THE BRAZING OF IRON AND THE METALSMITH AS A SPECIALISED POTTER

Anders Söderberg

Sigtuna Museum
Sweden
Email: anders.soderberg@sigtuna.se

Introduction

In early medieval metal craft, ceramics were used for furnace and forge linings and for crucibles and containers for processing metals, processes like refining, assaying and melting. Ceramic materials were also used in processes such as box carburisation and brazing, which is more rarely paid attention to. In the latter cases, we are merely talking about tempered clay as a protective "folding material", rather than as vessels. The leftover pieces from the processes, though, look very similar to crucible fragments, which is why the occurrence of brazing and carburisation easily gets missed when interpreting workshop sites. Yet, just like the crucibles, they tell about important processes and put the spotlight on the metalworkers as skilled potters.

Leftover pieces of what probably were clay wrappings used in box carburisation, performed as described by Theophilus in book III, chapters 18 and 19 (Hawthorne and Smith 1979, 94–95), seem to be relatively common at early medieval workshop sites in Sweden. They occur in medieval Sigtuna, on the Baltic island of Gotland and at the Migration period site at Helgö (Söderberg 2008). They also seem to occur in the West Slavic site at Bosau in northern Germany (Gebers 1981, 120 figs. 8–13 and 16) (Figure 1).

Vitrified ceramic fragments emerging from brazing in ceramic wrappings are even more common, and an aspect of this process was also described by Theophilus, in chapter 92 (Hawthorne and Smith 1979, 186). The method was used when joining iron bells for animals, in the manufacture of padlocks and to create the protective (?) copper alloy skins on Viking period iron weights, all processes that leave characteristic ceramic waste behind. There are traces of padlock brazing from the Viking ports-of-trade Ribe and Birka (Jakobsson Holback 1999), the early medieval town of Sigtuna (Söderberg and Gustafson 2007) and in Bosau. The process and its waste were not technically identified when the Bosau excavations were reported, but ceramic fragments appear unidentified in pictures in the catalogue (cf. Gebers 1981, 120 where figs. 1 and 2 may depict fragments of brazing packages for padlocks).

Figure 1. Map of Scandinavia, Denmark, the Baltic Sea and the different sites mentioned in this paper (A. Söderberg).

What are probably the remains of fragments emerging from the brazing of small bells, were found at Helgö and in Bosau (Figure 2; cf. Gebers 1981, 120 figs. 3-6), in early Christian Clonfad in Ireland (Young 2005, 3; Stevens 2006, 10) and in a Gallo-Roman smithy in Switzerland (Reymond *et al.* 2009, 94). The process was still in use in the rural production of bells for cattle and goats in the Swedish province of Dalarna as late as in the 20th century, and in the manufacture of padlocks in the 18th century (Björklund 1982, 342). The tradition of brazing bells was still kept alive in France in the 1990s (Laurence 1991) and has been experimentally explored by Tim Young (2007).

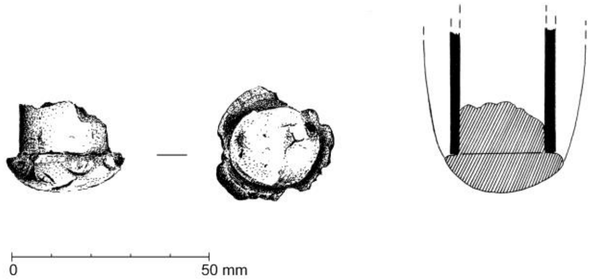

Figure 2. A "clay plug", formed at the end of a ceramic wrapping, possibly at the orifice of a small bell (coloured black in the reconstruction picture). Helgö, Sweden. Migration period (A. Söderberg).

Scandinavian early medieval weights were brazed in the same way as padlocks and bells. From the 9th century and four centuries on, the common weights used with trade in the Baltic region were spherical and polyhedral iron weights covered with a thin, 0.02–1 mm, layer of copper alloy (Figure 3). Fragments of the ceramic folding material have been found in German Haithabu and was described but never technically identified by Hans Drescher (1983, 183f). They were also found in Birka and in Sigtuna, where they occur in concentrated deposits in a few 10th-early 11th century workshops, of which two were tied to the early 11th century minting of King Olof Eriksson (Söderberg 2011 and forthcoming). Drescher named the fragments Schmeltkugeln, referring to their mainly globular shape, which in English would be the same as melting bowls.

