Lead Drops Keep Falling in the Air

The abbey Church of Sorø and the use of lead on roofs in 12th century Denmark

PER KRISTIAN MADSEN, THOMAS BERTELSEN, ARNE JOUTTIJÄRVI & KARL-MAGNUS MELIN

Abstract

This paper presents an analysis of lead from the original roof of the Cistercian abbey Church of Sorø which burned in 1247, compared to fragments of lead from the coffin of Archbishop Absalon, who was buried in Sorø 1201. His coffin was made of south English lead and the roof by lead from around the cities of Aachen and Cologne in north-western Germany. This is compared to the rather exclusive evidence of Absalon as a possible buyer of lead on the international market at the end of the 12th century. A survey of extant traces of original roofing material on churches in Scania challenges the general view of lead as the predominantly used roofing material in medieval Denmark in the 12th and 13th centuries. Further research into the origin, use and distribution of lead is recommended.

Absalon and the abbey Church of Sorø

Soon after having advanced to the episcopate of the diocese of Roskilde in 1158, the new bishop Absalon (Roskilde 1158-1192, archbishop of Lund 1178-1201) reformed his family monastery of Sorø, Central Zealand (fig.1). From being a traditional Benedictine Monastery, it was changed into an abbey of the new and prosperous Order of the Cistercians. The white monks were to carry on the commemoration of the founding magnate family, which was later given the popular name Hvide. Members of this powerful clan had close contacts to the Danish kings Valdemar the Great (1157-1182) and his two sons, who followed him successively on the Danish

Fig. 1. Abbey church of Sorø, north side. Photo: Thomas Olsen 2020.

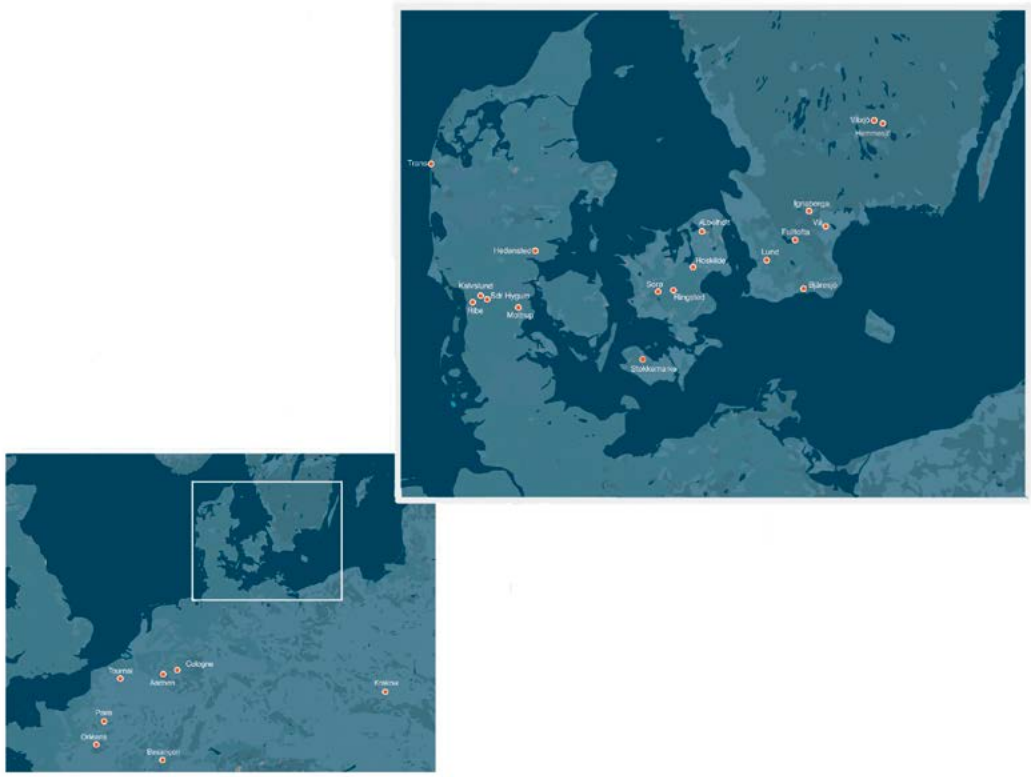

Fig. 2. Map of Medieval Denmark and Europe with the most important places which are mentioned in the text. Drawing: Karl-Magnus Melin 2022.

throne, Canute 6 (1182-1202) and Valdemar the Victorious (1202-1241) (Kræmmer 2001, 2012; Mørkeberg in press). Several members from the family were buried in the abbey church, including Absalon himself who died in his beloved Sorø after making his last will on his death bed (fig. 2) (DD/DRB 1201, no. 32; DK Sorø 1936-1938, 17 f).

Absalon and his relatives bequeathed the abbey with substantial donations (Nørlund 1927) and the still standing church was erected from c. 1160 and onwards. It was one of the first brick buildings in medieval Denmark and like the Royal Benedictine abbey of nearby Ringsted shows an influence of North Italian, Lombardic architectural forms and details (Clemmensen 1924; DK Sorø 1936-1938, 20 f; Johannsen 1988; Bertelsen 2021; Madsen 2022). At a first look, brick tiles would seem a proper roofing choice for the prestigious new church. The church loft has been thoroughly examined in 2011 and 2020 and fragments of flat, reused brick roof tiles can still be found in the eastern cell of the western vault above the nave. This vault was constructed after a devastating fire in 1247, and these fragments do not necessarily come from the destroyed roof of the church itself. Various finds from the large enclosure of the abbey may indicate the use of flat brick roof tiles on various buildings (Madsen & Bertelsen 2024).

In accordance with the so called Fontenay plan type from 1139 - 1147 Sorø presents itself as an about 70 metres long basilica with a large transept opening to the east into the main chancel and its side chapels. To the west

