MUINASAJA TEADUS 27

saints, bishops, towns and castles

Time travels into Middle and Early Modern Ages

Studies in Honour of Jaan Tamm

Compiled and edited by
Erki Russow and Valter Lang

Tallinn–Tartu 2018

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pühakud, piiskopid, linnad ja linnused

Ajaränna kuid kesk- ja varauusaega

Uurimusi Jaan Tamme auks

Koostanud ja toimetanud
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Tartu Ülikooli ajaloo ja arheoloogia instituudi,
Tallinna Ülikooli arheoloogia teaduskogu ning
Tallinna Ülikooli ajaloo, arheoloogia ja kunstiajaloo keskuse ühisväljaanne

Muinasaja teadus
(alates 1991. aastast)

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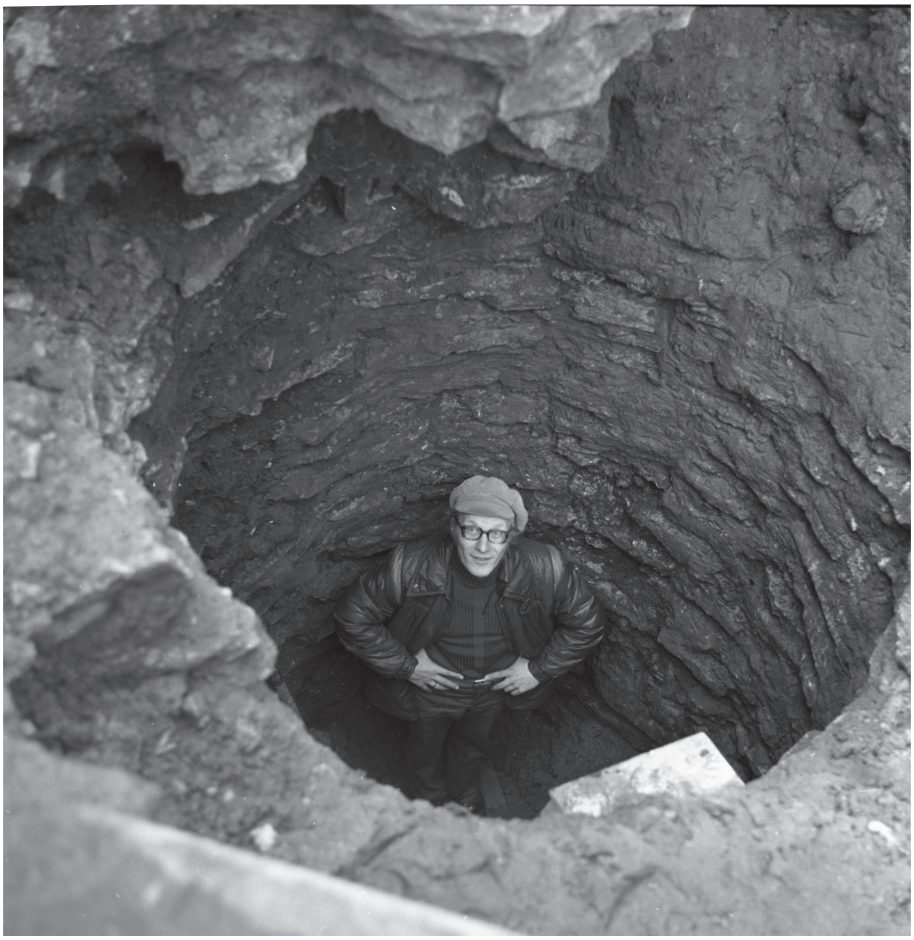

Fanny

Sisukord – Content – Inhalt

Relics from the Pirita Bridgettine Convent near Tallinn

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The interdisciplinary project of the Department of Archaeology of the University of Turku concerning relics of the Turku Cathedral studied as comparative material five bones, which had been used as relics and were discovered in the excavations of the Pirita Convent in 1977 and 1979. With the exception of one finger bone relic, the relics and their related textiles have been dated and determined. The results reveal that the relics are considerably older than the textiles. The isotope analysis indicates the origin of the persons, represented by the relic bones, inside the Estonian territory, or a geologically similar region. The DNA studies did not contribute to the identification of the saints.

Key words: Middle Ages, Pirita Convent, relics, saints, textile, DNA and isotope studies

Turu ülikooli arheoloogia osakonna Turu katedraali reliikviatele pühendatud interdistsiplinaarne projekt uuris võrdlusmaterjali saamiseks Pirita kloostri arheoloogilistel kaevamistel 1977. ja 1979. aastal leitud viit luuleidu, mis on olnud kasutusel reliikviatena. Kõik reliikviad ning nendega seotud tekstiilid, v.a üks sõrmeluu, dateeriti ja määratleti loodusteaduslike meetoditega. Isotoopanalüüs osutas, et reliikvialuud pärinevad kas Eesti alal või geoloogiliselt samasuguses piirkonnas elanud inimestelt. DNA-uuringud ei aidanud kaasa pühakute tuvastamisele.

Võtmesõnad: keskaeg, Pirita klooster, reliikviad, pühakud, tekstiili-, DNA- ja isotoopuuringud

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Introduction

In 2007, an interdisciplinary project was launched at the Department of Archaeology, University of Turku, to study the surviving medieval relics of the Turku Cathedral (Taavitsainen 2009; 2011a; 2011c), which were acquired by the cathedral during the Middle Ages but lost their liturgical importance after the Reformation. The relics were not all destroyed or thrown away – some were deposited inside a wooden reliquary casket attributed to the bishop called Blessed Hemming (in office 1338–1366); others were hidden in a wall niche in the sacristy and discovered by archaeologist and a building historian Juhani Rinne during the restoration of the cathedral in the 1920s. The surviving collection consists of approximately 90 relics including bones, wood, textiles, paper, a bag for relics, pieces of wax seals, a medieval coin, etc.

According to Rinne's estimations, there are approximately thirty saints represented among the relics besides Saint Henry, including King Eric, saints Margaret, Benedicta, and Pancras, the Holy Innocents, and (possibly) Saint Bridget, while small fragments of stone ascribed to Gethsemane are related to Christ. However, most of the relics and their fragments have remained unidentified. Rinne's research represented what was then the cutting edge of science, applying X-ray photography and anatomical analyses to the skulls and bones. He described every object and fragment in detail and accompanied his text with lavish illustrations and photographs (Rinne 1932).

