleagues from St Petersburg. A special volume of the Finnish publication series *Iskos* summarised the manyfold results of the five seasons of co-operation (Iskos 16, 2008).

Saksa was also invited to participate in the research projects of the Museum of Lahti and worked together with them in Jääski, Kirvu and a few other places in the Karelian Isthmus.

THE VYBORG EXPEDITION

The year 1998 was a turning point in Saksa's career. He became the leader of the new archaeological expedition in Vyborg and opened a test excavation at the foot of the Ratushnaya Tower (Raatitorni) of the medieval town wall. From the Finnish point of view, the site was extremely interesting. The Department of Archaeology at the University of Turku was an important partner for Saksa for many years to follow.

To summarise, the significant result of the Vyborg expedition was the discovery of relatively thick cultural layers and well-preserved wooden constructions that date from the 14th to 18th centuries. Similar observations had been reported by the Finnish town architect Otto-Iivari Meurman before the World War II, but only on a very limited scale. According to the Soviet archaeologist Vyacheslav A. Tyulenev, there would not be much "Swedish" to find in Vyborg.

Thanks to Saksa and his team, we now know that in the medieval find material, there are leather shoes, wooden and clay vessels, drinking glasses, iron knives and silver coins, fishing gear and items made of bone. The apparent similarities with corresponding finds from a few Swedish towns or German trade goods in Reval (Tallinn) speak for a lively medieval harbor in the Gulf of Vyborg and urban life inside the 15th century town wall.

Saksa found it very important that residents of the town became aware of its history and he invited young persons to work on excavations. For administrative reasons, the expedition left the layers and walls on the Vyborg castle island for other researchers to explore.

The Vyborg expedition would not have led to much progress without the long and fruitful co-operation with the Foundation for Karelian Culture (Karjalaisen Kulttuurin Edistämissäätiö) in Joensuu. From the Russian side, a major source of financial support was Gazprom Neft.

Excursions to maritime contexts became possible for Saksa in co-operation with the expedition of the Russian Geographical Society. Small-scale excavations were conducted on the islands Lavansaari (Мощный остров) and Tytärsaari (Большой Тютерс) in the Gulf of Finland.

Year after year, Saksa strived hard for the long-term protection of cultural heritage in Vyborg. The level of interest was very modest from the side of the local and regional administrations in the beginning. Nevertheless, Aleksandr Saksa's remarkable diplomatic skills led him to success. The public interest towards archaeology and early history gradually increased. Officials expressed their changing attitudes and agreements were signed that favored a few developments in heritage management.

Since 2013, the finds from town excavations have been on display in the permanent exhibition of the Hermitage-Vyborg Centre, located in the Bastion Pantsarlax in the outskirts of the medieval urban area. After Saksa's last field season in the town in 2015, the responsibility was given over to his successors from St Petersburg. Medieval archaeologists from the University of Helsinki last visited Vyborg in 2019 and took a few photos of the collection there. Future co-operation with the archaeological staff of the Castle would be desired.

The latest monograph by Aleksandr Saksa is a thorough description and interpretation of the historical plot Luostarinkatu Street 8 (Выборгская улица) in Vyborg (Saksa 2020). He conducted excavations there for three field seasons and explored the wooden buildings at the foot of the small stone house that today has a roof made of bricks in the medieval German style.

A SENIOR RESEARCH FELLOW AND FRIEND

In order to get a scientific qualification according to the standards of the Russian Academy of Sciences, Saksa defended his doctoral thesis for the second time in St Petersburg in 2007. The printed publication came out in 2010 (Saksa

2010). Altogether, Saksa published roughly 150 articles and participated in several joint publications.

Saksa was a member of the scientific councils of the Russian Academy of Sciences and a member of the presidium of the regional (St Petersburg) centre of the All-Russian Society for the Preservation of Historical and Cultural Monuments (ВООПИиК). His tireless fighting for the preservation of ancient sites of the Karelian Isthmus and the historical Vyborg is appreciated.

Aleksandr Saksa was fluent in Finnish and a frequent participant in scholarly and other events and projects in Finland. Regardless of whether he was invited there as the interpreter or not, he translated – and the translations were diplomatic in character, smoothly adapting to the social context.

The Finnish Antiquarian Society invited Saksa to become a foreign member, and he also was a member of the Finnish Literary Society, the Finnish Society of Church History and the Kalevala Society. He also was a frequent visitor of the Karelian Association in Helsinki as a speaker in public events or a highly appreciated guide on bus tours. The Association awarded him the Pro Carelia badge of merit in 2001. A few other societies for Karelian culture and heritage, too, had Saksa as a sincere friend. His way of telling the past and analysing present phenomena was unique, inspiring and enriched with smart anecdotes.

For decades, Saksa was the member – and a key person in the Soviet-Finnish and later Russian-Finnish working group in the field of archaeology. In this framework, among others, he always met a Finnish colleague with pleasure in Leningrad, later St Petersburg. We remember him standing at the railway station, guiding the guests to their place of accommodation and organising visits to museums, archives and archaeological sites. According to this true gentleman, a female archaeologist should have flowers in her office – thus he would buy her a bunch.

Aleksandr Saksa's sovereign way of navigating through the stormy waters of life was that of an optimistic researcher. Challenges were there to be overcome. "I am curious", he said. "Let's see how the problem will be solved." Insightful humor often loaded sorrows off from his shoulders and from those in his company. On the other hand, he sometimes was all too helpful and found it inconvenient to say "no" to any request, even at the expense of his own wellbeing.

Aleksandr Saksa's latest co-operation with Finnish scholars was the planning of the project *Europeanisation of Finland and the Karelian Isthmus AD 1100–1600*. The application for finances from the Academy of Finland was successful at last in 2022. For the following four years (2022–2026), the project will focus on fortifications and fortified sites, including the castle and town of Vyborg. In current circumstances, the knowledge about sites on the Russian side mostly rely on printed publications.

There was a philosophic undertone in Sasha's warm and bright, open but still somehow secret personality. In his company, a conversation would always bubble. He was genuinely enthusiastic about scholarly knowledge, such as archaeological discoveries, and willing to share this with everyone – in a learned society or an occasional discussion with a Leningrad taxi driver.

Due to the current Russian political issues, Aleksandr Saksa's Finnish colleagues were unable to follow his last journey from St Petersburg to the Gubanitsy graveyard in person. Our letters of condolence honour the memory of a cordial and benevolent friend.

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REFERENCES

Karelian Isthmus – Stone Age Studies in 1998–2003, 2008. Iskos 16. Helsinki: The Finnish Antiquarian Society.

Saksa, A. 1998. *Rautakautinen Karjala: Muinais-Karjalan synty ja varhaiskehitys*. Studia Carelica Humanistica 11. Joensuu: Joensuu University Faculty of Humanities.

Saksa 2010 = Сакса, А. И. 2010. *Древняя Карелия в конце I – начале II тысячелетия н. э.: Происхождение, история и культура населения летописной Карельской земли.* Санкт-Петербург: Нестор-История.