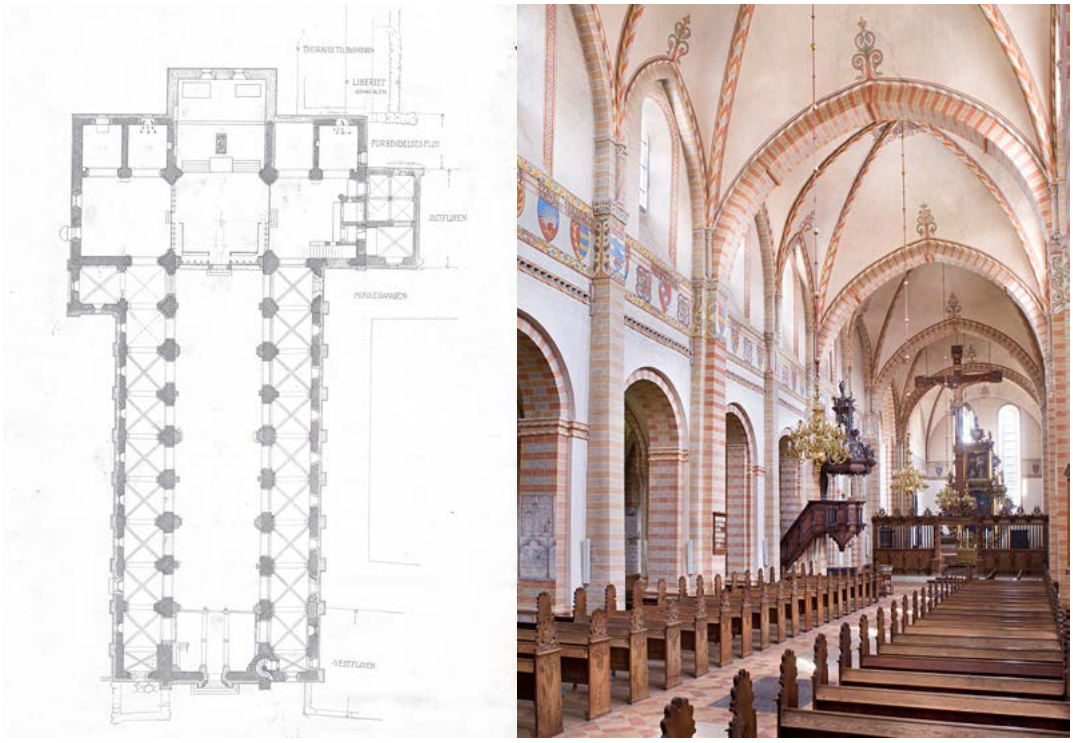

Fig. 3. Left: Abbey Church of Sorø, plan 1:600. In Antikvarisk-Topografisk Arkiv, the National Museum. Right: Sorø, church interior. Photo: Arnold Mikkelsen 2011, the National Museum.

of the transept followed the nave accompanied by its two side aisles (fig. 3). The church was finished at the beginning of the 13th century as the northern wing of the four-sided central part of the abbey (DK Sorø 1936-1938, 17 f; Rüffer 2008, 48 ff; Bertelsen 2024).

The abbey of Sorø became one of the wealthiest in medieval Denmark and prospered until the Danish Protestant Reformation in 1536. Today the Academy of Sorø is the owner of the former abbey Church (Mackeprang 1931). A thorough restoration in the 1870s left the church exterior with a quite uniform look due to its new facing wall. Until 1859-1860 the church had a roof of brick tiles, but then the whole building, including its magnificent timber roof on the main nave from 1515-1525 and 1540-1550 was covered by a new roof of dark slates (DK Sorø 1936-1938, 50; Bertelsen 2011, 18 ff). These were replaced in 1970 by a lead roof covering the whole church. In 2018 it became evident that a larger restoration of the church had to be carried out, inside as well as outside. One of the reasons was the bad condition of the lead roof on the southern part which needed to be fully replaced. The lead sheets were simply too thin, and water found its way into the wooden construction and the loft.

Normally a lead roof on a Danish church is supposed to have a lifetime of a hundred years or more and by recasting old sheets only some ten percent of new lead must be added. This means a somewhat unique percentage of reuse, however, the original lead rather quickly becomes mixed (Krogh 1967, 155). Modern industrialization methods aim at producing lead which is cleaned of almost all natural impurities. This means that the lead runs the risk of losing its elasticity which is absolutely

needed for roof sheets. Lead is poisonous and today it is not allowed in Denmark as a building material except in historic buildings such as churches. Water falling from a church lead roof contains lead which will concentrate in the earth along the wall down to a depth of only 50 centimetres (Rapport 2013, 73-74; cf. Charlier et al. 2017).

The lead roof of the church in Sorø and the lead coffin of Absalon

Lead melts at the relatively low temperature of 327,5 C which is easily reached in a fire, and which may be obtained without any sophisticated kind of melting kiln. Literature generally states that lead was commonly used for roofs on Danish medieval stone churches from the 12th and 13th century (Mackeprang 1944, 71; Krogh 1976, 154). This assumption will be discussed in some details later in this paper, but it seems still to be generally valid for the wealthy 12th century abbey of Sorø.

Sources tell that the abbey church burned in 1247 only some decades after its completion (DK Sorø 1936-1938, 18; Kræmmer 2012, 19 f). A rebuilding was soon initiated based on a donation from a wealthy lady of the founding family, and the church was secured by vaults, as can clearly be seen in the main nave (SRD IV, 481f; Ranvig 1986; DK Sorø 1936-1938, 18). In the 1920´s drops of molten lead were found in situ on the upper surface of the 12th century brick vaulting above the eastern end of the northern side aisles (DK, Sorø Amt 1936-1938, 38f). No drops have been noticed in the transept and its chapels. Available sources do not mention other devastating fires, neither before nor after 1247 so the lead drops most probably fell down by that occasion. In the second part of the 19th century, traces of molten lead were observed on the walls of the northern aisle, indicating that parts of the church had a wooden ceiling or an open roof which was also covered with lead (Høyen 1869, 68). If so, drops of lead may have hit the upper surface of a wooden ceiling inside the church in order to proceed from there to the floor where the metal could be recovered. In fact, traces of burning wooden beams have been recorded on the first tile floor just in front of the steps into the chancel (Hansen & Sørensen 2005, 211) (fig. 4).

Fig. 4. A small part of the oldest floor of glazed tiles from the abbey Church of Sorø, found in situ in front of the steps into the main chancel. The tiles show traces of fire from burning roof beams which had fallen from the roof. Photo: H. Stiesdal 1970, the National Museum.

In Lund Cathedral, large amounts of molten lead from a devastating fire in 1234 were found under the floor stones during rebuilding (Brunius 1854, 81). Molten lead has also been found on the vaults in the Cathedral of Roskilde, which is known to have burned in 1282, 1443, 1508, 1524 and in 1968 (DK Københavns Amt, 1944-1951, 1308, 1410 ff) A further example from Scania was documented in the church of Fulltofta where molten lead was found in the attic on the gable wall. The original tie beams, which

were dendrochronologically dated to the 1160s, quite miraculously survived the fire. The new rafters could be dated to the 1270s which presumably also dates the fire. In Ignaberga old church, very small molten lead drops have been found on the apse vault. The roof of the chancel was completely renewed in 1504/05 which probably also dates the event of the fire (Melin, Jansson & Börjesson forthcoming). And finally, molten lead was found on the barrel vault of the chancel in Vä church. This church is known to have burned in 1213 and 1810 (Græbe 1971). However, new investigations indicate there was a hitherto unknown fire in the 14th century (Melin & Jansson fortcoming). In Vä it has so far not been possible to tell which fire caused the molten lead. In the Swedish diocese of Växjö, which had strong connections to the diocese of Lund in the 12th century, medieval molten lead appears in the church of Hemmesjö (Gustafsson 1987). The roof trusses in Hemmesjö were put up after the fire and they are dated with craft scientific methods to the 12th-13th century. The molten lead, still present in the attic, might therefore represent the first roofing material of the church.

In 2018 the church of Sorø, including the vaults, was carefully examined before restoration. To our great surprise only some very sparse remains of the peculiar lead forms were still left in their original positions. Almost all lead had been removed from the top surface of the vaults, leaving only some few remains (fig. 5). In the archives and collections of the Academy of Sorø and the National Museum no records about the removal of the lead or its whereabouts could be found.