In medieval studies since the 1980s, the cult of relics has come to be seen as one of the most characteristic aspects of western Christianity. The veneration of relics is a vantage point from which, among others, the social construction of holiness, various responses to religious images, and the religious significance of sacred bodies have been analysed. Relics and reliquaries occupied a core position within medieval piety, and the cult of saints permeated the society (Angenendt 2007). Due to their central position in culture, the relics of Turku Cathedral offer glimpses of a range of material, social and cultural phenomena related to the medieval cult of relics. Moreover, an archaeological perspective on medieval relics provides a unique opportunity to incorporate a range of technologies and approaches and with that intention in mind the Turku relics project was initiated.

The project has presented its findings by discussing some relics in detail and highlighting a few specific problems (Arponen 2011; 2015; Immonen 2007; Immonen & Taavitsainen 2011; Karttila 2014; Kirjavainen 2015; Taavitsainen 2011b; Taavitsainen & Hiekkanen 2011; 2014; Taavitsainen *et al.* 2014; 2015). In order to obtain comparative material, the project was expanded to Estonia with the question in mind whether the five bones used as relics, discovered in the

excavations of the convent, might include those of Bridget's period and even of the saint herself. Bishop Hemming belonged to the circle of friends of the Swedish visionary Bridget. The saintly reputation of his memory apparently began to evolve primarily from his close connection with her. Hemming was beatified in 1514, but the canonization process was interrupted by the Reformation (Klockars 1960). Hemmings' friendship with Bridget gives reason to assume that St Bridget would be represented among the relics in Turku Cathedral. Furthermore, the altar of the Corpus Christi in Turku Cathedral, which was founded by bishop Magnus Tavast in 1421, was also dedicated to St Bridget (Rinne 1948, 58–59). The ^{14}C dating of the relic known as the cap of St Bridget (Rinne 1932, 355–364), however, preclude its connection to her. In Sweden, the skulls of St Bridget and her daughter St Catherine are kept as relics in Vadstena Abbey. The results of the recent ^{14}C and mtDNA investigations of the skulls, however, show that they do not belong to Bridget and Catherine (Nilsson *et al*. 2010). After the negative results in Vadstena and Turku it was natural to turn to the Pirita Convent to find relics of St Bridget. Positive results would be the first scientific evidence of one of the Patron Saints of Europe.

Excavations in Pirita and the relics

We know from history that after the pope had granted privileges to the Pirita Convent in 1411, its first female and male members began to arrive at Pirita from Vadstena the following year, carrying with them a number of relics. Among others, the convent's first abbess, Christina Tocke, and an experienced craftsman, Stephan Liongason-Lapidica, arrived from Sweden (LUB, VI Nr 2987; Raam & Tamm 2006, 19). The convent's church was consecrated in 1436.

The Pirita Convent has been archaeologically investigated at various points in time since the 1930s. In 1934–1936 the Chair of Art History of the University of Tartu initiated the first large-scale research there, supported by the Swedish state (Fig. 1). The research took place in the eastern part of the convent, on the site of the vestry and the parlatory as well as their annex rooms (Ahl 2007; Markus 2013; Pirita 1936; Tuulse 1936; 1938).

The area of the southern seclusion on the men's side was researched in 1962–1963 (Raam & Tamm 2006, 25). The most extensive archaeological excavations started in 1975 and lasted for six seasons, until the autumn of 1980 (Raam & Tamm 2006, 25). This excavation also unearthed the remains of the earliest church, presumably the Chapel of Saint Bridget (Birgitta) and the former altars within the church's surviving remains (Tamm 1981, 420). Despite the fact that

floor slabs of the convent church were re-used as building material in the construction works in Tallinn following fire damage to the eastern wing of the nuns' seclusion in 1564 (Olearius 1996, 116), the main body of the church with numerous altars survived until its destruction by the troops of Ivan IV on 1 February 1577 (Russow 1845, 230). Only then were the vaults and the pillars destroyed and probably also the altars, which were used for making cannon balls during the great siege of Tallinn. Most of the lower parts (and also some details from the upper parts) of the altars in the convent and the church survived (Raam 1984, 63–84). However, only in three cases we can assume the saint to whom the altar was dedicated. The main altar, dedicated to the Virgin Mary, stood by the eastern wall of the central nave of the church; the altar dedicated to St Bridget stood in the second bay from the west, in the north nave of the church. The altar dedicated to St Michael was located in the south-western chapel outside the church, which was connected with the south nave by a large vaulted opening.

Fig. 1. *Between 1934–1936 the first large scale archaeological excavations at the Pirita Convent were organised. This montage from 1934 shows the key organisers from Sweden and Estonia as well as a selection of found structures and artefacts.*

Jn 1. *1934.–1936. aastal toimusid esimesed suuremad arheoloogilised kaevamised Pirita kloostris. 1934. a fotomontaažil on kujutatud tööde peamised organisaatorid ning valik leitud struktuure ja esemeid.*

Photomontage / Fotomontaaž: Karl Akel

The relics were discovered in the excavations of the church in 1977 and 1979 (Figs 2–3). The bones were covered with braids and textiles brocaded with metal threads. The soil and debris were heavily mixed, which made it impossible to determine whether the bones had belonged to one and the same collection or whether they originated from different altars. The find spot was the same, the third bay from the east in the north aisle (Tamm 1978a, 13; 1978b, 43).

In 1977 fragments of two arm bones (TLM 18540: 371, 483) and fragments of two finger bones (TLM 18540: 484–485) were discovered. They were discovered from a fairly large area of a mixed floor layer under the debris of the vaults and it was therefore stratigraphically impossible to relate them to any of the three altars in the aisle. The relics had most probably been deposited in the aisle during the destruction of the church. Also, a fifth fragment of a relic (TLM 18437: 48) was discovered in the same aisle in 1979, though much closer to the northern wall. This fragment did not belong to an arm bone, but to a leg (Aus 1980, 15). The Pirita relics are the only relics known in Estonia, so far.