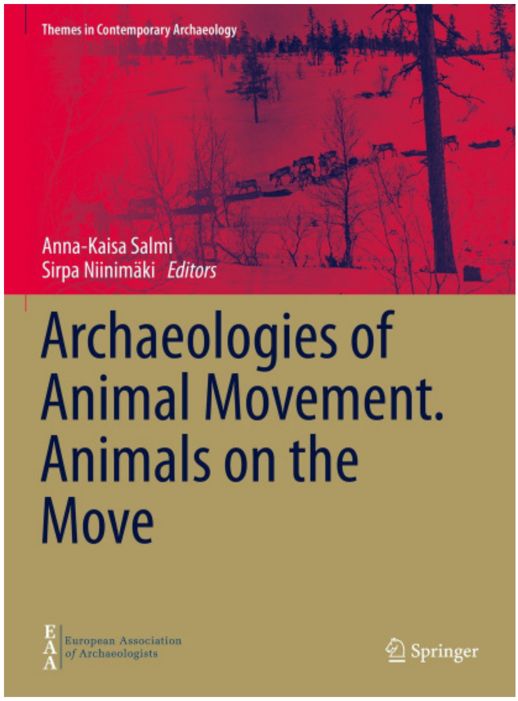
Saksa 2020 = Сакса, Александр 2020. *Из истории одного выборгского средневекового дома.* Санкт-Петербург: Арка.

Anna-Kaisa Salmi & Sirpa Niinimäki (eds): *Archaeologies of Animal Movement. Animals on the Move. Themes in Contemporary Archaeology.* Springer, Cham 2021. ISBN 978-3–030-68744-1. 106 + vii pp.

One of the latest instalments in the European Archaeological Association-backed 'Themes in Contemporary Archaeology' series from Springer, this volume has its roots in a session entitled "Understanding Activity Patterns of Animals: Methods, Applications, and Human-Animal Relationships" at the 2018 EAA conference in Barcelona. As one of many zooarchaeologists who missed that conference due to a clash with the quadrennial International Council for Archaeozoology meeting in Ankara, but who would surely have attended the session given the chance, I was excited to see the volume emerge.

Animal movement is a surprisingly underdiscussed topic within archaeology, as the editors – Anna-Kaisa Salmi and Sirpa Niinimäki, both of the University of Oulu – note in their helpful two-page preface. That is not to say that movements of animals at a range of scales are not the focus of a considerable amount of (zoo) archaeological research – they are, as demonstrated by the 18 papers that comprised the EAA session – but rather that it is seldom explored systematically as a topic. This is a shame, because 'animal movement' can cover a huge range of spatial and temporal scales, and of degrees of human intervention: from habitual daily activities, through seasonal migrations, to one-off long-distance droving. As the editors argue in their opening chapter, the relationships between these scales are complex and worthy of more explicit attention, not to mention improved clarity in the vocabulary used.

Organising a coherent conference session can be a challenging task, and the resulting publication still more so. Quality can be hard to assure, and authors may shy away from publication in traditional conference volumes with their often limited reach, or may indeed be presenting



previously published work. Contributions may stray off topic, or else be concentrated in one well-trodden corner of the broad field marked out by the organisers. In this context, Salmi and Niinimäki are to be congratulated on assembling a varied and interesting collection of nine papers that run the gamut from daily foraging activities to continental-scale imports of breeding stock, while surprisingly steering largely clear of some of the more commonly covered facets of animal movement. A priori, one might have expected contributions to a conference session on animal movement to gravitate towards the larger-scale end of the perennial topics such as transhumance or 'on-the-hoof' food supply to urban settlements, but neither really features here. Transhumance in particular is only mentioned in passing in two of the nine articles, but then has been well covered in a previous EAA volume (Costello & Svensson 2018). While it is true that a couple of the papers in Archaeologies of Animal Movement are more peripherally tied into the volume's theme than others, all remain valuable and complementary contributions.

In addition to varying scales, the nine chapters cover a range of taxa, periods, and methods. Geographical scope is largely limited to Europe, reasonably enough for an EAA volume, with the exception being Tekla Schmaus' study of Semirech'ye in Kazakhstan. Given the editors' own interests it is perhaps unsurprising that the volume is weighted towards Fennoscandia (four papers, with a further two on northern Europe) and reindeer (three papers), but most of the major Eurasian domesticates are also covered, with two papers each on cattle and on horse, one primarily concerning caprines, and one focusing on dogs and chicken. Methodologically the collection is impressively broad, with conventional zooarchaeology, pathological and entheseal change studies, stable isotopes, cementum annuli analysis, and historical sources all represented.

The opening chapter by Salmi and Niinimäki does an excellent job of articulating the editors' approach to animal movement through their own work on reindeer. Situating their research agenda within the idea of multispecies archaeology (see e.g., Pilaar Birch 2018) and the broader 'animal turn' within the humanities, they argue for the importance of appreciating the "bodily presence" (p. 2) of animals within human societies and the physical and personal nature of their interactions with humans. These are points with which it would be hard to disagree, but it is sometimes difficult to know how to bring such thinking to bear on zooarchaeological research in practice. Salmi's and Niinimäki's answer involves a focus on meeting points, an approach that helps to bridge the different scales of animal movement within their case study of northern reindeer herders, from day-to-day feeding and care to seasonal migrations. In the process, they provide some insights into concepts and processes of domestication that may be food for thought for researchers working on other herd animals.

This position statement from the editors represents a valuable perspective for studies of all extensively herded livestock species, but it is particularly useful in setting the scene for the two more detailed studies of reindeer in the volume. The first of these, by Emily Hull and colleagues (Chapter 4) explores pathology rates. The paper starts with a primer on the historical and ecological differences between wild forest reindeer and potentially domestic tundra reindeer (*Rangifer tarandus fennicus* and *R. t. tarandus* respectively) in Fennoscandia – extremely useful to those of us working at more southerly latitudes, for whom reindeer are mostly encountered as occasional antler imports at most! Working from modern collections, the authors demonstrate a markedly higher rate of trauma in wild forest reindeer than in free-ranging domestic tundra reindeer, raising the possibility that pathology rates might in future be used as an indicator of subspecies and/or domestication status – although the authors recognise and discuss the complexity of possible causes, as well as potential biases inherent in their samples.

A second specialist chapter on reindeer assesses another under-explored potential indicator of domestication: Salmi and Niinimäki (Chapter 5) turn to entheseal changes, i.e., modifications to the structure of muscle and tendon attachments that might reflect different life histories and activity patterns. Since wild reindeer spend much of the winter digging for lichen, provision of winter fodder by humans might be expected to result in reduced forelimb activity and hence entheseal changes. In a very promising study, the authors demonstrate just such a difference between modern zoo-kept and free-ranging reindeer, in *Biceps brachii* attachments on the proximal radius. They go on to show that a small archaeological collection from the Sámi offering site of Unna Saiva, dated as early as AD 1200, diverges significantly from the free-ranging sample, and hence may represent managed individuals. The authors caution, however, that both age and body size are potential confounding factors. This note is picked up and developed further by Markku Niskanen and Marion Bindé (Chapter 2), who – in the most strictly methodological paper of the volume – explore the relationship between size and expected physical strain in horses. While much of the technical detail here may be beyond the typical reader of this volume, the implications are clear: strain increases with size and future studies of entheseal changes must take body size, as well as age and sex, into account.