Figure 3. Two brazed iron weights, Sigtuna. A spherical weight of Steuer's type B2 (11th or 12th century) and a very small polyhedrical weight. Melting bowl fragments in the background. The objects are put on a 1 cm grid pattern (A. Söderberg/Sigtuna Museum).

Birka and Sigtuna, a contextual framework

Sigtuna, located only one or two days sailing from Birka (Figure 1), was founded in the late 10th century after the decline and gradual abandonment of Birka. The workshop contexts from early Sigtuna are similar to the ones from Birka in some ways, but in several ways not. The two sites were functionally different and this shows by the volumes and proportions of workshop waste. While Birka was an important port on the northern trade routes between the Orient, the Baltic region and the Frankish empire, early Sigtuna was more of a political construction, ruled by king Erik Segersäll and his son and grandson Olof and Anund Jakob. The primary purpose with the town was to act as a focal point in a Christian kingdom patterned from the kingdoms and empires in Britain, Denmark and the European continent. This was a new phenomenon in a region that had so far been ruled by heathen petty kingdoms.

When we see an extensive mass production of copper alloy jewellery and some gold, silver, glass and garnet jewellery in 9th century Birka (Ambrosiani 2013, 71ff), together with the production of padlocks to lock the luxury goods away, the late 10th and early 11th century workshops in Sigtuna were characterised by low-intensity production of high class luxury goods and an extensive production of coins and weights. The Sigtuna mints under King Olof and Anund Jakob (995 AD until the 1020s) were the first in Sweden and obvious expressions of the ambitions to form a Christian kingdom, with their production of coins mainly based on the patterns of contemporary Anglo Saxon Ethelred pennies.

So far we know of two early workshops in Sigtuna: "the mint" (the gold smithies A89/A79) at the Urmakaren site and the smithy "house X" at the Humlegården site (Figure 4).

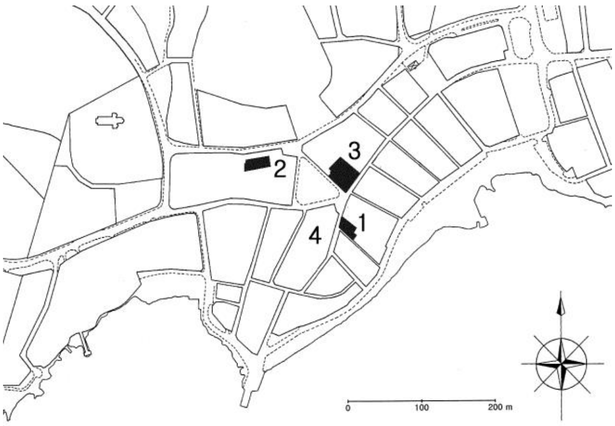

Figure 4. Map of Sigtuna, its still remaining early medieval town plan and the excavated sites mentioned here. 1) Urmakaren, 2) Humlegården, 3) Trädgårdsmästaren and 4) S:ta Gertrud, by some scholars believed to be the site of the King's manor (map by Sigtuna Museum and A. Söderberg).

These workshops were involved with the cutting of coin dies and with the production of weights. There was also antler and walrus ivory working, goldsmithing and glass working in the mint. Where the production at Birka aimed mainly for distribution through trade, which may be reflected in the vast mass production of women's brooches, the workshops in early Sigtuna was probably producing directly for the royal court, delivering few and unique objects of gold, glass and walrus ivory, beside the production of means of payment.

The brazing of padlocks in ceramic shells

The basic principle when brazing the different parts of an iron padlock together, was to fold the lock and the copper alloy solder in a wrapping of tempered clay that, after drying, served as a protective cover creating a reducing environment. Thus, the problem with oxidation was solved, and there was no need for a fluxing agent in the process. The use of an inner jig of charcoal or tempered clay, to keep the different parts of the padlock in place, has been hypothetically suggested (Gustafsson 2005, 21f). Probably, a piece of dry manure or peat would serve even better, as it would be easier to remove from the interior of the finished padlock. The firing would reduce the jig to charcoal; steady enough to act as a stabiliser throughout the rather quick process, when the package was put into the hot forge for the bronze or brass to melt. After firing and cooling, the clay package was broken up, unveiling the finished padlock. The vitrified remains of the wrappings are easily distinguished from crucibles and similar vessels, as they usually show imprints of padlocks on their inner surfaces, sometimes with impressions of cords used to bind the parts of the padlock together before brazing (Figure 5).