Fig. 2. *The area of the altars in the church of the Pirita Convent where the relics were found.*

Jn 2. *Pirita kloostri kiriku altarite piirkond, kust reliikviad leiti.*

Photo / Foto: Villem Raam

Fig. 3. *The area of the Chapel of Saint Bridget in the church of the Pirita Convent.*

Jn 3. *Birgitta kabeli ala Pirita kloostri kirikus.*

Photo / Foto: Villem Raam

The relics, their textiles, and dates

Five bone relics were found in the ruins of the church of the Pirita Convent, along with related textiles or their fragments. The relics, the textiles, and the results of their radiocarbon dating are discussed below.

Relic TLM 18437: 48

The relic is part of a long limb-bone (Fig. 4–5). It is 160 mm long, with a maximum width of 60 mm and maximum thickness of 30 mm. One end of the bone is fractured or broken off and the other end has been sawn off. A radiocarbon sample was taken from the broken end and a sample for a DNA analysis was drilled from the sawn end.

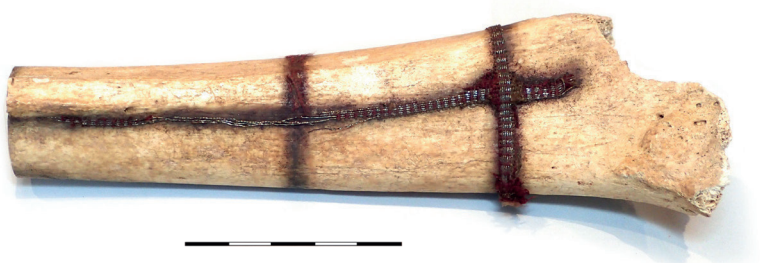

Fig. 4. *Relic TLM 18437: 48.*
Jn 4. *Reliikvia TLM 18437: 48.*
Photo / Foto: Aki Arponen

Fig. 5. *The crossing of braids in relic TLM 18437: 48.*
Jn 5. *Punutiste liitekoht reliikvial TLM 18437: 48.*
Photo / Foto: Aki Arponen

The braids on the bone originally formed a sparse grid, which can be seen as a dark pattern on the surface of the bone, caused by corrosion of the silver used in the braids. Three of the braids were placed lengthwise on the bone and at least two were wound around the bone as loops joining the lengthwise strips; a possible third loop disappeared when the bone was sawn. All the surviving braids are similar and in fragmentary condition.

The braid is 7 mm wide, with a red stripe on one edge and a brown stripe on the other. In between the stripes, there are red and silver threads forming crosswise stripes. There are 24 ends in the following order: 6 red threads on one edge, 6 silver and 5 red threads alternating in between, and 7 brown threads on the opposite edge of the braid. The ends are S-spun; in the middle part of the braid they are unplied and S-plied at the edge stripes. The brown pick is S-spun and plied without any definite direction.

This relic is presumably the only one from Pirita that has undergone conservation: the braids have been partly stuck to the bone. A textile fragment measuring 3 × 25 mm was also stuck to the surface of the bone in a place where there should be a braid. The fabric is of complex weave, possibly lampas or samite.

Table 1. *Radiocarbon dating results of relic TLM 18537: 48*

Tabel 1. *Reliikvia TLM 18537: 48 radiosüsinikdateerimise tulemused*

TLM 18437: 48	Ua-	BP	calAD (probability 95.4 %)
relic bone	41387	948±30	1020–1160
red end of the braid	42884	502±30	1390–1450 (probability 93.8 %)
silver end of the braid	42885	563±30	1300–1370 & 1380–1430

The relic bone dates to the 11th–12th centuries and is thus older than the crossing braids placed around it. The material of the braid is from the period 1300–1450, but if we assume that the fibres were spun into thread in turn woven into a braid within a short period, the braid was made at some stage between 1390 and 1430.

Relic TLM 18540: 371

The relic is part of a long bone of a limb (Fig. 6). It is 107 mm long, with a greatest diameter of 29 mm. Both ends are fractured or deliberately broken off and a sample was sawn from one end for a DNA analysis and radiocarbon dating.

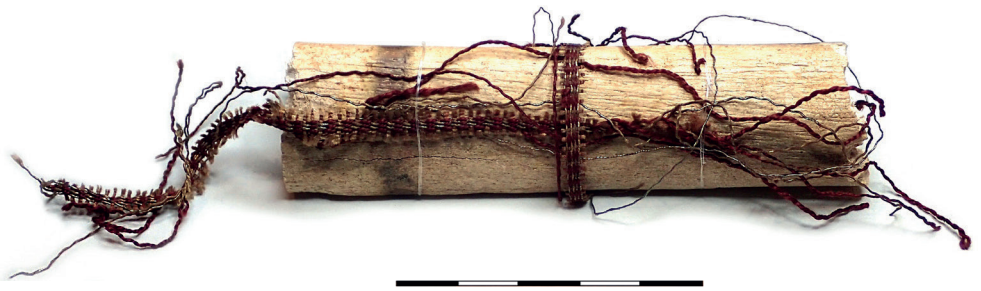

Fig. 6. *Relic TLM 18540: 371.*
Jn 6. *Reliikvia TLM 18540: 371.*
Photo / Foto: Aki Arponen

There were sparsely crossing braids on the bone. Three of them were placed lengthwise on the bone but there was only one braid wound around the bone – the other crosswise braid may have been wound around the part of the bone that was later broken or fractured. The braids are damaged and none of them have been preserved in their total width. It can be noted, however, that all the fragments are similar and the braid was at least 4 mm wide.

The braid contains four kinds of ends, yellowish, greenish, and red threads, all of which are Z-spun and S-plied, as well as silver threads, which were made by winding a 0.5 mm wide gilt band of silver anticlockwise around a yellowish S-spun thread. The braid presumably had 19 ends in the following order: 2 yellowish threads, 1 greenish thread, 7 red threads alternating with 6 silver threads, 1 greenish thread and 2 yellowish threads. In the middle of the braid, the red and silver ends alternate to form crosswise stripes. The brownish pick does not exhibit any distinct twist. According to microscopic fibre analysis, the red and silver ends and the pick are of silk.