The second horse-based study is at the opposite end of the spectrum in terms of methods and scope: Daniel Makowiecki and colleagues (Chapter 3) present a broad overview of horse-human relationships in early medieval Poland. In some respects, this is the most traditionally zooarchaeological paper in the collection, making use of metrical, age-at-death, pathological, and contextual analyses. It also draws fairly heavily on historical evidence, although in very broad terms given the limited sources available in this period. The discussion of horse remains from the remarkable offering site of Żółte site 33 on Zarańsko Lake is a highlight here, albeit based on previously published work (Makowiecki & Makowiecka 2014). Giedrė Piličiauskienė (Chapter 9) also integrates historical and zooarchaeological data, in a rather more focused study on the import and breeding of improved Dutch cattle in post-medieval Lithuania. Alongside a detailed historical case study of early cattle breeding/improvement efforts by the Radziwill family in the late 17th century – against the backdrop of war with Sweden – Piličiauskienė uses metrical data from urban zooarchaeological assemblages to show that cattle overwhelmingly remained small until the 19th century, when a second wave of import and improvement efforts took hold. Her work underlines the importance of mixed methods: zooarchaeological data alone would have missed the historically significant 17th-century efforts, whereas reliance on historical sources in isolation might have overstated the impact on Lithuanian cattle as a whole. As with previous studies of livestock improvement in other regions (e.g., Thomas et al. 2013), there is also a potential mismatch between accounts of breeding efforts on rural estates and zooarchaeological assemblages that primarily reflect the subset of livestock reaching urban markets.

Perhaps surprisingly, only two of the papers apply stable isotopic methods – though again one might note that another fairly recent EAA volume has addressed a related theme (Kristiansen et al. 2017) – and they do so in very different ways. Aurora Grandal-d'Anglade and colleagues (Chapter 6) explore carbon and nitrogen isotopic values in bone collagen from dogs and chickens (and a range of comparanda) at eight Ukrainian sites dating from the 6th century BC to the late Kievan Rus' period (12th–13th century AD). The link specifically to animal movement here is more tenuous than for some chapters, but the paper is a valuable contribution to understanding past management of these two omnivores in a region with little previous data. Overall, the conclusion is of remarkable dietary diversity, with high $\delta^{13}C$ values in many dogs and chickens indicating significant consumption of C_4 plants – reasonably assumed by the authors to represent millett. I was a little surprised that possible inputs from marine resources or diadromous fish weren't also considered, despite six of eight sites being close either to the coast or to the Dnieper. Marine consumption would conventionally be expected to elevate $\delta^{15}N$ values beyond those seen here, but this may not be true of Black Sea fish – which by analogy to both the Mediterranean and the Baltic are likely to have significantly lower $\delta^{15}N$. Clearly there is a pressing need for new marine baseline data from the region to assess this possibility.

The second isotopic study, by Karl-Göran Sjögren and colleagues (Chapter 7) tackles questions of animal movement more directly, using strontium isotope data from cattle teeth to infer patterns of movement in the Falbygden region of western Sweden during the Funnel Beaker Culture (TRB) period. Much of the data discussed is previously published (Sjögren & Price 2013), while some detail of new high-resolution sequential analyses is held back for a future publication. The previous bulk data demonstrate considerable movement between Falbygden and surrounding areas – more than half the cattle appear not to have been locally born – but most strikingly the new sequential data indicate remarkable variation in movement patterns between individuals. Seasonal transhumance is convincingly ruled out by the authors, who argue instead that this pattern of idiosyncratic "trajectories through the landscape" (p. 80) is best explained by generalised exchange between groups, presumably situated within systems of risk buffering, social transactions such as bridewealth, and so on.

Chapter 8, by Tekla Schmaus, analyses growth rings in dental cementum to assess season-of-death, and by extension mobility, of caprine herds at several sites in Semirech'ye region, Kazakhstan spanning the Late Bronze to Iron Age transition. This method has seen surprisingly little attention within zooarchaeology since a landmark publication by Lieberman (1994) almost 30 years ago, so it is good to see an effective application of it. Schmaus does not report new primary data here, but rather uses the space and flexible format of the conference volume to provide a summary and thorough discussion of detailed results published elsewhere (Schmaus et al. 2018; 2020). Having demonstrated a lack of clear change between Bronze and Iron Ages – site occupations appear more-or-less year-round in both periods, contrasting with previous models of highly mobile Bronze Age pastoralism – Schmaus discusses the possible implications for social organisation and particularly the impact (or lack thereof) of Scythian influence.

Taken as a whole, Archaeologies of Animal Movement doesn't quite fall into the category of a must-have for zooarchaeologists – with the exception of those particularly interested in reindeer! – but it certainly represents a valuable addition to libraries and bookshelves. The papers it contains are all well worth reading individually, and they come together to form a coherent and in places thought-provoking collection. There are relative gaps in thematic coverage – transhumance, droving – but as noted above these are precisely the topics most widely explored elsewhere; conversely, Salmi and Niinimäki have managed to produce a volume in which the conventionally less explored aspects of animal movement get the most attention, and that is surely a good thing.

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REFERENCES

Costello, E. & Svensson, E. 2018. *Historical Archaeologies of Transhumance across Europe.* London: Routledge.

Kristiansen, K., Bánffy, E., Attema, P., Ventresca Miller, A. R. & Makarewicz, C. A. 2017. *Isotopic Investigations of Pastoralism in Prehistory.* London: Routledge.

Lieberman, D. E. 1994. The biological basis for seasonal increments in dental cementum and their application to archaeological research. *Journal of Archaeological Science* 21: 525–39.

Makowiecki, D. & Makowiecka, M. 2014. Faunal remains. In W. Chudziak & Kaźmierczak (eds) *The Island in Żółte on Lake Zarańskie, Early Medieval Gateway into West Pomerania*: 311–66. Toruń: Nicolaus Copernicus University.

Pilaar Birch, S. (ed.) 2018. *Multispecies Archaeology.* London: Routledge.

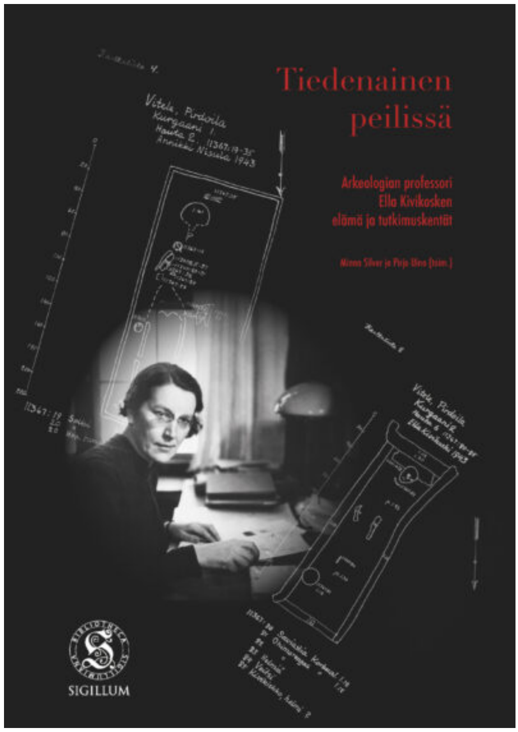
Schmaus, T. M., Chang, C., & Tourtellotte, P. A. 2018. A model for pastoral mobility in Iron Age Kazakhstan. *Journal of Archaeological Science: Reports* 17: 137–43.

Schmaus, T. M., Doumani Dupuy, P. N., & Frachetti, M. D. 2020. Variability in seasonal mobility patterns in Bronze and Iron Age Kazakhstan through cementum analysis. *Quaternary International* 545: 102–10.

Sjögren, K.-G. & Price, T. D. 2013. A complex Neolithic economy. Isotopic evidence for the circulation of cattle and sheep in the TRB of western Sweden. *Journal of Archaeological Science* 40: 690–704.

Thomas, R., Holmes, M. & Morris, J. 2013. "So bigge as bigge may be": Tracking size and shape change in domestic livestock in London (AD 1220–1900). *Journal of Archaeological Science* 40: 3309–25.