This situation changed later that same year when a row of containers with tens of thousands of pieces of pottery was emptied at one of the National Museum's storage facilities. One of them contained the missing lead stalagmites from Sorø, which were immediately recognized by the museum curator also involved in the restoration of Sorø. No proper indication of the origin of the lead was kept but indirectly some undated pages from a local newspaper "Sorø Amtstidende" and a couple of bricks with the large distinctively painted numbers from the Collections of the Academy of Sorø gave a further hint to the provenance. So did also a piece of paper with the name "Absalon" written on it which accompanied some quite differently looking fragments of lead sheets in their own separate box (fig. 6).

The pottery in the containers came from an excavation carried out decades ago by museum curator Tage E. Christiansen from

Fig. 5. The area on top of the vaults in the eastern end of the northern aisle where lead drops were discovered and later removed. Photo: Thomas Bertelsen 2018.

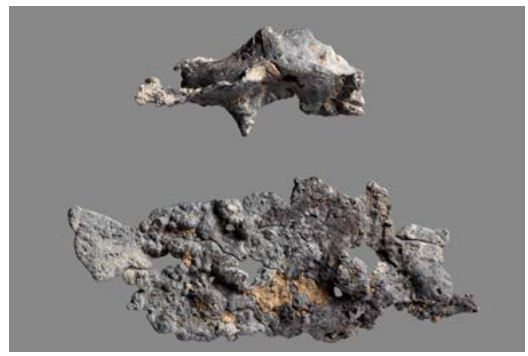

Fig. 6. Lead drops from Sorø found in a storage container with fragments from the lead coffin of archbishop Absalon. Photo: Arnold Mikkelsen 2018, the National Museum.

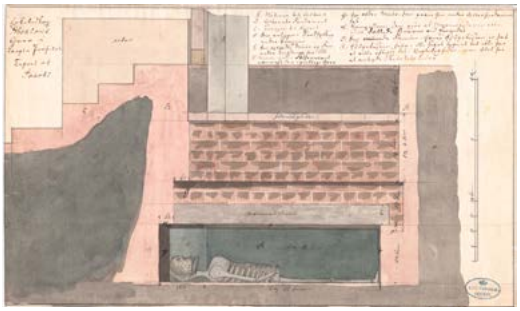

Fig. 7. The grave of Absalon, plan and drawings from excavation in 1827. Including his funerary chalice and paten and his finger ring as a bishop. Drawings and/or recent photos. In Antikvarisk-Topografisk Arkiv, the National Museum.

the National Museum who was known for his love of the abbey and the Academy of Sorø. In 1947 he participated in the last opening of the grave of archbishop Absalon under the guidance of the National Museum. Absalon died the 21st of March 1201 in Sorø and was laid to rest in a lead coffin in front of the main altar in the chancel. According to church habit he was buried in his magnificent shroud as an archbishop (Krag 2024). The first known opening of his grave took place in 1536, the year of the Lutheran Reformation. King Christian 3 was present and in the company of the first Lutheran bishop of Zealand, maybe in an attempt to demonstrate some kind of succession. In 1827, the grave was opened again in order to investigate the authenticity of the so-called "Absalon´s skull" in the Royal Kunstkammer (DK Sorø 1936-1938, 79f). Fragments of Absalon´s liturgical vestments, his finger ring, the funerary chalice and paten as well as a lead plate with an inscription to his commemoration were all taken out (Malling et al. 1836). These items are today on public display in the church (Mackeprang 1921; Krag 2024) (fig. 7).

The latest opening in 1947 confirmed the old report. However, the only known documentation is a brief description in a notebook by Tage E. Christiansen and some photos. Some of them were taken in 1948 when the lead coffin with its lid, and presumably the dead archbishop, had been removed to the National Museum in Copenhagen for examination or restoration (fig. 8). The bones, the funeral equipment and the garments of Absalon must have been taken care of and separated from each other while the bottom of the coffin was removed. That a quite considerable part of the coffin was still kept in the museum remained unknown until the rediscovery in the storage container in 2018. The relocated lead fragments seem to be a part of the bottom or maybe the lid at the head end, which was specially designed for the dead archbishop's head with his tall mitre.

Research analysis on lead – the results

The rediscovered pieces of lead from the vaults in Sorø and from Absalon's coffin were all subject to a scientific analysis by the Heimdal-Archaeometry Laboratory. Five samples were taken from the molten roof lead drops and three from the coffin. A metallurgic analysis showed that the two sets of lead differed from each other in the composition of impurities, most likely because the lead must have been brought in from two different geographical production areas. By comparing the content of lead isotopes in the samples with lead from a series of European lead producing districts it was found that the lead from the roof in Sorø originated from north-western Germany, more precisely the area around the cities of Aachen and Cologne. On the other hand, the lead from archbishop Absalon's coffin came from southern England (Jouttijärvi 2020).

Fig. 8. The lead coffin of archbishop Absalon during its temporary stay in 1948 in the National Museum's workshop in central Copenhagen. With and without lid. Photo: Niels Elswing 1948, the National Museum.

Absalon's procurement of lead

At the end of the 12th century, Abbot Étienne or Stephen (1128-1203) of the Sainte Geneviève abbey of regular canons in Paris planned to restore the church of his abbey. This was the place in Paris where students from Denmark used to stay since the middle of the 12th century during their attendance to university teaching (Munk Olsen 1996, 62, 70). Stephen wanted to get some good advice and support for his church restoration, including a new lead roof on the church. Therefore, in 1188, he wrote the Danish king Canute 6 and some most distinguished magnates of his realm and asked them to help him (DD/DRB 1188, no. 154-159; Roesdahl 2006, 2010). Stephen just mentioned that their forefathers, then still heathens, Norsemen and Danes, who became the ancestors of the present people of Normandy, had once sacked the church. Albeit a long time ago but now, time had come to pay back.

Absalon and Stephen were at the exact same age, and they may have met as young students although their subjects were different, or at some later occasion. Stephen left his hometown Orléans south of Paris in order to go to Bologna as a student of law. In Bologna he later became a teacher. He returned to Orléans and stayed there until 1176 when he went on to Sainte Geneviève in Paris as an abbot until 1192 when he became bishop of Tournai until his death in 1203. Absalon frequented as far as we know university studies in Paris until his return to Denmark no later than 1156 (Munk Olsen 1996; Ysebaert 2005, 286; Pennington 2019). Theoretically, Absalon may also have visited Bologna as well as he could have passed Paris in 1162 when he was a member of the retinue of king Valdemar, heading for his meeting with the Emperor Frederik Barbarossa in Besançon (Madsen 2022). A letter to Absalon from c. 1197 from the Abbot Vilhelm of the Monastery of Æbelholt,

who was himself born in Paris, and who was summoned to Denmark by Absalon (cf. DD/DRB 1171, no. 20) may indicate that Vilhelm was actually the one to connect Stephen with Absalon (VSD, 320f; DHL II, 213ff; DD/DRB, vol 3, Abbed Vilhelms Breve, no. II,21; Ysebaert 2005, 287, 298). Anyway, Stephen made his most kindly reference to their common relations when he wrote especially to Absalon that he knew about him buying lead of a sort called Roman. Stephen would, himself, prefer English lead for his church. English lead was the better of the two, because it remained watertight on the churches where it was used. Now he asked for Absalon's help to buy that sort of lead (DD/DRB 1188, no. 154). In yet another letter Stephen comments in particular on the use of lead by saying that he values its practical function and not its eventual symbolic meaning (DD/DRB, 1188, no. 156; cf. Thorsson 2021, 169, 350). By using the label Roman, Stephen may very well have had Rhenish lead in his mind.