Table 2. *Radiocarbon dating results of relic TLM 18540: 371*
Tabel 2. *Reliikvia TLM 18540: 371 radiosüsinikdateerimise tulemused*

TLM 18540: 371	Ua-	BP	calAD (probability 95.4 %)
relic bone	41388	985±30	980–1160
red end of the braid	41837	477±30	1405–1455
silver end of the braid	41838	511±30	1320–1350 & 1390–1450

The relic bone dates from the end of the 10th to mid-12th century and is clearly older than the braid. The material of the braid – silk – is dated to between 1320 and 1455. Assuming that the ages of the silk and the braid are approximately the same, the braid may have been woven in the period 1405–1450.

Relic TLM 18540: 483

The relic is part of the long bone of a thigh (Fig. 7). It is 274 mm long, with a largest diameter of 37 mm. Both ends of the bone are fractured or broken off and a sample for a DNA analysis and radiocarbon dating was sawn from one end.

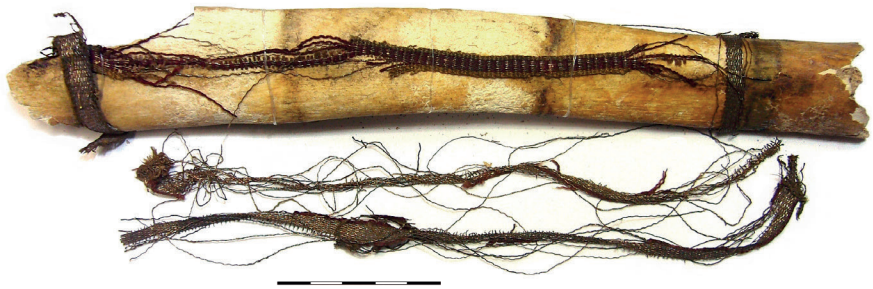

Fig. 7. *Relic TLM 18540: 483.*
Jn 7. *Reliikvia TLM 18540: 483.*
Photo / Foto: Aki Arponen

The bone was enclosed in loosely meshed braids indicated by a dark grid pattern that remained on the surface of the bone. There were most likely four braids running lengthwise and four encircling the bone, connecting the lengthwise braids. The braids were sewn together with sparse stitches at the points where they crossed, using yellowish S-spun and S-plied thread. There are four types of braids, all of them having survived in a fragmentary condition.

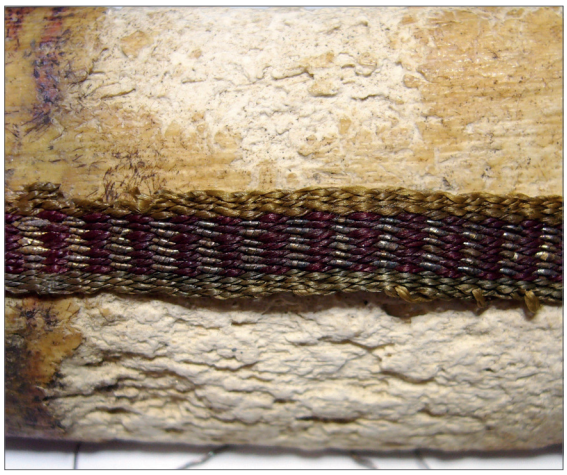

Fig. 8. *Braid 1 of relic TLM 18540: 483.*

Jn 8. *Punutis 1 reliikvial TLM 18540: 483.*

Photo / Foto: Aki Arponen

Fig. 9. *Braid 2 (horizontal) and braid 3 (vertical) of relic TLM 18540: 483.*

Jn 9. *Punutis 2 (horisontaalne) ja punutis 3 (vertikaalne) reliikvial TLM 18540: 483.*

Photo / Foto: Aki Arponen

Braid 1 is 7–8 mm wide (Fig. 8). It resembles the braid of the relic TLM 18540: 371, but with a different combination of colours. There are four types of ends comprising of yellowish, red, greenish, and silver threads. The yellowish and greenish threads are untwisted and S-plied; the red thread is Z-spun and S-plied. The silver thread was made by winding a 0.5 mm wide silver band anticlockwise on a greyish S-spun thread. There are 19 ends in the following order: 3 yellowish threads, 7 red and 6 silver threads in alternation, and 3 greenish threads. The brownish pick is untwisted. A microscopic fibre analysis of the yellowish and greenish ends showed them to be of silk.

Braid 2 is 8 mm wide (Fig. 9). It is decorated in a two-colour scheme running in lengthwise direction, with a wide silvery area in the middle, bounded

by narrow red stripes on the edges. There are 22 ends in the following order: 2 red, 18 silver, and 2 red threads. The red thread is Z-spun and S-plied. The silver thread was made by winding an approximately 0.3 mm wide silver band anticlockwise on a greyish S-spun thread. The greyish pick is Z-spun. A microscopic fibre analysis showed the red thread and the core of the silver thread to be silk.

Braid 3 is 4 mm wide (Fig. 9). It has red stripes along the edges between which there is an area of recurring silver and brownish crosswise stripes. There are 13 ends in the following order: 2 red threads, 5 brownish and 4 silver threads in alternation, and 2 red threads. The red and brownish threads are Z-spun and S-plied. The silver thread was made by winding an approximately 0.3 mm wide silver band anticlockwise on a greyish S-spun thread. The yellowish pick is Z-spun.

Braid 4 is 8 mm wide and resembles braid 2. It is decorated in a two-colour scheme running in lengthwise direction, with a wide silver-coloured area in the middle, but unlike in braid 2 the narrow edge-stripes are greenish. There are 22 ends in the following order: 2 of greenish, 18 of silver, and another 2 of greenish thread. The silver threads were doubled in two places, probably by mistake, which means that the number of ends can be counted as 24. The greenish thread is Z-spun and S-plied. The silver thread was made by winding a 0.5 mm wide silver band anticlockwise on a yellowish S-spun thread. The greyish pick is S-spun.

Two very small fragments of fabric are attached to braid 2 with stitches. One of the fragments measures 8 × 5 mm and was woven from yellowish threads of different thicknesses and different twists and plies. The weave is complex, possibly lampas or samite. The other fragment, measuring 6 × 4 mm, was also woven from yellowish thread. It is most probably of plain weave.