Minna Silver & Pirjo Uino (eds.):
Tiedenainen peilissä. Arkeologian professori Ella Kivikosken elämä ja tutkimuskentät. [A Female Scientist in a Mirror. Archaeology Professor Ella Kivikoski's Life and Research Fields]. Bibliotheca Sigillumiana 9. Sigillum, Turku 2020. ISBN 978-952-7220-15-3. 599 pp.



Ella Kivikoski (1901–1990) was the second Professor of Archaeology at the University of Helsinki. She succeeded A. M. Tallgren (1885–1945) in 1948 and remained in office for two decades until her retirement in 1969. Kivikoski is still considered a significant Finnish Iron Age scholar and Tiedenainen peilissä is a comprehensive and multifaceted tribute to Kivikoski's life and work.

In the preface to the book, the editors Minna Silver and Pirjo Uino characterize the volume as "*an anthology describing Kivikoski's life work rather than a biography*". This is an accurate description: the book encompasses a variety of themes and issues related to Kivikoski and concentrates on her professional journey as an archaeologist. Altogether 25 authors have contributed to the book.

The book is divided into seven thematic sections, which include 31 articles, essays, or other texts. Some of the sections are dedicated more to scientific articles, while some include compilations of shorter texts. The book also includes a timeline of Kivikoski's life events, a bibliography of her publications, and English abstracts of the articles in the book. The thematic variation and large number of texts is meant to cover Kivikoski's life from as many angles as possible, but occasionally this makes the book seem somewhat inflated and rambling. Although most articles work well as separate texts, some articles overlap with others and hence there is a certain amount of repetition. These parts could have been more strictly edited, but apart from these exceptions, the editors have done a good job, the texts are well written, and the language is fluent and enjoyable to read. The layout and visual appearance of the book are also pleasant to look at.

The first section is dedicated to Kivikoski's birthplace, Tammela, and her school years in Forssa. Apparently, there is very little material available about Kivikoski's childhood and life before she became an archaeologist, so the editors have chosen to provide general background details about the Forssa region and Kivikoski's life at school. Some texts, however, feel like they might have worked better in some other context, and parts of this first section would have benefited from more compressed contents. Juhani Kostet's description of Kivikoski's family and early life drifts towards becoming a description of Tammela and of other archaeologists who have spent time in the region. Perhaps this article could have been combined with Minna Silver's compilation of events happening at Kivikoski's school during her time there. Panu Nykänen's article on the industrial development of Forssa is admittedly interesting, but might not be relevant to a reader who picks up this book expecting it to be solely about Kivikoski's life. This section ends with Sirkka-Liisa Seppälä's 1986 interview with Kivikoski, which would have been an excellent start for the first section, though it also works to close it and further acts as an introduction to the themes that are to come in the next sections.

The following section describes the beginning of Kivikoski's career in the 1920s–1940s. Timo Salminen's article about the formation of Kivikoski's professional and personal relations with her Baltic and Scandinavian colleagues is one of the most interesting in the book. Salminen cites excerpts from her letters to several people, including Tallgren, bringing her voice and personality to life. Sadly, this article also brings to mind how we now can relate to the experience of carefree international collaboration coming abruptly to an end, with colleagues and friends subsequently lost behind insurmountable borders.

In an article by Leena Söyrinki-Harmo, Kivikoski's career as a civil servant with the National Board of Antiquities, the predecessor of the Finnish Heritage Agency, is examined. Milton Núñez describes Kivikoski's excavations and research trips to Åland. These both excellent and concise texts contain many intriguing details.

Tiina Kinnunen's article offers an interesting description of the effects of the Second World War on the Finnish science community and on research in Finland. During the Finnish occupation of East Karelia in 1941–1944, several Finnish researchers from different disciplines conducted research in the area of the present-day Republic of Karelia. The State East-Karelian Scientific Committee was in charge of coordinating the research, often seeking to find scientific proof to back up the Finnish claim to the area. Kivikoski was sent to excavate some kurgans in Vitele, near the northeastern shore of Lake Ladoga, in 1943. This research trip is described in a detailed and riveting way in Pirjo Uino's article.

Kinnunen brings up several topics relevant to Kivikoski's career. For example, the absence of men in the work force left women to take care of everything. It included not just manual labour or industrial work (which are possibly best remembered), but also the duties of civil servants and administrative work. On the other hand, academic women who had families were largely tied to domestic work and childrearing when their husbands were at war, and their careers were hindered on that account. Kivikoski, who stayed unmarried her whole life, did not have these kinds of obligations. As Kinnunen (p. 129) puts it, war polarized gender roles. After the war, many men were bitter towards their female colleagues for their "unfair advantage" of having been able to pursue their careers during wartime. On a number of occasions this accusation was thrown at Kivikoski, too, when she was competing with a male colleague over a vacant position.

Another important point that Kinnunen mentions is the way the academic community was divided into those who believed in a nationalistic Greater Finland ideology, and those, like Kivikoski and Tallgren, who were internationally oriented and/or bilingual, and therefore resented extreme Finno-Ugrism and ethnonationalism. These tensions are discussed in Visa Immonen's article about the conflict between the more nationalistically inclined historians, Jalmari Jaakkola and Arvi Korhonen, and archaeologists Tallgren, Kivikoski, and Aarne Äyräpää. Jaakkola and Korhonen opposed Kivikoski at different stages of her academic career, such as when her PhD dissertation was about to be accepted, when she applied for the title of docent, and when she applied for the position of professor. The main problem for Jaakkola was that he could not accept the conclusions of Kivikoski's doctoral dissertation about the Aurajoki river valley as a culturally and socially central area of the late Iron Age Finland, or anything to do with the Swedes and the Finns being at different "stages of development" during this time.

Immonen clarifies Jaakkola's ideological position: he held highly nationalistic views about the Finnish past, and also liked to emphasize the historical importance of his native province Satakunta over others. Jaakkola was a historian and medievalist who had an agenda to prove Finland's independent political agency as early as the Late Iron Age-Early Medieval period. Jaakkola's emphasis on a strong, dichotomic divide between the east and the west, and

Finland's role in this struggle, fitted well into the political atmosphere of the Continuation War, but it quickly fell out of fashion afterwards. Kivikoski's unpolitical and cautious style of interpreting the past was more suitable for the post-war decades.

The following thematic section is mostly devoted to a feminist reading of Kivikoski's career. Aura Korppi-Tommola gives an excellent introduction to the topic, clarifying the reality for women studying at university or launching an academic career both before and during Kivikoski's time. Kivikoski represented the next generation after the trailblazing first generation of educated women: in the year Kivikoski was born (1901), women received equal rights with men to study at university. However, for a long time women were excluded from working in certain positions or professions, therefore making it difficult for educated women to advance in their careers. After the Second World War, the tensions regarding gender roles and the career paths of men and women also had an impact. The first female (full) professor at the University of Helsinki was gynaecologist Laimi Leidenius, appointed by the Faculty of Medicine in 1930, and Kivikoski was the next, 18 years later. The whole teaching staff was mostly comprised of men: Korppi-Tommola mentions (p. 202) that the teachers' lounge in the Main Building did not even have women's toilets until the 1970s.

After Korppi-Tommola, Minna Silver continues to explore the gender issue with two articles (which include several shorter information texts). Silver aims to bring to light female archaeologists who were active before Kivikoski or her contemporaries. As Tuukka Talvio has previously pointed out in his review (2021), it is important that Anna Lisa Lindelöf (Brander), (1893–1988), Tallgren's student, and the self-proclaimed "first female archaeologist in Finland", is referred to in the text. Also, Tallgren's mother, Jenny Maria Montin-Tallgren (1852–1931), should be recognized as one of the pioneers of Finnish archaeology, even though she lacked formal education.