What may have come out of this request remains unknown. Connections regarding other matters of importance continued between Stephen and his Danish relations, and later research has claimed an influence from the architecture of the Cathedral of Tournai onto the Cathedral of Roskilde (i.a. Lange 1890; DK 1944-51, Københavns Amt, 1314ff). Stephen left behind a very considerable work of writing and some hundred letters demonstrating a most intimate phraseology of friendship, also towards church dignitaries, he certainly did not know (e.g. DD/DRB 1188, no. 157; Ysebaert 2005; Pennington 2019).

Trading and transporting lead

This single and rather outstanding glimpse of the international trade and use of lead for roofing in the second part of the 12th century naturally raises some further questions regarding the transport and trade system of this very heavy material (cf. KLNM, art. Bly). The flattering letter of recommendation from Stephen for the bishop of Ribe (DD/DRB 1188, no. 157), which Stephen had given his envoy to show to the bishop to secure his support, may indicate one of the points of this traffic. Since the Viking Age, Ribe was the main Danish port of trade towards the North Sea, prospering from the routes into the Rhineland, Flanders, and northern France. Regarding possible connections with English ports and direct import of English lead (Gustafsson 1999, 11), one must realize that trade in all different sorts of primary commodities and goods was not exclusively carried through directly between the supplying area and the one prime customer and user (Madsen 1998). Lead may have been traded commercially and on marketplaces such as for instance the ports of Flanders.

An extensive export from the Rhineland of building materials is clearly visible in the shape of numerous churches built by Rhenish tufa stone which are found along the north German and the Danish shores towards the Wadden Sea, including the Cathedral of Ribe (DK, Ribe Amt 1979-2003, 145ff.; Feveile 1996). A rather particular example is the small parish church of Kalvslund some 8 kilometres northeast of Ribe which shows quite an abundance of different materials and inspirations (fig. 9) (DK, Ribe Amt 1979-2003, 3346f). The roof construction on the nave has been dated 1225-1250 by dendrochronology. However, no lead roof was put on the church nave which probably was thatched from the beginning. Melting pits inside the nave may have had to do with the unknown roof of the chancel or perhaps some other, limited work (Madsen 2005). The oldest mention of a lead roof is known from the 18th century (DK, Ribe Amt 1979-2003, 3354f) and the present lead roof was

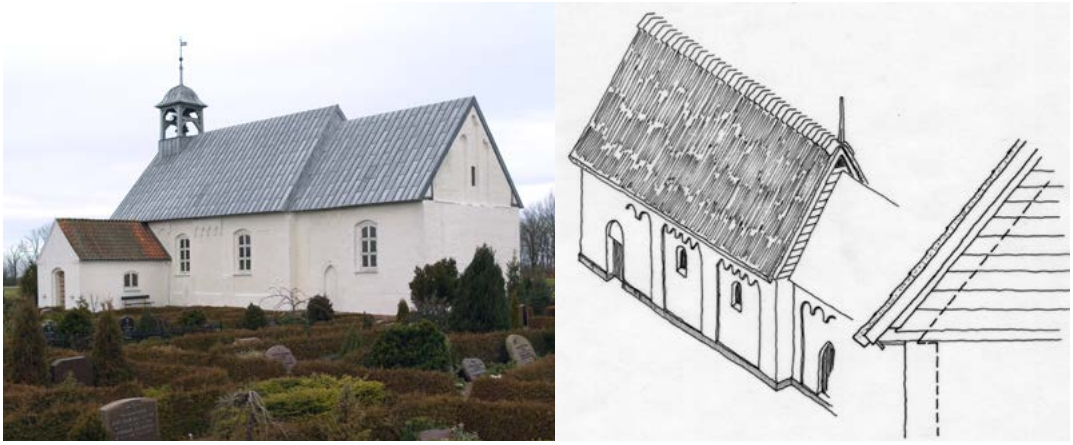

Fig. 9. Left: The parish church of Kalvslund, east of Ribe, from the southeast. Photo: Roberto Fortuna 2005, the National Museum. Right: A reconstruction of its thatched roof. Drawing: Niels Erik Jensen, after Madsen 2005.

put up in 1993.

Another source of lead may have been Eastern Europe, especially perhaps after the prime time of building stone churches in Denmark. A fine example is an exquisite find from the marketplace in the Polish city of Krakow of a lead ingot, holding a weight of no less than 693 kilos (fig. 10). It came from the lead mines some 40 kilometres northwest of Krakow and is dated to the beginning of the 14th century. Its marks indicate its weight followed by a stamp of the Polish king Wladislaw the Elbow-High (1320-1333).

Fig. 10. A lead ingot of 693 kilos, from Krakow. Photo: Per Kristian Madsen 2015.

Lead ingots of this heavy kind may, similarly to the Gotlandic baptismal sandstone fonts, have been exported by sea into Western Europe or across the Baltic Sea for Denmark and other Nordic regions. Any such traffic required not only ships for transport, but also wagons, oxen, and men. In the 12th and 13th century, quite a number of loaded ox wagons must have brought lead for the abbey Church roof in Sorø from some port of discharge, maybe on the western shore of Zealand towards the Great Belt. Viking Age/early medieval wagons could carry about 500 kilos although there might have been wagons built for heavier loads (Schovsbo 1987, 142). Church accounts from western Zealand from the second part of the 16th century indicate that a peasant's wagon could only carry one hundred bricks counting a total weight of some 500 kilos. Another source, however, mentions that in 1584 even loads of 500 bricks weighing some 2.500 kilos were carried by special wagons (Troels-Lund 1879 (1968), 163 f).

During the building of the Cathedral in Lund about 67.500 tonnes of ashlar were transported from the quarries. If the building campaign went on for 60 years, from 1085-

1145, and if the builders worked 6 days every week it has been estimated that 10 wagons each and every day transported about 500 kilos, 5 tons in total, of ashlar to the Cathedral (Ödman 2018). Sources further testify that magnates as Absalon and his kin were absolutely capable of ordering and mobilizing the necessary labour force whenever required, even causing a serious uproar against the archbishop in 1180 (Holm 1988; Melin 2022, 168 f with references).

Making lead roof sheets

Lead roof sheets are generally believed to have been produced locally and inside the churches. Single, or several, melting pits beneath the floors of parish churches have quite often been excavated as they are known from at least 43 medieval Danish churches (Rensbro 2007) (fig. 11). From the medieval diocese of Lund only 3 churches with melting pits have been documented in Scania, none in Halland, Blekinge or on Bornholm (Karlsson & Melin 2022).