Table 3. *Radiocarbon dating results of relic TLM 18540: 483*
Tabel 3. *Reliikvia TLM 18540: 483 radiosüsinikdateerimise tulemused*

TLM 18540: 483	Ua-	BP	calAD (probability 95.4 %)
relic bone	41389	1631±30	340–540
red end of braid 1	41839	469±30	1405–1460
silver end of braid 1	42886	572±30	1300–1370 & 1380–1430
red end of braid 2	42887	604±30	1290–1410
silver end of braid 2	41840	617±30	1290–1400
silver end of braid 3	42888	524±30	1320–1350 & 1390–1450
greenish end of braid 4	42889	721±30	1220–1310 (probability 90.6 %)
silver end of braid 4	42890	526±30	1300–1370 & 1380–1430

The relic bone dates from the 4th to the 6th centuries; thus it is considerably older than the braids attached to it. Nor are the braids of precisely the same age. The material of braid 1 dates from the period 1300–1460; it was probably woven between 1405 and 1430. The dating of braid 2 is almost similar; the material dates from the period 1290–1410, but the time of weaving of the braid cannot be dated any more closely. There is only one date for braid 3, since there was not enough material for another sample. The material of braid 4 dates from the period 1220–1430, and the time of weaving can possibly be limited to the period 1300–1310. Since braids 2 and 4 are of highly similar type, it is also possible that braid 2 dates from the beginning of the 14th century. The crossing braids placed on the relic bone thus display a chronological range of approximately one hundred years.

Relic TLM 18540: 484

The relic is a finger bone (Fig. 10). Its length, together with the fabric covering the ends, is 47 mm and its greatest diameter in the bare middle section is 8 mm.

Fig. 10. *Relic TLM 18540: 485 (left) and 484 (right).*

Jn 10. *Reliikvia TLM 18540: 485 (vasakul) ja 484 (paremal).*

Photo / Foto: Aki Arponen

Fig. 11. *Fabric and braid covering the wider end of relic TLM 18540: 484.*

Jn 11. *Kangas ja paelad reliikvia TLM 18540: 484 laiemal otsal.*

Photo / Foto: Aki Arponen

Both ends of the bone are covered with pieces of fabric (Fig. 11). The fabric is damaged, with some organic material and sand attached to it. The wider end of the bone was first covered with a piece of cloth and its edges were folded along the lengthwise axis of the bone. After this, another piece of the same fabric was wound around the end to cover the edges of the first piece. The narrow end of the bone is covered with only one piece of cloth.

The fabric is of rep weave, with 3 mm wide red and yellowish-brown stripes. Silver threads form 1.5 mm wide strips running in a direction perpendicular to the first-mentioned stripes. The position of the silver strips varies: there are no silver strips at the first red stripe from the edge; the silver strips cover threads 1–4 but not 5–6 of the first yellowish-brown stripe; the silver strips cover all 9 threads of the next red stripe; in the following yellowish-brown stripe there are no silver strips on threads 1–2, while the remaining threads 3–8 are covered by it; there are no silver strips on the next red stripe, of which the width of two threads survives. The threads of the fabric are Z-spun and S-plied. The silver thread was made by winding a 0.5 mm wide gilt silver band anticlockwise on a yellowish-brown thread similar to the one mentioned above. A microscopic fibre analysis showed the threads of the fabric to be silk.

A 4 mm wide braid was sewn on the inner edge of the piece of fabric that had been wound around both ends of the bone. The braid was comprised of 10 threads, which are similar to those of the fabric. They are in the following order: 2 red, 3 silver, 2 red, and 3 silver threads. A similar red thread was also used to sew the ends and the edges of the braid and the fabric together.

Table 4. *Radiocarbon dating results of relic TLM 18540: 484*
Tabel 4. *Reliikvia TLM 18540: 484 radiosüsinikdateerimise tulemused*

TLM 18540: 484	Ua-	BP	calAD (probability 95.4 %)
red thread of the fabric	41841	486±30	1405–1455
yellowish-brown thread of the fabric	42891	471±30	1405–1460

The dating results for the fabric samples are almost identical. The fabric was most probably woven between 1405 and 1455.

Relic TLM 18540: 485

The relic is a finger bone (Fig. 10). It is 50 mm long, with fabric covering one end, and its greatest width at its bare middle part is 8 mm. A sample for radiocarbon dating was taken from the wider end of the bone.

Both ends of the bone were originally covered with fabric, but this has disappeared from the narrower end, where only a few fibres remain fixed to the surface of the bone. The wider end is covered by pieces of fabric similar (and similarly positioned) to those at the wider end of the relic bone TLM 18540: 484. The fabric is damaged, with some organic material and sand attached to it.

A 4 mm wide braid was sewn to the inner edge of the piece of fabric placed around the wider end of the bone. At the narrower end of the bone, a similar braid has survived, although the fabric has disappeared. The braid resembles that of the relic TLM 18540: 484, but it was made with 8 threads in the following order: 2 red, 2 silver, 2 red, and 2 silver threads. A similar red thread was also used for sewing the ends and the edges of the braid and the fabric together.

Table 5. *Radiocarbon dating results of relic TLM 18540: 485*
Tabel 5. *Reliikvia TLM 18540: 485 radiosüsinikdateerimise tulemused*

TLM 18540: 485	Ua-	BP	calAD (probability 95.4 %)
relic bone	43561	781±30	1210–1285
red thread of the fabric	42892	391±30	1440–1530 & 1550–1630
silver thread of the fabric	42893	540±30	1310–1360 & 1380–1440

The material of the fabric dates from the period 1310–1630. This was most likely woven around the year 1440. The relic bone dates from the Middle Ages, but it is at least 150 years older than the fabric attached to it.

PXRF spectrometry in the characterisation of the thin metal bands used in the braids on the Pirita relic bones

The research of the relic bones from the Pirita Convent sought to apply analytical methods with the least possible impact upon the material. PXRF spectrometry is a non-destructive method for analysing elemental composition. This method was used to determine the character of the thin bands of metal woven around the silk thread used in the decoration of the relic bones.

A portable X-ray fluorescence (PXRF) spectrometer (Bruker S1 Turbo) was used for analysing the chemical composition of the metal bands that adorn the three relic bones (TLM 18540: 371, TLM 18540: 483, and TLM 18540: 485). The accelerating voltage was 40 keV, the collection time of the X-ray spectra 150 s, and the X-ray tube had an Rh anode. The analysed area was 8 mm in diameter. The quantification of the analysis results employed Bruker's Precious Metal Alloys

factory calibration. Prior to analysis, the metal bands were examined in reflected light mode, using a polarised light microscope (PLM). The bands appeared to be distinctly yellowish on the surface. It is difficult to estimate the original colour of the inner surface, because it was in contact with the silk thread.