Similarly, although some pioneering Russian female archaeologists are referred to, there is no mention of Countess P. S. Uvarova (1840–1924). After the death of her husband, A. S. Uvarov (1825–1884), archaeologist and "founder of prehistoric archaeology in Russia", the Countess was the chairperson of the Archaeological Society of Moscow for over thirty years (1885–1917). She was also appointed an honorary member of the St. Petersburg Academy of Sciences and she conducted surveys and fieldwork in the Caucasus. Uvarova was a prominent figure in organizing the Archaeological Congresses in Russia, in which Finnish archaeologists also participated until the Revolution. However, Uvarova was not a professional, academic archaeologist.

It seems evident that Swedish archaeologist Hanna Rydh had some influence in Kivikoski's career, but it also seems that maybe Kivikoski did not feel a particular need for female idols. In several parts of the book, it becomes evident that Kivikoski did not want to emphasize her gender, and opposed Rydh's and other Scandinavian female archaeologists' proclamation of doing archaeological research ”about, for, and by women". Rydh was also married and had children, which made a woman's academic career much harder and led to a number of obstacles that were absent from the life of a childless woman like Kivikoski. It should be borne in mind, therefore, that issues perceived as created by one's gender are actually created by many other individual circumstances as well.

Silver speculates that Rydh's book about the Paleolithic Age, *Grottmänniskornas årtusenden* (1926), was an inspiration for Kivikoski's pursuit of archaeology, since she owned the book and mentioned in Seppälä's interview a similar-sounding book her sister had received for Christmas. However, in the interview, Kivikoski refers to her sister's book (which is not named) as "my earliest memories related to prehistory", which seems odd if Silver's theory is correct, since Rydh's book only came out a year before Kivikoski began to study at university, and Kivikoski was then already 25 years old.

Korppi-Tommola notes that women studies and feminist philosophy were only introduced into the Finnish academic world during the 1960s–1980s, when Kivikoski was at the end of her academic career, and by 1969 was retired. Kivikoski was probably not an anti-feminist, but she did not wish to pay particular emphasis to gender issues. Professionally, she wanted to be recognized for her work and its scientific value, without any extra attention being paid to her on account of being a woman. And, after all, is that not what we all wish? It is worth remembering, that while the assumed gender of a person can greatly affect their opportunities in life and the way society sees them, the gender identity of the person themselves can be fluid and non-binary.

Silver's other article about women archaeologists in Europe during the late 19th and early 20th centuries is interesting but seems somewhat excessive in the context of this book. However, the thought comes to mind that there could be some demand for a separate book focusing solely on women and equality in Finnish archaeology, touching upon other related matters as well, such as the representation of minority groups.

The next section is dedicated to Kivikoski's work as a field archaeologist. The opening article by Mervi Suhonen and Mika Lavento is undoubtedly one of the best in the book. The quality of the writing, the inclusion of interesting details and thoughts, and the amount of work shown are all impressive. Among other topics, the article introduces interesting questions concerning the history of excavation methods in Finland, and especially the role of the workforce used to do the manual excavating. I have often wondered this myself: When did working as manual labour on excavations became the staple summer job for archaeology students and a subject of artisanal and professional pride, rather than the workforce being random workers recruited from the area? It seems that this change began during the 1970s, but why? This would be an interesting topic for a separate study on the history of archaeological fieldwork in Finland.

Somewhat surprisingly, in several articles it is mentioned that Kivikoski used to give a considerable number of interviews to magazines, both aimed at women, like *Me Naiset* and *Kotiliesi*, as well as others like *Yhteishyvä*. In the latter magazine, she famously said in a 1958 interview: "The work speaks for itself – gender is irrelevant". The title for this interview was "Nobody knows what an archaeologist has to suffer." She also wrote popular texts about archaeology for magazines and newspapers and gave lectures on radio. The interviews in women's magazines tended to describe Kivikoski as a person, her hobbies, or even her fashion sense, instead of her life as a professional. It seems that Kivikoski did not shun publicity, nor was she afraid of "building a personal brand" for herself, as the modern expression goes. No doubt the women's magazines were especially interested in writing about Kivikoski because of her gender, but I dare say that no other professor of archaeology in Finland has featured this prominently as a "celebrity".

Pirkko-Liisa Lehtosalo-Hilander describes Kivikoski's clearly difficult relationship with gender issues in her intriguing article. As mentioned earlier by Timo Salminen, Kivikoski represented Alfred Hackman's research orientation: They were both very careful with broad hypotheses or syntheses, instead preferring to observe typological, chronological, and spatial variation of artefact types. Kivikoski was interested in tracing ethnic and cultural patterns through archaeological material, as well as studying the relations and fluctuations between cultural spheres.

As Minna Silver mentions, many female pioneers of archaeology in Scandinavia were especially interested in the history of women, children, and families, as well as researching prehistoric societies from the viewpoint of their internal hierarchies related to gender and power. However, these intra-societal dynamics seemed to hold no interest for Kivikoski. As Lehtosalo-Hilander points out, sometimes it even seems as if she was deliberately avoiding that subject. It would appear that she was only willing to explore the agency of adult men in Iron Age societies. While she did not have any trouble describing traditionally male activities like hunting, anything related to women or the household felt awkward to her. As Lehtosalo-Hilander states, in Kivikoski's writing, Iron Age women are like lifeless mannequins who wear jewellery, which can then be studied to reveal typological change and cultural contacts.

Consistent avoidance of discussing gender and relations between individuals could stem from some personal experience or possibly an awkward or uncomfortable relationship with one's own gender identity. When these kinds of experiences or emotions are left unprocessed, it can lead to dissonant approaches. In this respect it is particularly fortunate that the book presents a previously unknown work by Kivikoski which throws a new light on the discussion of her and gender. In 1930, Kivikoski wrote her laudatur

(Master's) thesis in Finnish and Scandinavian history on the role of women. The study mainly discusses women in Medieval Finnish and Scandinavian society, without avoiding such topics as celibacy, but it also includes discussion of Iron Age women, stating that Viking Age women in Finland and Scandinavia were not repressed but were brave and worthy like the men, and were quite possibly warriors.

The examiners of the thesis, history professors Jalmari Jaakkola and Gunnar Suolahti, graded Kivikoski's dissertation *cum laude approbatur.* Pirjo Uino speculates (p. 327–329) that since Kivikoski was used to achieving higher marks for her studies, a *cum laude* would have discouraged her from researching women's history in the future and might also have prompted her to transfer to archaeology for her doctoral degree. Whatever may be the case, it would seem to have changed Kivikoski's perceptions about researching gender-related topics. Uino remarks that it is unlikely that Suolahti would have graded the work poorly because of its subject, since his students commonly wrote dissertations about their own interests, and there is nothing controversial in Kivikoski's dissertation: after all, it praises Finnish women. Perhaps the problem was Jaakkola, and would then be related to something about the way Finnish as opposed to Swedish women were described: Kivikoski examines the much-debated topic of Finns as Vikings. Unless some new sources depicting Kivikoski's own thoughts surface, the matter of the strange relationship between Kivikoski and gender issues will remain a mystery.

Later in the book, Lehtosalo-Hilander (p. 494) reminisces about the time when as Kivikoski's student she asked her about the archaeological traces of warrior women in the Viking Age. Kivikoski snorted that if such women ever existed, they soon came to their senses, got married, and were buried like all the other women. It seems that even today, some people perceive studying gender in the past to be irrelevant, but it can be argued that the study of a past society remains largely incomplete if all other groups than adult males are omitted from the picture.