Figure 5. Sigtuna: a fragment of a brazing package with the imprint of a cylindrical padlock, and different types of padlock. The box-shaped padlock to the left is corroded and some strips of the copper alloy solder are visible at the lower left corner, sticking out from under the iron where the joints used to be (A. Söderberg/Sigtuna Museum).

The manufacture of padlocks was an important activity in the 9th century metal workshop in Birka. Among the 25,000 fragments of ceramic casting moulds were also 5,600 fragments or 9.5 kilograms of ceramic fragments probably mainly emerging from brazing (Jakobsson Holback 1999, 7ff). Padlocks seem to have been an important part of the metalsmith's production.

In Sigtuna, padlock manufacture was very sparse until the 12th century, when the connections with Kiev Rus and Byzantium flourished and wealth also seem to have reached the common town plots. But the production never reached the high levels of the 9th century Birka workshop, by far. After a peak of 350 grams of collected ceramic fragments from the 980s, the finds from the Urmakaren site maintain levels below 100 grams per building phase until the 13th century when the level peaks again, to the modest level of 350 grams per building phase. A similar pattern can be seen at the nearby Trädgårdsmästaren site, excavated in 1988-1990; the levels stay below 100 grams per building phase during the 10th and 11th centuries (each phase was approximately 25-50 years), and rises in the 12th century, reaching 450-700 grams per phase (Söderberg and Gustafson 2007, 18ff). Padlocks were made in Sigtuna, but probably just occasionally to fulfil local needs. On the contrary, the large volumes of waste from the extensive 9th century production in Birka may be the reflection of a more dynamic activity with mass manufacture, trade and external distribution.

The brazing of iron weights

The technology of brazing early medieval iron weights was similar to the brazing of padlocks, with the difference that the weight and solder were wrapped in a small textile bag before folding it in clay (Figure 6). This wrapping is equivalent to the binding with cords that sometimes was practiced when brazing padlocks. The cloth has left distinct textile impressions inside the melt bowl fragments, just like the cords sometimes leave impressions inside the fragments emerging from padlock brazing.

There are finds of ceramic waste emerging from the brazing of weights from a mid-10th century workshop context in Birka (Söderberg 2011, 21), preceding the Sigtuna workshops and possibly hinting about a continuity between the two towns. The production on the site was characterised by high status goldsmithing and glass working and by rather modest volumes compared to the extensive production in the 9th century workshop mentioned before. Thus, the later Birka workshop seems more related to the Sigtuna workshops, rather than to the earlier.

In Sigtuna, large deposits of waste from the manufacture of weights have been found in and outside the late 10th and early 11th century workshops

