ON BRONZING IRON OBJECTS – ARCHAEOLOGICAL EVIDENCE OF WEIGHT-MANUFACTURE IN VIKING AGE SCANDINAVIA?

Anders Söderberg and Lena Holmquist Olausson
Archaeological Research Laboratory, Stockholm University, S-10691 Stockholm, Sweden

Abstract

The clay packings called *Schmelzkugeln* (Melt Bowls) have earlier been found in Haithabu, Schleswig. Since two large finds of melt bowls recently have been found at Birka and in Sigtuna, Sweden, a deeper study of the fragments has been made, mostly on an experimental basis. The study shows that they could descend from a bronze-plating process, as the reducing athmosphere inside the clay shell provides an exellent method in bronzing iron objects. As a result a hypothetical connection is made between the bowls and the Viking Age bronze-coated weights.

The subject of bronze-coating iron objects in Iron Age and Early Medieval times causes questions concerning the techniques used by the ancient craftsmen. The questions often rise when dealing with Viking Age spherical bronze-coated iron weights (Fig. 1); how were these coatings created?

Theophilus "On Divers Arts" is believed to be written only some decades after the end of the Viking era. In chapter 92 he describes a process in hard-soldering iron objects by wrapping a thin strip of copper around the join and baking it into a clay packing. When the clay is dry, it is all to be put into hearth. No flux has been required. (Hawthorne & Smith 1979:187).

This is the help given regarding contemporary written words, but are there archeological evidences for bronzing or copper-plating that could tell more about the technique? Some answers seem to be found among silicate slags and crucible fragments from workshop sites. In Bergen, Norway, vitrified clay fragments are found, with imprints of padlocks inside. Medieval iron padlocks were often bronze-coated and the fragments are believed to be remains of a coating process similar to Theophilus soldering method (Brinch Madsen 1996). In Viking age town of Haithabu in Schleswig, Germany, a large amount of sintered clay sherds of different shapes are found. Among them are remains of small clay bowls with imprints of textile in their cavities, called *Schmelzkugeln* – Melt Bowls. Silicon castings of their cavities show small textile bags covered in clay before drying and heatened (Fig. 2) (Drescher 1983:183f). These melt bowls seem possible to be put into a technical context, most likely tied to a bronzing process.

Similar fragments have been found in a ninth-tenth century workshop site situated on older longhouse terraces close to the town rampart of Birka, Sweden, since several years investigated by the Archaeological Research Laboratory of the Stockholm University (Fig. 3) (Holmquist Olausson 1993). The workshop area shows signs of ironsmithing, bronze-casting and bead-making. 1374 grams of melt bowl fragments were found in 1995–96, the major part concentrated in a sooty layer among a few crucible fragments and other workshop-related objects. Earlier, in 1990, some even larger concentrations – 7467 grams in total – were found in an early eleventh century workshop in Sigtuna, Sweden. This is strongly believed to be remains of the royal workshop of king Olof Eriksson Skötkonung, since it is situated close to the place of the king's recidence and since lead pieces with die-impressions of Olofs-coins were found (Malmer, Ros & Tesch 1991). This is the earliest evidence of mintage in Sweden and the workshop is, due to its royal context, of great interest.

The fragments of Birka and Sigtuna

The shapes of the fragments indicate an origin in spherical and completely closed vessels or clay-packings (Fig. 4). They have been ≈20–55 mm in diameter, some bowls have been larger but are too broken to be measured. The thickness of the fabric is irregular and varies from ≈1 mm to ≈20 mm. It is greyish, porous, filled with gas bubbles and more or less vitrified. The glassy outer surfaces are greyish green in colour, sometimes with red spots of various spreading and size. The cavities have imprints of textile and the inside surfaces are matt grey and porous contrary to the hard outside surfaces. Measurements of the more or less round/oval cavities give a size-span of ≈13x17 – ≈27x28 mm, the cavities of the larger packings have been wider. Castings show images of small textile bags, often covering thin sheets or rods wrapped around cores of uncertain shapes.

The clay is tempered with sand and the proportion is high, more than 50%. Charcoal inclusions indicates a smaller quantity of crushed charcoal or a temper of other vegetabile origin; small imprints of short fibres (<2 mm) in the cavity walls could tell about a possible adding of cattle or horse spillings. In Haithabu, common local crucible material has been used (Drescher 1983:183).

Some fragments still carry traces of metal, small concentrations of green oxide. A series of qualitative XRF-analyses have been made on the oxide traces as well as on the surfaces in the cavities. Detected elements in the oxide-concentrations are Ca, Fe, Cu, As, Mg, Al, Si, P, S, Pb, Cl, K, Sn. In the fabric are traced Ca, Ti, Fe, Cu, Ni, Na, Mg, Al, Si, P, S, Pb, Cl, K. Copper (Cu), Tin (Sn), Lead (Pb) and possibly Arsenic (As) tell about an origin tied to bronze-handicraft.