In the church of Trans on the west coast of Jutland, one pit was found beneath the first floor of the nave and between its two doors. Seven more pits in the same part of the nave belonged to later periods. Melting pits of this kind were mostly, and somewhat automatically explained, as production furnaces for the church roof sheets, each of them having a weight of some 25 kilos (Mackeprang 1944, 71; Krogh 1976, 156ff). A single late medieval find from the church of Hedensted in eastern Jutland not only showed the melting pit itself, but also the remains of a wooden frame for the lead sheets which were used during a rebuilding of the church (Mikkelsen 2016, 48-51). Inside the pits and around them, drops of lead, charcoal, and the obvious traces of heating the pits have been recorded. Still, the question remains whether or not these small circular pits of some 50 centimetres in diameter and a depth of 20 – 30 centimetres, could really have been used to melt lead for the casting of lead sheets for the whole roof of a parish church, not to speak of the abbey Church of Sorø, nor the Cathedral of Roskilde, where no finds at all of melting pits are known. On the other hand, no melting pits for lead or any traces of melting lead whatsoever have been recorded outside churches. Continuous burial activity on the church yards doublessly managed to destroy all traces of this eventual activity. The need for lead for a single parish church of ordinary size has been estimated to some 15 - 20 tons of lead, which must have required a substantial period of preparation if only one or a few pits were active. Experiments have shown that lead needed for five to six sheets at a time could be melted in a pit during some five to six hours of intensive firing (Krogh 1976, 154).

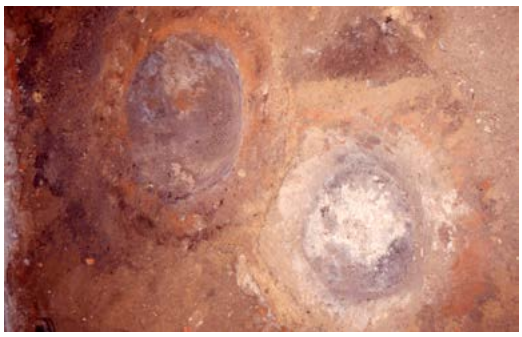

Fig. 11. Two melting pits, still holding some lead, from an excavation in the parish church of Moltrup, southern Jutland. Photo: Birgit Als Hansen, 1994, the National Museum.

Later, from the 14th century and onwards, we know lead was also sold as rolled sheets (Gustavsson 1999, 11). After a sheet was made it could easily be rolled up and transported, as is still done today. Post-Reformation church accounts from Scania indicate that minor completions could be made with already made lead sheets, bought from other places, or brought in by the lead roofer (Karlsson & Melin 2022). If rolled lead sheets were traded

in Scandinavia as far back as the 12th century is not known. If this was the case, it would have made it quite easy to buy pre-made lead sheets which would restrict the use of the melting pits to minor casting at the sites. Some of the lead pits are also dated stratigraphically to be secondary and the youngest example was dated with coins to the 18th century (Rensbro 2007). It was common practice to reuse old sheets and on Horne church on Funen lead roofers have left a series of sheets with inscriptions showing the years: 1734, 1743, 17.., 1849, 1932, 1932, 1949 and 1988. So, this rather complicated present roof at least had supplies of new lead sheets cast during eight different campaigns (Kristiansen 1991).

The melting pits might have been used mostly during repairs when only some of the sheets needed to be recast. Church archives from the 17th century and onwards describe continuous and partial maintenance work (Karlsson & Melin 2022). Yet, it is plausible that some of the excavated melting pits have been used for casting lead cames for stained glass windows.

From the Late Middle Ages lead melting is known to have taken place in fireplaces which were built from stone inside the church porches in quite a few Danish churches (Bertelsen 1998) (fig. 12). The Scanian lead furnaces in the post-Reformation era are often mentioned as *"gruva"*, which indicates a structure with a pit or cavity. Generally, the cost for materials (basically clay of proper quality) for a *"gruva"* was recorded as an expense with every reroofing with lead sheets. The reuse of furnaces in parish churches is a possibility but has so far only been found once in the written accounts from the diocese of Lund, when the roof at Bjäresjö church was repaired in 1768 it was stated that *"The furnace (gruva) was ruined and has been repaired")* (Karlsson & Melin 2022). For big enterprises like cathedrals and abbey churches it would probably be very impractical to use the church room for melting lead compared to the situation in parish churches. According to church archives from the Cathedral in Lund from 1690 and onwards a building close to the cathedral was used for storage and casting of lead (kind information from Andreas Manhag, Lund Historical Museum).

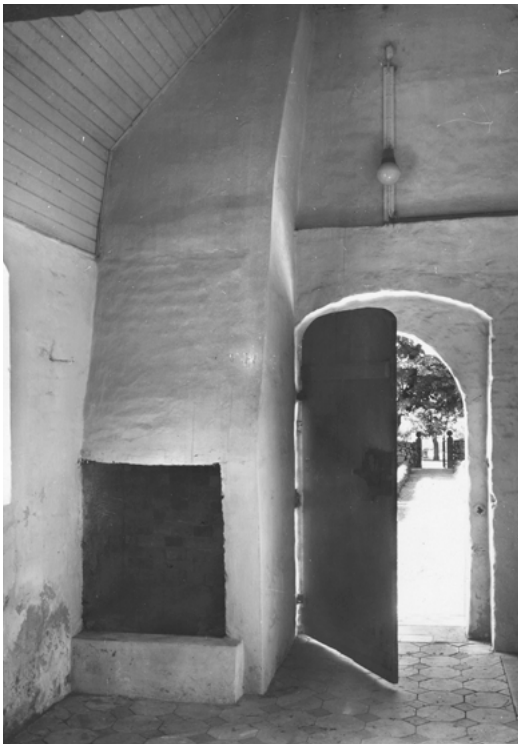

Fig. 12. A fireplace built with bricks in the porch of the church in Sdr. Hygum in southern Jutland. Pieces of molten lead have been found in it. Photo: Elna Møller 1952, the National Museum.

Lead – the predominant roofing material in the 12th century?

For the recent restoration of the roof in Sorø in 2018-2020, more than 83 tons of lead were used only on the southern half side of the church roof. That amount must have been around the same in the Middle Ages and melting a total of some 160 tons of lead

into individual sheets of about 25 kilos each will produce some 6 400 sheets. Based on the results from the experiments by Krogh some 1000 hours of labour are required to make the lead sheets for the abbey Church of Sorø. On top of that an unknown number of working hours must be added for the handling of molten lead in the sand forms. Still it may have been possible to accomplish the whole melting process in approximately one year if, and that remains a strong question, enough lead ingots or rolled lead sheets were at hand. Expenses were doubtlessly considerable, even for an archbishop and his family. On the other hand, one of the other wealthy members of the Hvide clan, Sune Ebbesen, who was the cousin of Absalon, is known to have owned more than 600 farms on Zealand (Nørlund 1927, 167). He died in 1186 and was laid to rest in the church chancel in Sorø – if he had sent just one servant from each of his estates these 600 men would have presented a labour force per year as large as the one required for the erection of all Zealandish parish stone churches (H. Nielsen 2012, 43 f). Obviously though, Sune Ebbesen was not the only magnate of his time.

In 1749, Carl von Linné wrote in his travel diary *"The churches in Scania are predominantly covered with lead roofings, this is seldom seen in the upper Provinces"* (Linné 1751, 60). In 1976, 227 years later, Knud J. Krogh wrote *"The lead roof was introduced with the stone churches, and lead was according to all knowledge from this starting point the dominant roofing material."* (Krogh 1976, 154). The citations are but two examples putting forward the opinion that Danish churches in general initially had lead roofs. When other roofing materials were recorded in the oldest available and much later sources it could easily be explained to depend on later alterations and poor church economy.