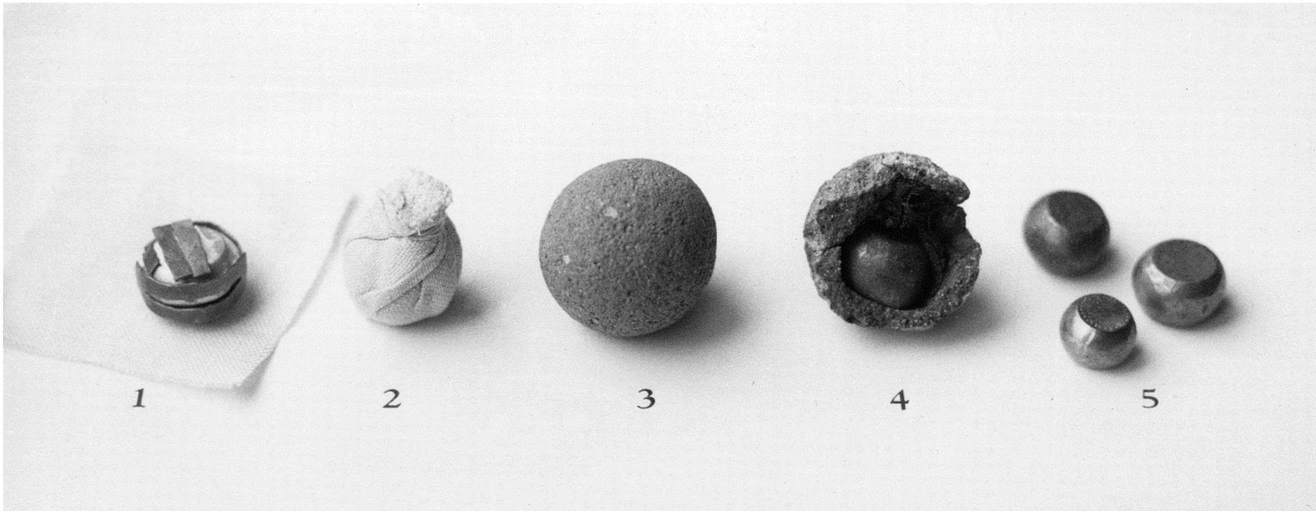

Figure 6. The brazing of weights: (1–2) the iron weight is folded in a cloth together with pieces of copper alloy, before (3) it is folded in clay. The dried clay bowl is put in the forge and heated to 900–1000 °C. After cooling the bowl is opened (4–5). The process of brazing padlocks is virtually the same (A. Söderberg).

A89/A79, "the mint", and outside the contemporary smithy "house X" (Figure 7).

So far, 25 kilograms have been found, roughly equivalent to the production of approximately 900 weights, if we assume that the average complete melting bowl shell may weigh 25-30 grams.

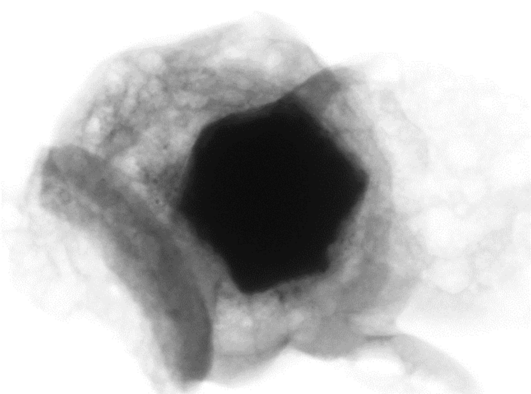

Figure 7. X-ray image of the only melting bowl, so far found, that the King's artisans forgot to open. It contains a polyhedral weight, folded in clay and brazed. From the context around the A89 workshop, late 10th century. The weight is approximately 10 mm wide (X-ray photo by Folktandvården Sigtuna).

There also appears occasional smaller finds at other sites, probably mainly telling of secondary deposition, but we cannot rule out the possible existence of more, but yet undiscovered, workshops involved with the production. At the Trädgårdsmästaren site finds are negligible, and probably results of secondary deposition.

Research has explained the production of weights, simultaneous with the minting, as a result of difficulties to introduce a monetary system in a silver bullion economy with strong traditions. King Olof was not powerful enough to maintain a system with overvalued coins and to exclude the old customs of payment. He had to take control over the weighing system as well (Gustin 1997; Kilger 2011). According to Heiko Steuer (1984), there are two types of spherical iron weights that seems to have been introduced in the Baltic region by the time of King Olof Erikssons reign; type B1 (middle type) and B2, of which B1 is the type found at the Urmakaren site. Steuer's distribution maps of the two types show the highest densities in the mid-Swedish lake Mälar region (the Sigtuna area) and in southern Finland by the entrance to the Gulf of Finland and the important waterway to Novgorod (Steuer 1984, 286f). According to the distribution pattern, it seems fair to suggest Sigtuna as the main production site of brazed iron weights in the early 11th century.

The ceramic material in the brazing packages and the melting bowls

Torbjörn Jakobson Holback describes the ceramic fabric in the Birka fragments as "probably a local silty clay with strains of temper of crystalline rock" (Jakobsson Holback 1999, 5, my translation). This description was based upon not yet published analyses made by Dr Alan Vince, Lincoln, of industrial ceramics from the large Birka excavation in 1990-95.