The following articles in the book very much resemble those found in a *festschrift*,[1] but they nevertheless fit into the anthological character of the book. All these articles include interesting and detailed information. Pirjo Uino has written about the jewellery company Kalevala Koru and manufacturing replicas of Iron Age jewellery. Kristiina Korkeakoski-Väisänen and Auli Bläuer examine the interpretations made about the cremation burial ground in Lieto Ylipää, and Terttu Lempiäinen describes the history of researching archaeological macrofossils in Finland.

The *festschrift* feeling continues in the last article section, which goes back to exploring the history of the region of Häme, where Kivikoski spent her early life. Articles by Eero Ojanen, Päivi Maaranen, and Riho Grünthal examine different interdisciplinary aspects of archaeology, history, geography, and linguistics in relation to Häme and Finland in general. The wide-ranging articles by Christian Carpelan and Eva Ahl-Waris, about the changing interpretations of migration and continuity in Finnish prehistory and the Late Iron Age, respectively, are excellent. These kinds of reflective articles addressing Kivikoski's interpretations of the past, and the further development and changes in her research themes, could have been more numerous in the book.

The last two sections resemble a scrapbook of all things Kivikoski. The anthology of memories about her by former students, colleagues, and friends is engrossing, funny, and warm-hearted, bringing her personality alive even to those who never had the chance of meeting her. The quirks of her personality are not glossed over. Several contributors, for example, reminisce on Kivikoski's tendency to pick favourites among her students, some of whom later were employed by her and became lifelong friends. However, her favouritism is always mentioned in a cordial way. Either none of her acquaintances felt slighted, or then those who had something against Kivikoski did not provide memories for the book. It should also be noted that the events described happened decades ago, and Kivikoski's former students have now already retired themselves.

The final section presents Kivikoski's letters, postcards, and interviews. The title of the book *Tiedenainen peilissä* ("A woman scientist in the

1 An actual festschrift was dedicated to Kivikoski in 1973 (Sarvas & Siiriäinen, eds.).

mirror") is explained; it comes from a book review written by Kivikoski about Veijo Meri's *Nainen peilissä* ("A woman in the mirror"). Even if the last two sections are a rather exhausting smorgasbord of small titbits, they include a great deal of information. Everything there, as well as in the book as a whole, will undoubtedly serve as a useful source for future scholars studying Kivikoski or the history of Finnish archaeology in general.

Biographies or memoirs of Finnish archaeologists are rare (Kivikoski 1960; Meinander 1991; Edgren 2013; Salo 2014; see in addition Relas & Metsola 2017), and this book has been eagerly awaited. It includes much original research and previously unpublished information. Writing and editing has required massive work by the contributors and editors, to whom we should be grateful, and this book can be considered an important and influential work. But one question still remains: who now will pick up the thread left by Kivikoski (1960) and complete a thorough study of the life and works of A. M. Tallgren?

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REFERENCES

Edgren, T. 2013. *Carl Fredrik Meinander. Arkeolog med perspektiv.* Helsingfors: Museiverket.

Kivikoski, E. 1960. *Tehty työ elää. A. M. Tallgren 1885–1945.* Helsinki: Suomen Muinaismuistoyhdistys.

Meinander, C. F. 1991. *Carl Axel Nordman.* Helsingfors: Svenska litteratursällskapet i Finland.

Metsola, M. & Relas, J. (eds.) 2017. *Sakari Pälsi. Elämä ja työt.* Helsinki: Into Kustannus & Sakari Pälsin seura ry.

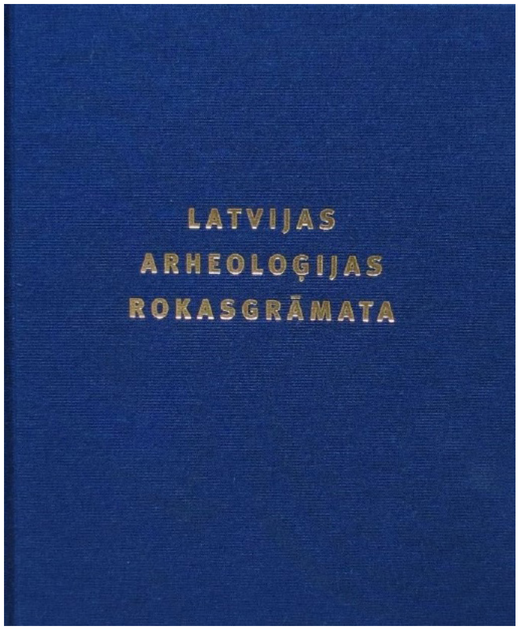
Rydh, H. 1926. *Grottmänniskornas årtusenden.* Stockholm: P. A. Norstedt.

Salo, U. 2014. *Iso tammi. Lehvän taittajan tarina.* Edited by M. Vesterbacka. Sastamala: Warelia.

Sarvas, P. & Siiriäinen, A. (eds.) 1973. *Honos Ella Kivikoski.* SMYA 75. Helsinki: Suomen Muinaismuistoyhdistys.

Talvio, T. 2021. Kunnianosoitus Ella Kivikoskelle. *Muinaistutkija* 1/2021: 46–51.

Andrejs Vasks & Gunita Zariņa (eds.): *Latvijas arheoloģijas rokasgrāmata*. Zinātne, Rīga 2021. ISBN 978-9934-599-08-8. 678 pp.



Latvijas arheoloģijas rokasgrāmata (Handbook of Latvian Archeology) is a massive edited volume aiming to provide an overview of the state-of-the-art of archeology in Latvia at the beginning of the 2020s. It is based on more than a century of research and continues a series of comprehensive presentations of the prehistory of Latvia. The first account was *Latvijas archaioloģija* (Archaeology of Latvia) in 1926, followed by *Senākie laiki: Latviešu senvēsture* (The Ancient Times: Latvia's Early History) in 1938; Both volumes were edited by Francis Balodis. Two works were published during the Soviet occupation, compiling the accumulating evidence and new discoveries: Harri Moora´s monograph *Pirmatnējā kopienas un agrā feodālā sabiedrība Latvijas PSR teritorijā* (Prehistoric Societies and the Early Feudalism in the Latvian SSR) appeared in 1952 and *Latvijas PSR arheoloģija* (Archaeology of the Latvian SSR), edited by Anatolijs Bīrons et al. in 1974.

After regaining independence, two more general reviews on Latvian prehistory were compiled: *Latvijas aizvēsture, 8500. g. pr. Kr.–1200. g. pēc Kr.* (Prehistory of Latvia, 8500 BC–AD 1200) authored by Andrejs Vasks et al. in 1997 and *Latvijas senākā vēsture, 9. g. t. pr. Kr.–1200. g.* (The Oldest History of Latvia, 9th Millennium BC–AD 1200) edited by Jānis Graudonis et al. in 2001. Although both contain new research, they draw largely on material presented in *Latvijas PSR arheoloģija*. In addition, a book for a wider audience, *Arheoloģisks ceļvedis latviešu un Latvijas vēsturē* (Archaeological Guide to the History of the Latvians and Latvia), was published in 2012 by Arnis Radiņš. This background highlights the need for a new volume summarising Latvian pre- and early history and presenting an overview of the development of Latvian archaeology in the post-Soviet decades. Therefore, *Latvijas arheoloģijas rokasgrāmata* can be considered the most substantial and ambitious compilation of Latvian archaeology in almost 50 years.