However, if all churches, built in medieval Denmark during the 12th and 13th centuries, were originally roofed with lead, more than 30 000 to 40 000 tons of lead would have been brought into the country, an amount of trade which can be compared to the import of more than 7 000 tons of volcanic tufa stone from the Rhineland during the 12th and 13th century (Feveile 1996, 42). Estimates of the total production of English lead in the period 1125-1225 came to the amount of 33 000 tons or in average 330 tons each year (Blanchard 2001, 795ff).

From the 15th century the total English production is known for some few years: 1400, 385 tons, 1450, 400 tons and in 1525 625 tons (Homer 1991, 63). Even if the total European production of lead cannot be estimated it still seems doubtful if an amount of lead, corresponding to the total known production in England, would be exclusively at hand for the churches in medieval Denmark during a period of about a hundred years.

The latest survey by the Danish National Museum on lead roofs in 2002 came up with the number of at least 815 churches (ca. 50% of all extant medieval parish churches in present day Denmark) which at that time had a lead roof on at least some part of the building. The majority of lead roofs were, and still are, found in Jutland, numbering 715 churches (Nielsen 2002, 73). This situation may, however, have developed only gradually as an effect of church repairs and may have left its impression onto modern estimations on how things were in the Middle Ages when churches were constructed. In the diocese of Lund, only 32 churches have at least one roof covered with lead; in 17 cases it is only the apse (Gustavsson 1999; Karlsson & Melin 2022). Church accounts and building inspections propose that about 70 % of the churches in Scania in the mid-17th century had roofs of lead on the whole or a major part of the building. This reminds with the estimation by Kinné from 1751. The situation in Blekinge and Halland was significantly different, with

none, respectively approximately 25 % of churches with lead roofs. Wooden shingles were of greater importance at that period in these landscapes, especially in Halland, while a large share of the churches in Blekinge had tiles on their roofs. In the diocese of Lund, as in other parts of the former Danish realm, more research needs to be done into the question of how lead became such an important roofing material on churches: Was it really more closely connected with the great wave of church-building in the 12th and 13th century, or was lead as we know it introduced during that time in order to become rather predominant in a later gradual process?

Variations apparently existed in 12th and 13th century church architecture. A recent inventory of the medieval diocese of Lund showed we only have knowledge about a handful of original roofings: Four massive stone roofs, two shingled roofs, one tile roof and one probable board roof (Melin forthcoming). We did not find one single proof of an original lead roof. Even if the cathedral in Lund had a lead roof when it burned in 1234 it is still possible that another type of roofing material was used originally. The number of massive stone roofs is due to the fact that this type of roofing is better preserved and easier to distinguish. Doubtlessly massive stone roofs were rare during the 12th century and most known examples are from Bornholm and southeastern Scania. Generally, churches had wooden roof trusses or ridge beam constructions (Melin, Christensen & Madsen forthcoming), but their initial roofing material is only sparsely documented.

Discussion - conclusion

Referring to the initial results of the scientific analysis of lead from Sorø it seems obvious to continue similar analysis. The material for sampling should be sought out carefully from church roofs whenever possible. Samples ought to be taken mainly or exclusively from lead which can be ascribed to initial use of lead in the specific church under investigation. Later building phases normally reused lead and mixed it up with some new metal. And it was quite common for the parishes to sell off their lead to other churches. Even when lead is found on church gables as part of the initial building phase this does not mean that the whole roof was made with lead. It may only have been used as a protective strip on the apex and where a roof was built into the masonry of a wall.

We are aware of 82 churches in the diocese of Lund that have undergone at least one fire (Melin & Ranta 2020). The number of previously unknown fires is continuously increasing as more evidence is gathered when churches are investigated. During archaeological cleaning of the apse vault in Ignaberga, very small drops of lead were found. It is probable that similar molten lead might be found in other attics if it is systematically searched for.

Another source would obviously be stratigraphically well-dated melting pits found beneath undisturbed floor layers with drops of lead still extant on the inside clay wall. These drops should be analysed. Funeral equipment such as lead coffins, like archbishop Absalon's, would be worth testing as well, for instance the one in the Cathedral of Lund which keeps the mortal remains of his relative and successor Anders Sunesen (deceased in 1228) (Rydbeck 1926). Yet another relevant group of finds to be tested are the leaden tablets from some medieval graves of high rank, for instance the funerals of King Valdemar the Great and those of the Hvide family such as Absalon himself and his forefathers (DK Sorø 1936-1938, 79f, 163f; Bertelsen 2021, 6ff, 38ff). Traces of lead may also be found and analysed from lead cames in wooden window frames, especially if these

can be dated by dendrochronology (Melin 2022). Dating is essential here and the same is true for lead amulets with their inscriptions (Imer & Stemann-Petersen 2016), as well as the lead inclusions in altar sepulchres and their small lead boxes with relics which may often have come from rather far away (cf. Karlsson 2015, 67ff). Analysing such samples within a dating frame may perhaps show a pattern of origin, trade and use of lead amulets and reliquaries. One fine example to include would certainly be the lead reliquary from Stokkemarke church on Lolland (DK Maribo 1948-1951, 458; Moltke 1976, 360) (fig. 13). It still shows its runic inscription from a reconsecration of the altar, telling the name of the bishop in charge, who held his seat between 1286 – 1300. Perhaps the lead came from across the Baltic Sea.

Another quite interesting subject are the possible lead pipes for water from the abbey of St. Thomas and the Paraclete in Æbelholt, northern Zealand (fig. 14). In one of his letters Abbot Vilhelm referred to the difficulties with the water pipes during the construction of his new institution (DD/DRB, 1. Rk., vol 3, Abbed Vilhelms Breve no. II,35; DK, Frederiksborg Amt, 1964-1975, 1435, annotation no. 49 and 40). Unfortunately, he did not mention the material of these pipes as other pipes made from clay have been found at Æbelholt as well. No matter whether the lead fragments really represent lead pipes or simply folded pieces, analysis may be able to show from where the Parisian Vilhelm got his lead.

The idea that churches in medieval Denmark generally got a full lead roofing in the 12th and 13th century cannot be confirmed by the available sources. Maybe in some cases the roof got a temporary roofing before the lead roof could be afforded, and this may have taken quite some time. The sources are vague, and the answers are elusive. If the ideal was to get lead roofs for all country parish churches

Fig. 13. The lead reliquary from Stokkemarke Church with its runic inscription. It reads in Latin: "Bishop Gisiko" (1286 – 1300). Photo: Roberto Fortuna 2018, the National Museum.

Fig. 14. Possible water pipes of lead from the abbey of St. Thomas and the Paraclete in Æbelholt, northern Zealand. Photo: Kjartan Langsted 2022, Museum Nordsjælland.

approximately 30 – 40 000 tons of lead would be needed and this really seems a very high percentage of the estimated total production of lead in contemporary Europe. Moreover it seems that no available sources indicate a similar dominant use of lead in any other European context. Of the confirmed original roofing materials in the diocese of Lund there are massive stone roofing, shingles, boards, and tile. However so far not one confirmed lead roof. Research needs further tracing of original roofings in order to carry out more analyses on the origin and trade of lead. However, our tentative hypothesis is that the estimated high rate of medieval lead roofs in Denmark evolved over time and maybe reached its climax only after the Middle Ages.