In 2008, thin section petrographic and chemical analyses by ICP-MS of one brazing package fragment and two melting bowl fragments from the Humlegården site in Sigtuna, were made together with analyses of crucibles for the excavation report. The results seem to confirm the pattern from Birka. A common clay used by craftsmen at the Humlegården site, was named "fabric E" by Vince. This fabric includes abundant angular quartz inclusions, up to 0.3 mm long and several with shard-like shapes; abundant elongated voids up to 1.5 mm long and 0.2 mm wide, left by burning off the organics, many still containing carbonised material; sparse angular plagioclase, some lath-like in shape; and occasional sub-angular fragments of an unidentified cryptocrystalline, up to 0.2 mm across. The quartz-rich fine sand is probably of glacial origin and the complete lack of rounding and extreme angularity of some grains suggests that this is a lacustrine clay containing material derived from the frost-shattering and ablation of pro-glacial gravels (Vince 2008, 4f) (Figure 8).

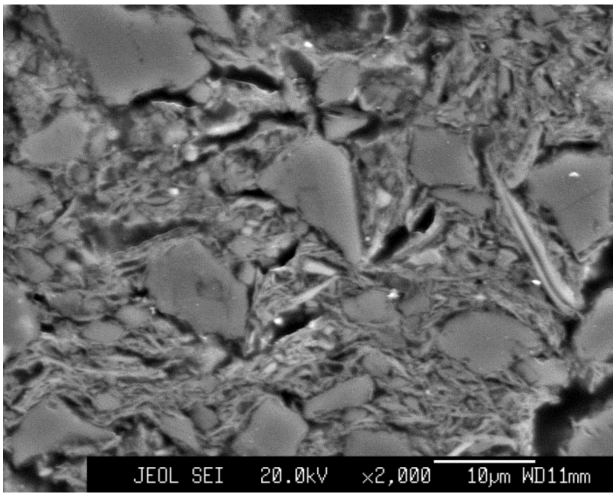

Figure 8. SEM image of a polished sample of a glass melting crucible from the Humlegården site, showing the angular shard-like fine quartz sand in Vince's "fabric E" and the filaments of the vitrified ceramic (after Faber 2008).

Obviously, this is a glacial clay, partly or completely tempered "by nature" and mainly with low lime contents, typically 1.82-2.82% (12 samples analysed). Vince also refers to a similar ceramic material in 9th century bronze casting moulds from Birka.

A similar fabric seems to be present at the Urmakaren site, in houses A89/A79, as reflected by thin section, ICP-MS and ICP-AES analyses of furnace linings recently performed by Dr Patrick Quinn at the University College London and by the Department of Earth Sciences, Royal Holloway University of London. Diatom frustules occur in some samples, inconspicuous siliceous microfossils produced by aquatic algae that may be evidence for the use of a lacustrine clay source. In addition to the abundant mono-crystalline quartz, polycrystalline quartz, feldspar, biotite and muscovite mica and amphibole occur, as well as occasional small rock fragments of quartz and feldspar that may be metamorphosed plutonic igneous rock. This suite of inclusions is not inconsistent with the types that might be found in glacial material eroded from the Precambrian bedrock of the Sigtuna area (Quinn 2014a, 6) (Figure 9).

Skilled artisans, selective in their choice of clay

For the report of the Humlegården excavation, Vince also analysed six samples of daub and loom weights by thin sectioning, ICP-MS and ICP-ES, for comparison with the data from the industrial ceramics. What is obvious is that different clays were chosen for different purposes. While the clay used for the pyrotechnical crafts of metal and glass contained natural quartz inclusions and low lime contents, the clay used for domestic purposes ("fabric G") was a fat clay with higher lime content (3.58-6.09%). "[...] it is clear that the fired clay used for daub is identical to that used for loom weights but that the clays are completely different from those used for industrial ceramics. The lack of quartz silt in "fabric G" might indicate the use of a marine clay, deposited below the tidal zone. Quaternary marine clays are exposed throughout coastal Scandinavia, often at some distance from the present coastline, as a result of glacial uplift" (Vince 2008, 10f). Probably, this clay was excellent for use without firing, as it gets hard and durable after drying, but less suited for firing because of the very dense structure and the low refractory quality. Loom weighs are often found unfired at excavations in Sigtuna, and when found fired they usually show dramatic signs of unintentional firing, probably in house fires. In those cases, they are generally shattered into small fragments after exploding when the chemically bound water is released during firing.

There was another rather special clay appearing at the Urmakaren site, geochemically similar to the clay used for loom weights at the Humlegården site. This was a frost-shattered and fired clay that may have been a deposit left to mature over the winter that was never used, as it probably was destroyed in a house fire (Figure 10).