The volume is credited to the editors Andrejs Vasks and Gunita Zariņa, followed by the editorial board consisting of Jānis Ciglis, Arnis Radiņš, Antonija Vilcāne and Juris Urtāns. The book is authored by a large collective – 50 people in total – including a number of archaeologists, but also specialists in palaeogeography, palaeobotany, bioarchaeology, numismatics, folklore, history, landscape architecture and ethnomusicology. The list of authors includes scholars, who started their career decades ago, but also introduces a new generation(s) of Latvian archaeologists; 27 authors are women, 23 men. Each author's contribution varies widely from single or a few short entries to dozens of pages and topics. The largest contributors are Vasks (over 60), Vilcāne (over 50) and Urtāns, Ciglis, Ieva Ose and Tatjana Berga (over 30 entries each). The selection of the authors is usually based on personal scientific interests, which are reflected in the text as a broad knowledge base and expertise. At the same time, the large number of authors leads to recurrent variations and imbalances between the form and content of the different parts, chapters and entries of the book.

Latvijas arheoloģijas rokasgrāmata is large by its external dimensions: the hardcover volume has 678 pages and weighs around 3.5 kg. The book contains nine main chapters, a summary in English, a list of references, and indexes of the archaeological sites and persons mentioned. Instead of being a traditional national prehistory, *Latvijas arheoloģijas rokasgrāmata* is a reference work – hence the name handbook. Consequently, the reader is not presented with an organised chronological or thematic narrative, but rather detailed descriptions and data under various headings from which understanding must emerge. While this may be troublesome to some general readers, it serves the professional audience well and allows for in-depth treatment of numerous topics. The majority of the book is dedicated to presenting key sites and main find groups (Chapters IV and V, which take up about two-thirds of the volume), but some basic concepts, methods, history and current practice in archaeology are also illustrated. Starting from the Late Palaeolithic, the volume thus covers more than 12,000 years of archaeology in the territory of what is now Latvia.

Chapter I is simply titled *Archaeology* and aims to give a general introduction to the field. It contains short entries of central theoretical directions (culture-historical, processual and post-processual) and traditional terms (archaeological culture, diffusion, migration and autochthonism) of archaeology – the selection reflects a rather old-fashioned view of archaeology and largely misses theoretical discussions (references) and concepts, which were introduced in the 2000s. A similar take on archaeology is also reflected in numerous other entries and interpretations presented in the volume. The description of different sub-fields of archaeology introduces newer approaches, but presents a limited number of fields, including aerial, underwater, experimental, social, military and ethnoarchaeology and archaeology of dark heritage (labeled here terror).

Dating methods of different scales and accuracies are presented in ten entries. This is justifiable since (absolute) chronology is the backbone of any archaeological inquiry. Still, some of the treatment is somewhat outdated, for example, the discussion of radiocarbon dating focuses mostly on conventional method rather than AMS, and marine or freshwater reservoir effects are not discussed at all in the book, even if they are known to have potentially large impact in the area (see e.g., Meadows et al. 2016). Although the *Preface* (p. 7) mentions that radiocarbon dates are presented as calibrated, the calibration curves used and other bases for the chronologies remain unspecified, and BC and cal BC datings are presented side-by-side.

It is unfortunate that the next section of Chapter I, periodization, does not include a concise overview of the temporal division and chronology of Latvia's prehistory. A graph or table would have been helpful to understand at a glance the framework on which the book is based. The section contains descriptions of the main periods as defined in Latvian archaeology. The welcome inclusion of periods younger than about AD 1200, i.e. the mediaeval, pre-Modern and Modern times, has not been common in the general archaeological overviews and finds parallels only in the 1974 volume. However, the descriptions of the different periods vary in style and content: part of the entries focus only on the territory of Latvia, while others present a broader context of (northern) Europe. Such inconsistencies run throughout the book. Likewise, the inability of heading levels to reflect the hierarchy of the text is a recurring problem (here, for example, periods and their sub-periods are marked with similar headings).

Chapter II presents some of the methods and materials from other humanities, social and especially natural sciences used in archaeology, called 'auxiliary sciences' in Latvian archaeological parlance, including paleogeography and paleobotany. The chapter also contains a detailed entry on numismatics, the coins and their minting in Latvia throughout the prehistory and history – method aside, it remains unclear why this is included in Chapter II, as the other entries summarising groups of primary materials are found in Chapter V. The reminder of the chapter is grouped under the title *Bioarchaeology*, the content of which is again divided in two. Part of the entries provides brief introductions to selected topics (zooarchaeology, paleopathologies, isotope and aDNA analyses), while half of the section consists of a series of presentations of paleodemography based on physical anthropology on Latvian materials during different periods.

Chapter III gives a compact overview of the history of Latvian archaeology since the 19th century and describes five main periods of its development, all of which are closely connected to the political situation of the country. The chapter highlights the possibilities and difficulties faced by the practice of archaeology over the years and under different regimes, and introduces some of the main figures involved in the development of Latvian archaeology.

Chapter IV is one of the main chapters of the book and consists of a catalogue of different types of archeological sites in Latvia. In addition to general descriptions of site types, entries of about 280 locations are included (actually the number is higher, as several entries cover more than one site or multi-period locations). Overall, the presented monuments make up approximately 10% of the archaeological sites registered in Latvia (see data on p. 109). Sites are roughly divided into habitation and burial places. The former consists of settlement sites, (Iron Age) pile dwellings, hillforts as well as partially overlapping categories of historical towns and castles. The latter includes burials, burial grounds and cemeteries divided into Stone, Bronze and Iron Age as well as mediaeval and historical monuments. Other site categories featured include deposits (hoards), ecclesiastical (Christian) monuments, sacred places, fossilised fields and production places, historical earthworks (fortifications) and other later infrastructure.

The *Preface* indicates that only the most important sites are included (p. 7), but no actual criteria for selection are given; one might imagine that these are related to the representativeness of material and the general focus of research. The most numerous site types presented are different Iron Age burials (93), hillforts (50), settlement sites (41, nearly all being from the Stone Age) and castles (33). Compared to the general composition and dating of all sites (p. 109), settlements and castles are somewhat over-represented and burials under-represented, balancing the choice of sites illustrated. Apart from deposits, only a few or no examples are included for the other site categories. The geographic balance of the presented sites is hard to assess as there is no map showing their distribution.

The space given to each monument varies from just some rows to several pages. This can be attributable to the availability of material and the scope of the studies conducted, but also to the personal touch and preferences of the authors, and results in presentations that are not necessarily comparable. Despite these problems, the chapter gives a broad cross-section of archaeological monuments in Latvia and can be used as an index of the key sites and their research.

Chapter V forms the second major block and presents the main find categories. The task is challenging due to the amount of material and its variability and the categorization remains nonsystematic. It is primarily based on the (presumed) function or use context of artefacts (including the following main categories: tools, weapons, saddlery and horseman´s accessories, jewellery, vessels, hygiene and household items, artefacts connected with trade, toys and games, writing equipment), but in a few cases on the raw material used (categories: clothing, leather goods, building materials and details), or on neither (categories: Latvian musical archaeology, miniature objects, stray finds and ornaments). Furthermore, the division of roles between Chapters V and VI is unclear and overlaps. The latter deals with raw materials and their working and discusses flint and stone, bone and antler, bronze, iron, wood, leather, cloth, amber and glass – but clay, for example, is missing.

The varying presentations of artefacts are focused on the metal and later periods. Stone tools are meagerly described, and materials such as flint are mentioned only in Chapter VI. Various objects of organic materials from the Stone Age, numerous in Latvia (e.g., Vankina 1970; 1999; Loze 1988), are largely omitted. Stone Age amber ornaments are only displayed in Chapter VI, while the animal tooth pendants known in thousands (see Macāne 2022) are not included beyond a passing mention. Among the categories presented, two entries stand out. The first by Irita Žeiere gives a comprehensive overview of the Late Iron Age – historical clothing and dress in different parts of Latvia. The second by Baiba Dumpe presents a compact and systematic summary of the clay vessels used in Latvia from the Stone Age to the historical period.