Analyses of elements from relics TLM 18540: 371 and TLM 18540: 485 were hindered by the fact that the braids were still attached to the relic bones and therefore some of the elements detected in the metal bands were from the bones themselves. For this reason, analyses of elements were also made of the bones, and these results were compared with the results from the metal bands. In the case of TLM 18540: 483, some of the metal bands had come off the surface of the bone and were analysed separately. The results are given below as percentages by weight. The sign (+) indicates that the element in question was present but its amount was too small to be measured.

Table 6. *Elements (percentages by weight) of the metal bands in the braids*
Tabel 6. *Paeltes kasutatud metallribades esindatud elemendid (kaaluprotsent)*

TLM 18540: 371	TLM 18540: 483	TLM 18540: 485
Ag 82.3	Ag 89.0	Ag 90.0
Cu 6.3	Cu 4.0	Cu 3.5
Au 5.6	Au 4.0	Au 3.3
Pb 0.2	Pb 0.5	Pb 0.3
Fe (+)	Fe (+)	Fe (+)
Zn (+)	Zn (+)	Zn (+)
Bi (+)	Bi (+)	Bi (+)
	Hg (+)	Hg (+)

The PXRF-spectrometry results and the PLM examination show that all three thin bands of metal are of a gilt silver alloy. The amount of silver is greater in TLM 18540: 483 and TLM 18540: 485 than in TLM 18540: 371. In addition, no mercury was detected in TLM 18540: 371.

In church textiles in the 15th century Swedish collections, the thickness of the thin gilt bands of silver varies between 10 and 50 µm; in these pieces, the gilding is extremely thin, ranging between 0.03 and 0.12 µm (Tronner *et al.* 2002). The 40 keV acceleration voltage used in the PXRF analyses is so high that the elements measured represent the content of the entire thickness of the gilt silver band and not merely that of its surface. Therefore, it cannot be said from which layer of the band the detected elements originate. It has been suggested that in

the thin gilt bands of silver of Oriental origin the amount of silver is higher than in the silver bands of European provenance (Hoke & Petrascheck-Heim 1977).

It was not possible to verify with the PXRF-analyses and PLM examination whether the metal bands were also gilded on their reverse sides (inside). This would be important information for dating, since silver bands gilded on both sides are known to have come into use in Europe from around the 16th century (Bergstrand *et al*. 1999).

Further research will seek to establish the type of gilding of the metal bands with a field emission-scanning electron microscope (FE-SEM) fitted with an energy-dispersive X-ray spectrometer (EDS). There are also plans to carry out comparative analysis with the PXRF technique of contemporary gilt metal bands in Finnish collections.

DNA analysis of the relics from the Pirita Convent

In 2011, two of the relics from the Pirita Convent (TLM 18540: 371, 483) were sampled for a DNA analysis (Fig. 12). The small pieces of bone were cleansed and pulverised in a bone mill, using liquid nitrogen as a cooling agent. Two independent extractions were made from both samples. Approximately 0.3 g (TLM 18540: 371) and 0.5 g (TLM 18540: 483) of bone powder was dissolved in a lysis buffer containing 0.5 M EDTA and 4 mg Proteinase K per 1 g bone powder. The dissolved DNA was extracted with the silica method and further purified (Rohland *et al*. 2010). The HV1 region of mitochondrial DNA was then amplified with four overlapping 135–141 bp fragments (Melchior *et al*. 2008). Controls were used in all steps to detect possible contamination. The DNA amplification products were visualised on an agarose gel, further purified and sequenced.

Of the parallel samples from the relic TLM 18540: 371, three of the four fragments could be amplified and sequenced. Indications of cytosine determinations, characteristic of aDNA, could be found in the sequences. Based on the 274 bp mitochondrial DNA (mtDNA) sequence ranging from position 16132 to 16405, the haplogroup of the sample was assessed to be H, which is the most common haplogroup (ca. 40 %) in Europe (Ghezzi *et al*. 2005). The result was confirmed further by amplifying and sequencing specific mtDNA SNP (single nucleotide polymorphism) for H-, V-, and HV-haplogroups in coding region position 14766. A confirmation could only be obtained from a single sample (TLM 18540: 371) although an increased template amount was used. It should be remarked that no cloning was performed and confirmation was not repeated independently in another laboratory. It was also attempted to determine the sex of the sample

TLM 18540: 371 by using two different kits (AmpFlSTR® Yfiler™ and AmpFlSTR® Minifiler™, Applied Biosystems) amplifying STRs (short tandem repeats).An elevated amount of the PCR amplification cycles (36) and an increased amount of template were used for these analyses. Except for positive control, no results could be obtained.

No results were obtained from the samples from the relic TLM 18540: 483. Several amplifications were carried out with varying template amounts to avoid the effects of possible inhibitors. A negative result from the sample is logical when considering its greater age (1631±30 BP, compared with the 985±30 BP of TLM 18540: 371).

Samples were taken from the relic TLM 18437: 48, but so far the DNA has not been extracted or analysed. No samples were taken from the finger bone relics (TLM 18540: 484 & 485), because this would not have been possible without destroying the relics excessively.

Fig. 12. *Sampling of the relic TLM 18540: 371.*
Jn 12. *Proovi võtmine reliikvialt TLM 18540: 371.*
Photo / Foto: Aki Arponen

The result from the relic TLM 18540: 371 encourages further investigation into the DNA of the relics. The mtDNA of the relic TLM 18540: 371 belongs to the most common haplogroup in Europe (H) and as such it does not permit precise interpretations of the origin of the relic. For a possible identification of

the relic it would be crucial to have a reference sample for comparison. The only relevant sequence comparison could be done with the two mtDNA sequences of the putative remains of Saint Bridget, which we unfortunately lack. With some additional sequencing, a further resolution to the sequence could be acquired to define the exact haplogroup of the relic. The results should be confirmed by the NGS or by cloning the sequences and performing an ancient DNA authentication analysis, for example with the C statistic (Helgason *et al.* 2009).