The experiments

In order to, if possible, find out what metallurgical process the fragments have been part of, a series of experiments has been made. Since an early stage the basis was that the sherds descend from a brazing process of some kind, like the fragments from Bergen and like the process described by Theophilus. Soon it was clear that Theophilus recommends an exellent method in brazing, working with copper as well as with bronze. The clay shell is an elegant solution to the oxidation-problem, the reducing athmosphere inside allowing the two metals (iron and copper/copper alloys) to join together.

The experiments were made in a laboratory furnace and to imitate the reducing conditions in an open hearth – as close as possible – the bowls were burnt inside a lidded crucible filled with charcoal. Most of the experiments were made at a temperature of 1100 degrees C with a process time of 30 minutes as this worked well with the metals used; Cu + >10% Sn (an unspecified alloy, melting point 960 degrees C), Cu + 6% Sn + 0.2% Pb and the latter alloy with an addition of 10% Pb; the iron was a Lancashire iron with a low coal content, 0–0.3%. Thermal Colour Tests (TCT) of the original fragments showed colour changes between 800–900 and 900–1000 degrees. This could indicate plating with alloys of slightly lower melting points than the alloys used in the experiments. As tin-bronze sometimes left parts of the surface uncovered, a leaded tin-bronze was used which has a better fluidity. This corresponds well to the XRF's, which indicates use of a leaded bronze.

As a result from the experiments the following hypothetic process was reconstructed: *An iron core of required shape is covered with sheets or thin rods of leaded tin-bronze. Iron and bronze is packed into a connecting piece of linen-cloth which is baked into clay, tempered with sand and organic material. A small bowl is rolled and put to dry. The dry bowl is put into the hearth at 1100 degrees C. The bronze melts and covers the iron core, the connecting textile bag transforms into a charcoal layer which prevents the bronze from getting attached to the clay during the melting. After 30 minutes the bowl is taken out of the hearth and cooled down, after which it is crushed. The coated object can now be polished. When dealing with weights they could be weight-adjusted by filing and weight-markings can be punched on the flat poles.*

File marks are observed on a weight from the Birka town rampart. The experimental coatings required filing, as coatings thicker than ≈0.2 mm tended to be irregular in thickness. As the coatings are fairly thin, filing weights is hazardous and the ideal circumstance must have been not having to do this. Perhaps coatings with better regularity is merely a matter of technical know-how. Measured weight-coatings from Birka and Sigtuna are 0.2–1.6 mm thick. (Sperber 1996:82 & 90).

Evidences of weight-manufacturing? A short discussion

A criticism on the reconstructed process would be that an exellent method in bronzing is certainly found here, but nothing proves this was the method used by Iron Age and Medieval craftsmen. Yet, the clay fragments created are very similar to the archaeological ones. There are metal drops stuck to the cavity walls – the process often leaves an amount of "lost" bronze in the bowls – corresponding to the small oxide concentrations in the original sherds. After the successful experiments done, it seems hard to suggest another origin but a bronzing technique. Especially since the process used in the experiments is structurally the same as Theophilus' brazing process.

Suggesting this to be the method used when bronze-coating weights could be criticized as far too a big step to make under present circumstances. This could be true, as the archaeological context of the Birka site doesn't further connect the melt bowls to weight manufacturing. No semi-manufactures are found except for a thin bronze sheet from the sooty layer, which as well could origin from anywere but in a bronzing process. The hypothetical connection was made when searching for artefacts matching the cavities in size. Measured weights from Birka and Sigtuna (Sperber 1996:82 & 90f) all suits well within the range of measurements made from the cavities – except for the larger weights, but as mentioned there are fragments of larger bowls that couldn't be measured. Concerning the alloys in the weight-coatings there are analyses (Sperber 1993:148 & 1996:79, 86 & 90) indicating use of leaded tin-bronze or copper/lead-alloys, just like the alloys that could be reconstructed from the XRF-analyses of the melt bowls. There's also a chronological connection, as these weights appear on the Scandinavian scene by the end of the 9th century.

An interesting point of wiew is the royal context of the Sigtuna workshop, the workshop to where English craftsmen were called to fulfil the king's project in manufacturing coins. It wouldn't be too a far assumption that mintage and weight manufacturing could have been linked together, in the recently founded court's efforts to secure power and to control trade in 1100th century Svealand. It seems fair to suppose that the weight-master has been a skilled craftsman with knowledge not only in the technical process, but as well in weight systems and in mathematics like the mint-master. As a mint probably was in constant need of weights, the mint-master and the weight-master could have been the same person. If the linkage King – Invited Craftsman – Weights – Melt Bowls is to be confirmed this could perhaps help placing the workshop of Birka into a social context, as this workshop still is a rather anonymus one.

Thus there are no evidences to tie the weights and the melt bowls together, but the indications are strong enough to give the hypothesis a convincing probability. This probability is so far what we will have to put up with, while waiting for further research to be done.

References

Brinch Madsen, H. 1996. Personal communication.

Drescher, H. 1983. Metallhandwerk des 8.–11. Jh. in Haithabu auf grund der Werkstattabfälle. In: Das Handwerk in vor- und frügeschichtliger Zeit. Teil II, archaäologische und philologische Beiträge. H. Jankuhn (Ed). Göttingen.

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

Holmquist Olausson, L. 1993. Aspects on Birka. Investigations and surveys 1976–1989. Theses and Papers in Archaeology B:3. Stockholm.