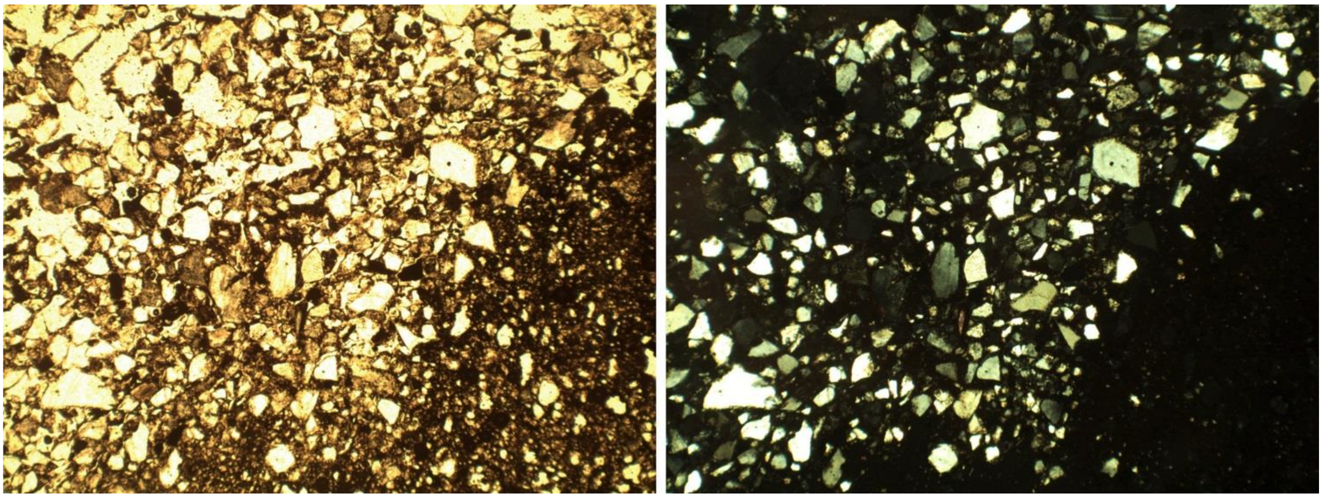

Figure 9. Thin section photomicrographs of a sample of furnace lining from the mint A79. Image width = 2.9 mm. Left picture: plane polarised light; right picture: crossed polars (after Quinn 2014a).

Quinn also finds a geochemical relation to earlier analysed, not yet published, samples of local medieval pottery from Sigtuna (Quinn 2014b, 4). It may have been a household's clay storage to be used for domestic pottery.

Figure 10. Frost-shattered and fired clay from the Urmakaren site. It seems likely that it had been deliberately stored at temperatures below zero over the winter to create the crumbly structure, making it more easily mixed with temper prior to pottery making (A. Söderberg/Sigtuna Museum).

Conclusion

In Sigtuna, we see that the metalsmiths and glass artisans collected clay from different sources than the people involved with pottery making and weaving. Clay was, together with stone and wood, a basic material in Middle Age everyday life, and knowledge of the different varieties and qualities of clays must have been common among medieval men and women. This knowledge was probably even more specialised among the people working professionally with ceramics – and metalcraft. On the basis of the analyses described above, craftsmen were fully aware of differences in clay quality and they knew where to search for different sources of clay, suitable for the different purposes.

Acknowledgement

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References

Ambrosiani, B. 2013. *Stratigraphy, vol. 1. Part one: The Site and the Shore. Excavations in the Black Earth 1990-1995*. Birka Studies 9. Stockholm.

Björklund, H. 1982. *Lima och Transtrand: ur två socknars historia 1*. Malung.

Drescher, H. 1983. Metallhandwerk des 8.-11. Jh. in Haithabu auf grund der Werkstattabfälle. In Jahnkuhn. H. (ed.) *Das Handwerk in vor- und frühgeschichtlicher Zeit*, II, 174-192. Göttingen.

Faber, E. 2008. *Firing temperature estimation of early medieval glass crucibles.* MRF report 08/01, Microanalysis Research Facility, Department of Archaeology, University of Nottingham.

Gebers, W. 1981. *Bosau, Untersuchung einer Siedlungskammer in Ostholstein.* V:1, Der slawische Burgwall auf dem Bischofswarder, 1: Katalog.