Strontium isotope analysis

The strontium isotope analysis is used in archaeology to study migrations of people (see, e.g., Sjögren *et al.* 2009; Frei & Price 2012). The method is based on correlation of $^{87}Sr/^{86}Sr$ ratio in underlying geology and human calcified tissues. This is based on two important principles. Firstly, calcium and strontium behave similarly and can replace each other unintentionally. This leads to a small strontium concentration in any calcium-bearing substance, such as plants. When the plants are consumed by humans, strontium is carried into their calcified tissues (Montgomery 2010). Secondly, strontium isotopes have a relatively small mass difference and there is no notable fractionation in biological processes. Thus, the strontium isotope ratio in plants and their consumers is approximately the same if strontium is not obtained from elsewhere (Fietzke & Eisenhauer 2006). However, strontium is also present in other sources, such as dust and water (Capo *et al.* 1998). Inhaling dust and drinking water imports strontium from the environment into the human body. The total strontium isotope ratio is a combination of all digested strontium. This process is still not well understood and it is unclear how the concentration of strontium from different sources is incorporated into the calcified tissues.

Estonian bedrock geology (Fig. 14) is characterised by five sedimentary stone systems of different age: Ediacaran (Upper Vendian; a very restricted geographical area), Cambrian, Ordovician, Silurian, and Devonian (Kalberg *et al.* 2007). The Vendian, Cambrian, and Devonian systems are mainly silt, clay, and sand formations, while the Ordovician and Silurian formations are mainly limestone, dolomite, and marl (Kalberg *et al.* 2007). The Ordovician formation is part of the Baltic Klint, and the Silurian systems belong to the Gotland–Saaremaa Klint. Both of these klints cover wide areas from the Scandinavian Peninsula to Russia (Kalberg *et al.* 2007).

Samples were taken from three different relic bones discovered in the Pirita Convent. They were prepared in the Northern Centre for Isotopic and Elemental

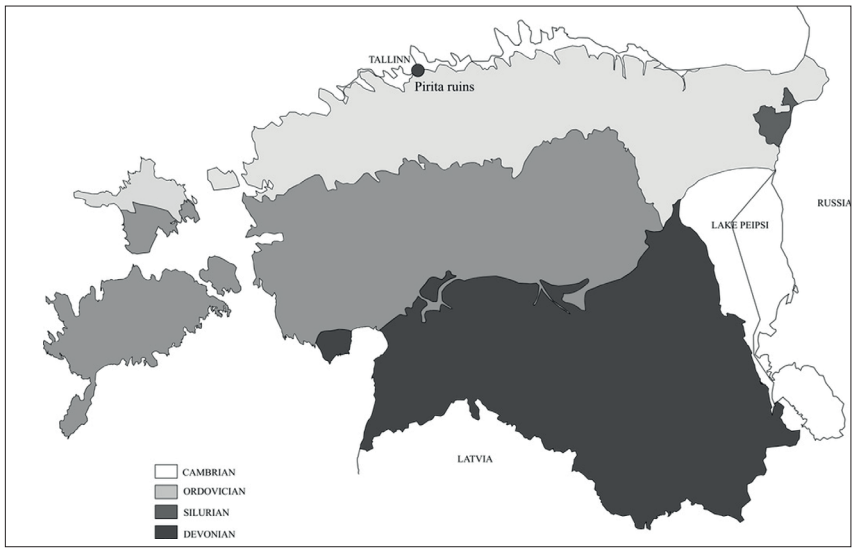

Fig. 14. *A simplified map of geological formations in Estonia (redrawn after Kalberg* et al. *2007).*

Jn 14. *Eesti lihtsustatud geoloogiline aluskaart (ümber joonistatud Kalberg* et al. *2007 järgi)*

Tracing (NCIET) at the Department of Earth Sciences of Durham University, by using column chemistry (published in detail in Charlier *et al*. 2006). The samples were measured with Multi-Collector Inductively Coupled Plasma Mass Spectrometry (MC-ICP-MS), using a Neptune MC-ICP-MS. The results are given in Table 7. The strontium isotope ratio range is 0.001082 (0.15 %). The difference is larger than the strontium isotope ratio variation discovered in plant samples from different-age bedrocks in Britain, excluding the granite formation (Evans *et al*. 2010). The difference may be large enough to suggest separate places of origin for individual bones.

Table 7. *Standardised strontium isotope ratios of the three samples taken from the Pirita relics. Analytical error of the samples was 0.000013 or smaller*

Tabel 7. *Strontsiumi isotoobi standarditud väärtus kolmest Pirita reliikviast võetud proovis. Analüütiline viga oli 0,000013 või väiksem*

Sample reference	Sample no.	Weight of the sample (mg)	$^{87}Sr/^{86}Sr$
TLM 18540: 483	A	83.49	0.7109
TLM 18540: 371	B	31.24	0.7117
TLM 18437: 48	C	40.92	0.7107

The bones had been exposed to weather and soil contamination before they were discovered in the archaeological excavations. The conditions had been far from ideal to ensure the survival of the original isotopic ratios. Due to the water-solubility of strontium, the bone material is very sensitive to diagenetic alterations (Nelson *et al.* 1986). Because the soil surrounding the relics was not sampled, it is uncertain what kind of strontium isotope composition it possessed. Weather conditions could also have affected the results. The ruins of the church of the Pirita Convent are not protected by a roof and the relic bones have been exposed to rainwater for 400 years. Currently no studies on strontium isotope ratios of rainwater in Estonia are being carried out, but on the Scandinavian Peninsula these vary between 0.7098 near the Atlantic Ocean and 0.7194 closer to the Baltic Sea (Andersson *et al.* 1990). It is likely that the strontium isotope ratios of rainwater in Estonia would be closer to the ones from the Baltic Sea zone of the Caledonian mountains (i.e. to the higher end of values), but further research is required to confirm this.