Acknowledgements

The Academy of Sorø most kindly financed the analysis of lead in 2020. Roesdahl (2006, 91) was the first to propose such analysis.

The investigations of roofing materials in the Diocese of Lund were funded by Marcus and Amalia Wallenbergs Fund and by the Diocese of Lund through the project; Historic carpentry art in the diocese of Lund.

Diminik Lulevics, Oddzial Rynek Podziemny, Krakow, most kindly informed about the find of the lead ingot from Krakow which is on display in the Rynek Underground Museum in the Centre of the City of Krakow.

Many thanks go to archaeologist, Dr. Mattias Karlsson at Kulturen in Lund for proofreading and giving comments on the paper.

References

Bertelsen, T. 1998. Kirketage. -Danske kirkers tagbeklædning i middelalderen, *KUML 1997–98. Årbog for Jysk Arkæologisk Selska*b.

- 2011. *Træ fortæller. Dendrokronologiske undersøgelser af Sorø Klosterkirkes Tagværk*. København.
- 2021. *EX LATERIBUS COCTIS. Ringsted Klosterkirke og den tidligste tegl*. København.
- 2024. Sorø Klosters romanske teglkirke – og dens forgænger. In Aarbøger for Nordisk Oldkyndghed og Historie 2021, København.

Blanchard, I. 2001. *Mining. Metallurgy and Minting in the Middle Ages, vol. 2: Afro-European Supremacy 1125-1225*. Stuttgart.

Brunius, C.G. 1854. *Nordens äldsta metropolitankyrka*. Lund.

Charlier, P. et al. 2017. Did the Romans die of antimony poisoning? The case of the Pompeii water pipe (79 CE). *Toxicology Letters* 281.

Clemmensen, M. 1924. Slægtskabet mellem lombardisk og dansk Teglstensarkitektur. *Aarbøger for Nordisk Oldkyndighed og Historie* 1922.

DD/DRB (*Diplomatarium Danicum/Danmarks Riges Breve*): 1. række, bind 1–7, 789-1249. København 1975–1990.

DHL (*Danske helgeners levned*), I - II, i oversættelse ved H. Olrik, 2. udg. København 1968

DK (*Danmarks Kirker*). 1933- . Nationalmuseet, København.

Feveile, C. 1996. Tufstenskirkerne i Sydvestjylland. *By, marsk og geest* 8.

Græbe, H. 1971. *Sveriges kyrkor 139. Kyrkorna i Vä: Gärds härad, Skåne*. Stockholm.

Gustafsson, E. 1987. Recensioner, Anita Liepe, Medeltida lantkyrkobygge i Värend. Ett försök till relationsanalys kyrka - bygd. Kronobergsboken 1984–85. *Fornvännen* 82 1987,

Gustafsson, L. 1999. *Blytak* (Riksantikvarieämbetet). Stockholm.

Hansen, B.A. & Sørensen, M.Aa. 2005. *Ornamenterede middelalderlige gulvfliser i Danmark.* København.

Holm, P. 1988. De skånsk-hallandske bondeoprør 1180-82. In Bøgh, A., Würtz Sørensen, J. & Tvede-Jensen, L. (eds.), *Til kamp for friheden: sociale oprør i nordisk middelalder*. Aalborg.

Homer, R.F. 1991. The lead and pewter. In Blair, J & Ramsey, N. (red.), *English Medieval Industries*. London & New York.

Høyen, N.L. 1869. Kirken og Klosteret i Sorø, In C.F. Holm, Heinrich Hansen, Herbst, C.F., Høyen, N.L., Kornerup, J., Strunk, C.A. & Worsaae, J.J.A. (eds.), *Danske Mindesmærker* 1. Kjøbenhavn.

Imer, L. & Stemann-Petersen, K. 2016. Vi folder historien ud – amuletter af bly fra middelalderens Bornholm. *Nationalmuseets Arbejdsmark*. København.

Johannsen, H. 1988. Vore tidlige teglstenskirkers oprindelse. En kommentar til Mogens Clemmensens studier om slægtskabet mellem lombardisk og dansk teglstensarkitektur. In Andersen, Aa., Dahlerup, T., Lund Hansen, U., Jensen, J.S. & Liebgott, N.-K. (eds.), *Festskrift til Olaf Olsen*. København.

Karlsson, M. 2015. *Konstruktionen av det heliga, Altarna i det medeltida Lunds stift*. Skånsk senmedeltid och renässans 23. Värnamo.

Karlsson M. & Melin, K.-M. 2022, Yttertak på kyrkor i Lunds stift 1100–1850. Material, teknik och betydelse. *Kulturens rapporter nr 12.*

KLNM (*Kulturhistorisk Leksikon for nordisk middelalder*). 1956–1978. København.

Krag, A.H. 2024. Absalons grav i Sorø Klosterkirke – nye analyser af farverne på ærkebiskoppens dragt. In Aarbøger for Nordisk Oldkyndighed og Historie 2021.

Kristiansen, P. 1991. Blytaget på Horne kirke. In *Bygnings Arkæologiske Studier* 91.

Krogh, K.J. 1976. Tag af bly. *Nationalmuseets Arbejdsmark* 1976.

Kræmmer, M. 2001. Efterslægtstavle for Skjalm Hvide, *Dansk Adelsforening, Danmarks Adels Årbog* 2009–2011.

Kræmmer, M. 2012. Sorø Klosters ældste historie i de skriftlige kilder. *hikuin* 39.

Lange, J 1890. Bemærkninger om Roskilde Domkirkes Alder og Stil. *Aarbøger for Nordisk Oldkyndighed og Historie* 1890.

Mackeprang, M. 1921. Kunstkamrets Absaloniske Sager. Et Stykke Museumshistorie. *Aarbøger for Nordisk Oldkyndighed og Historie* 1921.

- 1931. Akademi og Kirke i 18. og 19. Aarhundrede. *Sorø. Klosteret, Skolen, Akademiet gennem Tiderne* 2 (Skrevet af gamle Soranere). København.

- 1944. *Vore Landsbykirker*. København.

Madsen, P.K. 1998. Ribe – a medieval Hanse town? A survey of the 'long lines' of the trade of Ribe and its Baltic connections. In *A North Sea Region, West Jutland and the World, II, Procedings of the Lemvig Conference, April 3-5,* 1995. Esbjerg.

- 2005. Kalvslund Kirke – en tilsyneladende beskeden kirkes alder og stråtag. *By, marsk og geest* 17.

- 2022. Radulf, en bagmand fra 1100-årene – eller den varme sten i sengen. *Kirkehistoriske Samlinger* 2022.

Madsen, P.K. & Bertelsen, T. 2024. Fra bly til bly – klosterkirkens tagbeklædninger. In Aarbøger for Nordisk Oldkyndighed og Historie 2021.