The title of Chapter VII, *Ethnic groups*, may catch the eye of a reader unfamiliar with the ethno-historical research tradition that combines archaeology, linguistics and historical ethnic groups. The chapter gives brief descriptions of the ethnic units constructed in the area of Latvia, the Balts (Curonians, Semigallians, Selonians, Latgallians) and the Baltic Finns (Livs and Vends). Such a culture-historical approach is still present in Latvian archaeology, especially in relation to the later parts of prehistory, and is also reflected in the more recent archaeogenetic studies.

The remaining two short chapters focus on the present day. Chapter VIII deals with the protection, conservation and management of archaeological and cultural heritage, as well as the applicable national and international legislation. Chapter IX introduces the main repositories and keepers of archaeological materials and documentation in Latvia. However, entries on higher education in archaeology, the academic and museum network and their pedagogic activities, general ethical issues in archaeology, metal detecting and citizen science, and private sector and contract archaeology would have contributed to a fuller understanding of the various aspects of current Latvian archaeology.

The bibliography is extensive, although references are used variably between different parts and entries in the volume. It contains quite little new literature, which reflects the general content of the handbook: traditional tones prevail, while the new methods are only introduced and the first results are preliminary. It is likely that *Latvijas arheoloģijas rokasgrāmata* will later be seen as a snapshot of Latvian archaeology at the crossroads of research traditions and generations.

All in all, the handbook has been a massive undertaking. The background of the work can be found in an earlier project on an electronic archaeological lexicon, which was eventually transformed into a handbook (see Sprēde 2022). This remains visible to some extent as unsystematic treatment and imbalance between the different parts of the outcome. Despite the encyclopaedic nature, a more rigorous editing would have been desirable. On the technical side, too, more attention could have been placed on consistency. On the other hand, the length of the work and the number of authors make such errors quite understandable.

Richly and colourfully illustrated, the book includes hundreds of photos and drawings of sites and artefacts, as well as archival sources and field documentation. The layout by artist Mārtiņs Plotka is generally clear. The text runs in two paragraphs, opening up opportunities for the interplay of illustrations and text, but occasionally fitting too many images, captions, headings and author names on a single page or opening makes the layout uneasy to the eyes. In a few cases, the illustrations are unnecessarily truncated or overlapped (e.g., pp. 466, 472, 580–81). The visual appearance is quite varied as the sources of the images are diverse. Maps are numerous and an important source of information, but a revision to a more consistent outlook would also have been advisable, at least for maps created specifically for this handbook. In addition, their usage is sometimes inconsistent, and the reader might have hoped, for example, for maps for all the periods presented in Chapter I (now the Late Iron Age and later periods maps are missing).

Despite the above remarks, *Latvijas arheoloģijas rokasgrāmata* is a significant addition to the existing Latvian archaeological literature, providing an overview of the main archaeological sites and some of the recent developments in the field of archaeology. It not only serves the archaeological community and the next generation of researchers, but also the wider public who are interested in Latvian prehistory in general or in certain sites or fields of research in particular. The merits have already been recognized by the handbook being voted as one of the most significant scientific achievements in the annual competition of the Latvian Academy of Sciences in 2021.

As *Eesti esiaeg* (Prehistory of Estonia; Kriiska et al. 2020) published a year earlier, *Latvijas arheoloģijas rokasgrāmata* documents the development of Latvian archaeology, particularly after regaining the independence in the early 1990s. The Soviet occupation left deep marks and cast long shadows also in the field of archaeology, in research and excavation methods, as well as in the education system – a 'legacy' that takes time to overcome. At the same time, much archaeological materials produced during this period in major infrastructure projects and field expeditions are still actively used and will also serve the future generations of scholars, but without top-down dogmatic ideological constraints.

Given the rapid development in archaeological research and various scientific methods – which are also underlined in the volume – many entries in the handbook will soon be outdated. Nonetheless, the site and material descriptions are unlikely to change quickly, emphasising the value of the book. Still, one can wonder how practical or popular a heavy volume of nearly 700 pages is in 2021. Wouldn't an electronic version also find its niche and demand in the current market?

While *Latvijas arheoloģijas rokasgrāmata* is clearly aimed at Latvian audiences, it has broader, international value. Latvian territory and archaeology is still fairly little known internationally and this volume gathers in one place a lot of information previously scattered in numerous monographs and hard-to-find journals. The problem in this context, as in many of the previous publications, is the Latvian language: 680 pages compressed into just three pages of English summary are hardly enough. However, rumour has it that an English version of the handbook is already being prepared

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REFERENCES

Balodis, F. (ed.) 1926. *Latvijas archaioloģija*. Rīga: Valters un Rapa.

Balodis, F. 1938. Senākie laiki: Latviešu senvēsture. In F. Balodis & A. Tentelis (eds.) *Latviešu vēsture I*: 12–55. Rīga: Valters un Rapa.

Bīrons, A., Mugurēvičs, Ē., Stubavs, A. & Šnore, E. (eds.) 1974. *Latvijas PSR arheoloģija.* Rīga: Zinātne.

Graudonis, J., Mugurēvičs, Ē. & Vasks, A. (eds.) 2001. *Latvijas senākā vēsture. 9. g.t. pr.Kr. – 1200. g.* Rīga: Latvijas vēstures institūta apgāds.

Kriiska, A., Lang, V., Mäesalu, A., Tvauri, A. & Valk, H. 2020. *Eesti ajalugu I: Eesti esiaeg.* Tartu: Tartu Ülikool.

Loze, I.A. 1988. P*oseleniya kamennogo veka Lubanskoy niziny: mezolit, ranniy i sredniy neolit.* Riga: Zinate.

Macāne, A. 2022. *Stone Age Companions: Humans and Animals in Hunter-gatherer Burials in North-Eastern Europe.* GOTARC, Series B, Gothenburg archaeological theses 81.

Meadows, J., Bērziņš, V., Brinker, U., Lübke, H., Schmölcke, U., Staude, A., Zagorska I. & Zariņa. G. 2016. Dietary freshwater reservoir effects and the radiocarbon ages of prehistoric human bones from Zvejnieki, Latvia. *Journal of Archaeological Science: Reports* 6: 678–89.

Moora, H. 1952. P*irmatnējā kopienas iekārta un agrā feodālā sabiedrība Latvijas PSR teritorijā*. Rīga: Latvijas Valsts izdevniecība.

Radiņš, A. 2012. *Arheoloģisks ceļvedis latviešu un Latvijas vēsturē.* Rīga: Neputns.

Sprēde, A. 2022. Patriotisma paraugs – Latvijas arheoloģijas rokasgrāmata. <htt-ps://www.lu.lv/par-mums/lu-mediji/zinas/zina/t/69940/> Read 6 Dececmber 2022.

Vasks, A., Vaska, B. & Grāvere, R. 1997. *Latvijas aizvēsture, 8500. g. pr. Kr. – 1200. g. pēc Kr.* Rīga: Zvaigzne ABC.

Vankina, L. 1970. *Torfyanikovaya stoyanka Sarnate.* Riga: Zinatne.

Vankina, L. 1999. *The Collection of Stone Age Bone and Antler Artefacts from Lake Lubāna: Catalogue.* Riga: N.I.M.S.