Neumünster.

Gustafsson, Ny B. 2005. On Norse padlocks – production and use. Examples from the Birka Garrison. *Jonas 15 - Journal of Nordic archaeological science,* 19-23.

Gustin, I. 1997. Islam, Merchant or King – Who was behind the making of the Viking Age weights? In Andersson, H., Carelli, P. and Ersgård, L. (eds.) *Visions of the past. Trends and Traditions in Swedish Medieval Archaeology*, 163-178. Lund.

Hawthorne, J. G. and Smith, C. S. 1979. *Theophilus; On Divers Arts. The Foremost Medieval Treatise on Painting, Glassmaking and Metalwork*. New York.

Jakobsson Holback, T. 1999. Svårtolkade spår efter en metallurgisk process – ett danskt exempel och dess paralleller i omvärlden. *By, marsk og geest* 11, 5-12.

Kilger, C. 2011. Hack-Silver, Weights and Coinage: The Anglo-Scandinavian Bullion Coinages and their Use in Late Viking-Age Society. In Graham-Campbell, J., Sindbæk, S. M. and Williams. G. (eds.) *Silver Economies, Monetisation and Society in Scandinavia, AD 800-1100*, 259-281. Aarhus.

Quinn, P. S. 2014a. *Petrographic Analysis of Industrial Ceramics from Medieval Sigtuna, Sweden*. Ceramic Petrography Analytical Service, UCL Institute of Archaeology. 2014:82.

Quinn, P. S. 2014b. *Geochemical Analysis of Industrial Ceramics from Medieval Sigtuna, Sweden*. Ceramic Petrography Analytical Service, UCL Institute of Archaeology. 2014:86.

Reymond, S. (ed.), Eschbach, F. and Perret, S. 2009. *La villa romaine du Buy et sa forge. Dernières découvertes à Cheseaux, Morrens et Étagnières (canton de Vaud, Suisse).* Cahiers d'Archéologie Romande 115. Lausanne.

Söderberg, A. and Gustafsson, Ny B. 2007. Från prestigevarugjutning till myntning, tidigmedeltida metallurgi i kvarteret. *Trädgårdsmästaren, Sigtuna. Situne Dei* 2007, 17-40.

Söderberg, A. 2008. Metallurgical clay packages. In Clarke, H. and Lamm, K. (eds.*) Excavations at Helgö* XVII, 159-169. Stockholm.

Söderberg, A. 2011. Eyvind Skáldaspillir's silver-refining and standards in pre-monetary economies in the light of finds from Sigtuna and *Gotland. Situne Dei* 2011, 5-34.

Steuer, H. 1984. Feinwaagen und gewichte als Quellen zur Handelsgeschichte des Ostseeraumes. In Jankuhn, H., Schietzel, K. and Reichstein, H. (eds.) *Archäologische und naturwissenschaftliche Untersuchungen an Siedlungen im Deutschen Küstengebiet.* Vol 2, Handelsplätze des frühen und hohen Mittelalters. Bonn.

Vince, A. 2008. Characterisation studies of industrial ceramics from Sigtuna, Sweden. Avac 2008006. On CD-rom in Wikström, A. (ed.) *På väg mot Paradiset – arkeologisk undersökning i kvarteret Humlegården 3 i Sigtuna 2006*. Meddelanden och rapporter från Sigtuna Museum nr 33. Sigtuna.

Young, T. P. 2005. Interim report on the evaluation of metallurgical residues from Clonfad 3 (A001:036). *GeoArch Report* 2005/09.

Electronic resources

Laurence, P. 1991. Cloches, grelots et sonnailles. Terrain - Revue d'ethnologie de l'Europe, March 16 1991, published on-line on April 12, 2005. URL: http://terrain.revues.org/2994 (November 16, 2014).

Stevens, P. 2006. A monastic enclosure site at Clonfad, Co. Westmeath. Archaeology Ireland, summer 2006. URL: http://www.nra.ie/archaeology/archaeology-ireland-articles/monastic-enclosure-at-clonfad.pdf (November 16, 2014).

Young, T. P. 2007. Early Medieval Handbell Reconstruction. URL: http://www.geoarch.co.uk/experimental/bell.html (November 16, 2014).