Jankuhn, H. 1943. Die Ausgrabungen in Haithabu (1937–1939). Vorläufiger Grabungsbericht. Berlin-Dahlem.

Malmer, B. Ros, J. Tesch, S. 1991. Kung Olofs mynthus i kvarteret Urmakaren, Sigtuna. Sigtuna museers skriftserie 3. Sigtuna.

Sperber, E. 1993. Finds of weights from the 1988 excavation. In: L. Holmquist Olausson; Aspects of Birka. Investigations and surveys 1976–89. Theses and Papers in Archaeology B:3. Stockholm.

Sperber, E. 1996. Balances, Weights and Weighing in Ancient and Early Medieval Sweden. Theses and Papers in Scientific Archaeology 2. Stockholm.

Söderberg, A. 1996. Schmelzkugeln – Identifikation av en hantverksprocess. Fyndmaterial från Birka och Sigtuna. In: CD-uppsatser i Laborativ Arkeologi 95/96. Del 2. Stockholm.

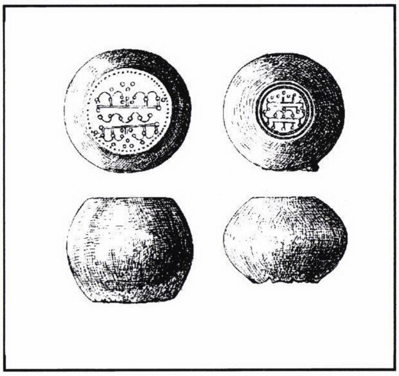

Fig. 1. Weights from Haithabu, 2/3. After Jankuhn 1943.

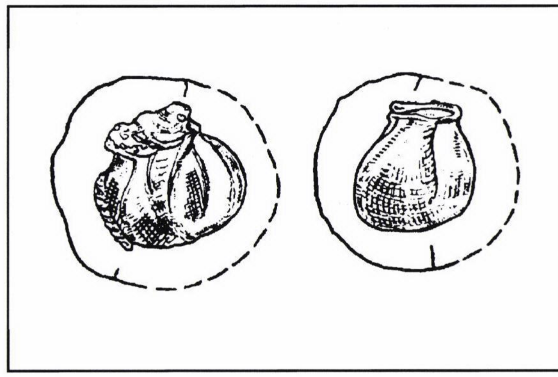

Fig. 2. Schmelzkugeln from Haithabu, textile bags reconstructed, 1/1. After Drescher 1983.

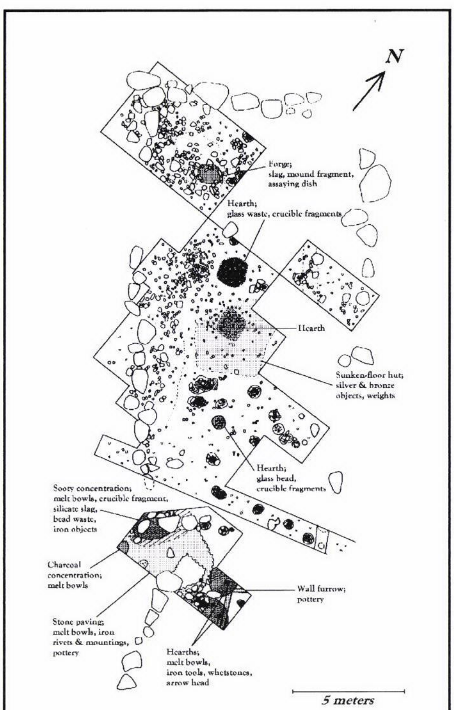

Fig. 3. The excavated area nearby the Birka town rampart. Graphics by Anders Söderberg, after original plans by Michael Olausson.

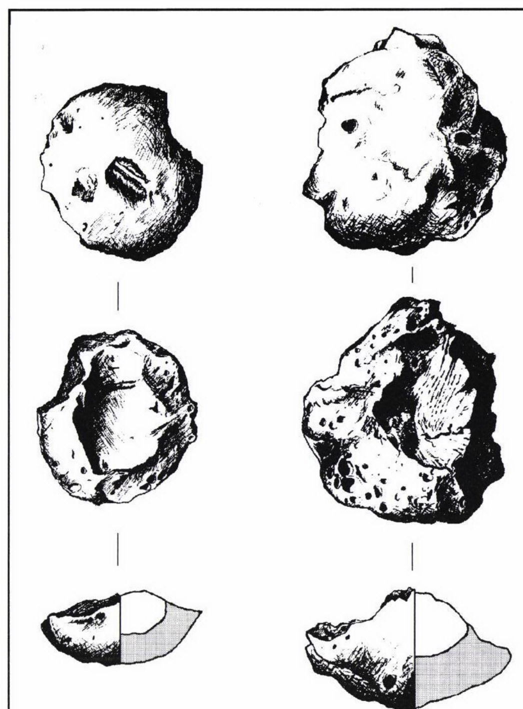

Fig. 4. Melt bowl fragments from Birka (left) and Sigtuna (right), 1/1. Drawings by Anders Söderberg.