Malling, O., Münter, F. & Thomsen, C.J. 1836. Beretning. *Nye Danske Magazin*, 6. bd., 2, København.

Melin, K-M. & Ranta, H. 2020. Historic Carpentry art in the Diocese of Lund. In Park, T. L. & Artolo-Guijarro, T. (eds.), *22nd IIWC International Symposium Wooden Heritage Conservation: beyond disciplines*.

Melin, K.-M. 2022. Medeltida inmurade fönsterramar i Lund stifts kyrkor – 1100-talets kamp om naturressurser, och hantverk i förändring. *Aarbøger for Nordisk Oldkyndighed og Historie* 2018.

Melin, K.-M. 2022. Yttertak i Europa, utblick. In Karlsson, M. & Melin, K.-M. (eds.)

Melin, K.-M., Christensen, A.C. & Madsen, P. K., forthcoming. Datierte Dachwerke in Dänemark. In Klein, U. & Lohrum, B. (eds.). *Das romanische Dach, Datierte Dachwerke vor 1230 (1250).*

Melin, K.-M. & Madsen, P. K., forthcoming. Die datierten Dachwerke in Schweden, Beispiele aus dem südschwedischen Schonen. In Klein, U. & Lohrum, B. (eds.). *Das romanische Dach. Datierte Dachwerke vor 1230 (1250).*

Mikkelsen, H. 2016. En romansk stenkirke bliver til og forandres – arkæologiske resultater. In Andersen, M. & Mikkelsen, H. (eds.), *Hedensted Kirke. Undersøgelser og restaureringer*. København.

Moltke, E. 1976. *Runerne i Danmark og deres oprindelse*. København.

Munk Olsen, B. 1996. Absalons studier i Paris. In Birkebæk, F., Christensen, T & Skovgaard-Petersen, I. (eds.), *Absalon fædrelandets fader*. Roskilde.

Mørkeberg, S. (in press). Den forfejlede korstogsfærd til Det Hellige Land – Historia de profectione Danorum in Hierosolyman, et vidnesbyrd om de magtpolitiske spil i den sidste halvdel af det 12. århundrede. In Aarbøger for Nordisk Oldkyndighed og Historie 2021.

Nielsen, H. 2012. *Et byggeri for Vorherre og evigheden, Danske romanske kirker, planlægning, planer og målforhold*. København.

Nørlund, P. 1927. Jorddrotter paa Valdemarstiden. In Nørlund, P. (ed.), *Festskrift til Kristian Erslev*. København.

Pennington, K 2019. Stephen of Tournai (Étienne de Tournai). In Descamps, O. & Domingo, R. (eds.), *Great Christian Jurists in French History*. Cambridge.

Ranvig, S. 1986. *Sorøkrøniken*, bind 2. København.

Rensbro, H. 2007. *Spor i kirkegulve. De sidste 50 års arkæologiske undersøgelser i kirkegulve som kilde til sognekirkernes indretning og brug i middelalder og renæssance*. Ph.d thesis, Aarhus Universitet. Aarhus.

Roesdahl, E. 2006. Danske sponsorer, vikinger og et blytag til Sainte-Geneviève i Paris 1188. In Kjær, U., Jørgensen, M.-L. & Christensen, J.H. (eds.), *Skæve vinkler. Festskrift til Kjeld de Fine Licht i anledning af 75 årsdagen*. København.

- 2010. Danish sponsors, English lead, Vikings, and a new roof for the church of Sainte-Geneviève in Paris. In de Groote, K., Tys, D. & Pieters, M. (eds.), *Exchanging Medieval Material Culture. Studies on archaeology and history presented to Frans Verhaeghe*. Brussels.

Rüffer, J. 2008. *Die Zisterzienser und ihre Klöster*. Leipzig.

Rydbeck, O. 1926. *Ärkebiskop Andreas Sunessons grav i Lunds domkyrka. En undersökning*. Lund.

Saxos Danmarkshistorie 2015. (2. udg.). Zeeberg, P. (trans.). København.

Schovsbo, P. O. 1987. *Oldtidens vogne i Norden: arkæologiske undersøgelser af mose- og jordfundne vogndele af træ fra neolitikum til ældre middelalder.* Diss. Odense University.

SRD, *(Scriptores Rerum Danicarum)*, IV, CXXI, Liber Donat. Monasterii Sorensis,

Thorsson, A.N. 2021. *När andra ser, Gravmonument, social praktik och aktörskollektiv under 1100- och 1200-talen i Vänerlandskapet*. Gotarc series B. Gothenburg, Archaeological thesis no. 77.

Troels-Lund, T. 1968. *Dagligt Liv i Norden i det sekstende Århundrede* 1, 6. udgave ved Erik Kjersgaard. København.

VSD (*Vitae Sanctorum Danorum),* ed. M.Cl. Gertz. København 1908-1912.

Ysebaert, W. 2005. Medieval Letter-Collections as a Mirror of Circles of Friendship? The Example of Stephen of Tournai, 1128-1203. *Revue belge de Philologie et d'Histoire*, Annee 2005, 83-2.

Ödman, A. 2018. Domkyrkoentreprenaden-förspel, genomförande och avslutning. In Cinthio, M. & Ödman, A. (eds.), *Vägar mot Lund*. Lund.

Upubliceret materiale

Christiansen, T.E. 1947. *Tage E. Christiansens efterladte papirer, Lommebog 1947*. In Antikvarisk-Topografisk Arkiv, Nationalmuseet.

Jouttijärvi, A. 2020. *Analyse af bly fra tagene på Roskilde Domkirke, Sorø Klosterkirke og Absalons kiste*. In Antikvarisk-Topografisk Arkiv, Nationalmuseet.

Melin, K.-M., Jansson. P., Börjesson, K. forthcoming. *Ignaberga gamla kyrka. Arkeologisk städning och hantverksvetenskaplig undersökning av kor och apsis. Rapport*, Knadriks Kulturbygg AB & Regionmuseet i Kristianstad.

Melin, K-M & Jansson, P. forthcoming. V*ä kyrka. Hantverksvetenskaplig undersökning med efterföljande dendrokronologisk analys. Rapport.* Knadriks Kulturbygg AB & Regionmuseet i Kristianstad.

Nielsen, P. 2002. *Rapport om blytage udarbejdet for Kirkeministeriet*. In Antikvarisk-Topografisk Arkiv, Nationalmuseet.

Rapport 2013. *Rapport om forureningsundersøgelser, 10 kirker i Horsens Kommune.* Region Midtjylland. Viborg. In Antikvarisk-Topografisk Arkiv, Nationalmuseet.

Per Kristian Madsen,
National Museum of Denmark, Frederiksholms Kanal 12, DK-1220 Copenhagen K.
Per.Kristian.Madsen@natmus.dk

Thomas Bertelsen,
Over Byen Arkitekter: Kløvermarksvej 70A, DK-2300 Copenhagen S.
tbe@overbyen.dk

Arne Jouttijärvi,
Heimdal-archaeometry, Skovledet 30, DK-2830 Virum.
heimdal@archaeometry.dk

Karl-Magnus Melin,
Knadriks Kulturbygg AB, Lejongatan 12, S-289 33 Knislinge.
kalle@timmermanskonst.se