The ruins of the Pirita Convent are situated on top of Cambrian sedimentary systems. Near the convent, the Pirita River runs from the Ordovician formation into the Baltic Sea. Given the lack of local environmental samples in this study, it is important to compare the results with the strontium isotope ratios in other studies. The strontium isotope ratio in the northern Estonian coast has been shown to vary between 0.7105 and 0.7159 (n=8, Oras *et al.* 2016). A study on Saaremaa Island, which is mainly Ordovician stones, showed that the biologically available strontium isotope $^{87}Sr/^{86}Sr$ ratio varied between 0.7084 and 0.7188 (n=13, Price *et al.* 2016). Similarly, these Ordovician and Cambrian formations can be found on the island of Öland (Ebneth *et al.* 2001). On this island, the local, biologically available strontium isotope ratio has been estimated to vary between 0.7102 and 0.7158 (Fornander *et al.* 2015). Also, Silurian, Cambrian, and Ordovician bedrock formation in Great Britain has $^{87}Sr/^{86}Sr$ ratios between 0.7096 and 0.7123 (Evans *et al.* 2010).

In Estonia, above the bedrock, lie Quaternary deposits, formed partly by Estonian sediments (Kalberg *et al.* 2007). This might also affect the soluble and environmentally available strontium isotope ratios. A well-studied area for comparison is Denmark, which is mostly covered by Quaternary sediments. Strontium isotope values from a Danish sheep bone (0.71093; Frei & Price 2012) are similar to two samples studied here. However, the upper limit for the range of locally derived strontium $^{87}Sr/^{86}Sr$ ratio in Denmark is 0.7098, leaving Sample B outside this range (Frei & Frei 2011; Frei & Price 2012). Nonetheless, considering the values in Saaremaa, northern Estonia, Öland, and Great Britain, areas with bedrock formations of the age and type similar to that of Estonia, values this high can be found in Estonia.

Relic bones are seldom subjected to strontium isotope analysis, which is widely used in archaeology to study mobility of people and matters. This analysis yields important information on the origin of the relics and gives a future reference to similar studies. The resulting strontium isotope ratios of the three bone relics are similar to the values found in reference areas, which suggests an origin inside Estonia or a geologically similar area. Moreover, variations in the strontium isotope composition suggest that these bones may originate from at least two different locations within the country. Nonetheless, with a limited number of biological samples from Estonia and in view of possible variations, it is not impossible to rule out implications of the contrary.

Results

The radiocarbon dates show that the relic bones from Pirita are significantly older than the textiles attached to them, most of which were produced in the first half of the 15th century. Braids 2 and 4 of the relic TLM 18540: 483 are from the early 14th century, but braid 1 proves that the earliest date for the making of the braid decoration was the beginning of the 15th century. Braids 2 and 4 thus show that old material could be used in the adornment of relics.

The braid decoration of relics TLM 18437: 48 and TLM 18540: 483 were made between 1390/1405 and 1430. They could thus date from the founding of the Pirita Convent – the pope had granted the convent its privileges in 1411 – and it is thus possible that the relics were transferred from Vadstena at the same time with the convent's first activities on the spot.

Since the fabric pieces covering relics TLM 18540: 484 and TLM 18540: 485 are identical, it is most probable that they are from the same fabric whose weaving took place around 1440. The consecration of the church of the Pirita Convent took place at around the same time, in 1436, and we are tempted to assume that these relics were obtained for an altar of the new church.

By the age of the bones we can assume that the dated relics cannot be associated with Saint Bridget. The result of the strontium isotope analysis suggests the geological type of the area from which the relics originate in the first place but a more precise definition may be obtained only after more strontium isotope measurements from the environment are available.

For the time being, the Pirita relics remain unidentified. Most likely we have to accept what was observed, for example, in the relic catalogue of the Stavanger Cathedral in 1517: the relics from Pirita should be assigned to the group comprised of 'the bones of many other holy men, whose names have been lost to memory, but are nonetheless marked in the book of life in heaven' (Rinne 1932, 380).

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Viis reliikviat Pirita birgitiinide kloostrist

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Turu ülikooli arheoloogia osakonna Turu katedraali reliikviate uurimisele pühendatud interdistsiplinaarne teadusprojekt analüüsis võrdlusainese saamiseks viit Pirita kloostri 1977. ja 1979. a arheoloogilistel kaevamistel leitud reliikviat. Kõik reliikviad, v.a üks sõrmeluu, dateeriti ja määratleti luid katnud materjal. Isotoopanalüüs tehti kolmest proovist. Need osutavad, et reliikvialuud kuuluvad kas Eestist või geoloogiliselt sarnasest piirkonnast pärit inimestele. DNA analüüs ei pakkunud sellele teabele lisa.

Reliikvialuude radiosüsinikudateering osutab, et Pirita luud jäävad ajaliselt keskaja eelsesse perioodi. Samas on kõik luid katnud tekstiilid keskaegsed – enamik valmistatud 15. sajandi esimesel poolel, TLM 18540: 482 reliikvia punutised nr 2 ja 4 on 14. sajandi algusest, ristpunutis nr 1 viitab aga 15. sajandi algusele. Punutised 2 ja 4 näitavad, et luud ümbritsev vanem materjal oli esinduslik. Reliikviaid TLM 18540: 484 ja TLM 18540: 485 kattev kangas on identne ning mõlema valmistamisaeg võis olla 1440. aasta paiku.

TLM 18437: 48 ja TLM 18540: 483 ristpunutised valmisid perioodil 1390/1405–1430. Need reliikviad võivad seetõttu kuuluda Pirita konvendi asutamisaega (paavst kinnitas privileegid 1411), mistõttu näib võimalik, et kõnealused reliikviad tõid Piritale esimesed asukad Vadstena emakloostrist. TLM 18540: 484 ja TLM 18540: 485 reliikviaid katnud tekstiili dateeringut (u 1440) on kiusatus seostada kloostrikiriku uue altari pühitsemisega, mille tarbeks võidigi uusi pühasid säilmeid muretseda.

Reliikvialuude dateering näitab üsna selgelt, et neid ei saa ajalooliselt seostada püha Brigittaga. Ehkki isotoopanalüüsi tulemused võivad osutada reliikviate algupärale, jäävad need hetkel siiski lähemalt tuvastamata. Seetõttu peame nõustuma 1517. aastal Stavangeri katedraalis reliikviate kataloogimisel tehtud nendingu pädevusega ka Pirita kloostri leidude osas: "paljude teiste pühade meeste luud, kelle nimed on unustatud, kuid kes on sellegipoolest ülesse tähendatud taevases eluraamatus".