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Abstract

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This paper focuses on Bronze Age melting crucibles in southern Scandinavia. The shape and purpose of the crucibles have long been known, but the process of making one has not been studied thoroughly. The crucibles have in some cases been reconstructed in order to replicate the casting process or the finished product, but have rarely been the main subject of research. In this paper crucibles found in Broåsen, Grimeton parish in Halland (southern Sweden), are studied. The aim of the study is to investigate the level of skill of the person who made the crucibles. In turn, this can help us understand the social status of the craftsperson. Experiments have shown that crucibles similar to the ones found at Broåsen have a "life expectancy" of at least 20 castings. Since traces of use on the Broåsen crucibles correspond to those on the crucibles used in the experiments, we have to regard the (Broåsen) crucibles as items that were used for multiple castings. This also tells us that there were in this case skilled craftspeople working with crucible production. We may also speculate about the status in society these people would have had because of their skill in making durable tools used in the bronze casting process. When compared to other material in southern Scandinavia it is clear that the quality of the crucibles varies, as does the number of times they were used. Different people with different levels of technological skill and different status in society were therefore connected to this craft. It is possible that it was the casters themselves, the local potter or some other group in society, that made the crucibles; this would differ between contexts.

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Introduction

This study focuses on the making of melting crucibles, an item as necessary as the mould in the process of casting bronze. What information can they contribute? Crucibles as archaeological material are one of few items of debris from bronze production that are still available for us and possible to study, making the investigation of bronze casting partly dependent on the study of crucibles. I have chosen to focus on a site called Broåsen in Halland, in southern Sweden (presented below). In this article I shall start by discussing the knowledge that was needed or possessed by the people making crucibles. Secondly, who were these people, and thirdly, how was their status compared to others?

What knowledge did they possess?

Craft knowledge is sometimes hard to recognize through archaeological material. Michael B. Shiffer and James M. Skibo (1987, 2010) divide knowledge into three main parts: first the recipes for action, meaning the knowledge of what type of raw material to use and how to acquire it. Second, the teaching framework, meaning the learning of the skill by verbal instruction, trial and error, imitation etc. Third, the techno-science, meaning the technological principles behind the craft that the craftsperson may or may not be aware of (Shiffer & Skibo 1987, pp. 597 f.; 2010, pp. 93 ff.). The second part of Shiffer and Skibo's definitions of knowledge may be divided, according to Jacques Pelegrin (1990, p. 118), into *connaissance* (know-how) and *savoir-faire* (knowledge). In this division know-how is something that may only be obtained by the craftsperson through practical experience, while knowledge is obtained by words, written language, etc. In this text I refer to the terms "technical knowledge" and "skill" which are both intended to correspond to Shiffer and Skibo's term knowledge or Pelegrin's *connaissance* and *savoir-faire*.

One way to recognize or define technical knowledge through material culture is that a person's technical knowledge or skill would apply to the produced object in terms of the quality (Apel 2000, pp. 147 ff.). What quality really is can be discussed since ideas of design, usability, durability, and so on most certainly have varied through time. Helle Vandkilde divides the function of an object into three categories: practical function, social function and symbolic function (2000, pp. 21 ff.). The preferences of quality for an object would naturally differ depending on which category is in focus. In this case the practical function will be in focus. The idea of what high quality is concerning objects that are used in a practical context, such as tools, seems to have been more static through human history: As long as the purpose is the same, the requirement of a high-quality tool is still very similar. In this case, therefore, I choose to view the technical knowledge of the craftsperson through the usability of the products that person made. However, according to this theory, a skilled craftsperson will appear unskilled if doing what is defined as typically unskilled labour. Therefore, depending on the type of production (skilled or unskilled), a craftsperson's technical knowledge can or cannot be seen in the products of the craft. This means that a low-quality object does not necessarily derive from production conducted with the help of unskilled labour. A high-quality object, however, can only be produced by a person possessing a certain level of technical knowledge (skill). In other words, one way to look at the presence or absence of knowledge is to consider the usability of the crucible, indicating high/low quality.

A major issue connected with usability is durability; how many times can the crucible be used before being discarded or repaired? Earlier studies have concluded through experiment that crucibles made in the same shape as crucibles during the Bronze Age have a durability of around five castings (Kjærulf Andersen 2007, p. 26), although this may depend on the experience of the archaeologist. Mats Lönnberg has been working with reconstructing bronze casting for 14 years and uses both Bronze/Iron Age and medieval techniques; in his experience the durability of the bronze age type of crucibles is around 5–10 castings (Lönnberg, M., personal communication).

To investigate the level of technical knowledge possessed by the crucible makers I have studied material from Broåsen, Grimeton parish in Halland (southern Sweden). Broåsen is a till ridge on which around 40 stone structures and mounds interpreted as graves dating to the Late Iron Age have been registered.

Nearby the remains of a settlement dating to the Bronze Age were discovered in connection with the building of a housing area (Weiler 1996; Lindälv 1967, pp. 133 ff.). In 1915–1918 George Sarauw excavated a stone cairn at the site and found there the debris of Bronze Age pots, moulds and crucibles. This was interpreted as the remains of a bronze casting workshop from the Bronze Age (Sarauw 1919). Among the crucibles three were still in one piece, another 17 were refitted (Lindälv 1967, p. 133) and 222 fragments or roughly 2.4 kg were not possible to refit (Eklöv Pettersson 2011, pp. 5 f.). This material was assumed to represent the debris from large-scale production. If a particular type of knowledge is required to make a useful sustainable crucible, it should be visible in that kind of material.

Several studies have shown that different types of temper were used when making crucibles compared to, say, household pottery (e.g. Hulthén 1991, pp. 24 ff.; Johansson 1993, p. 92; Stilborg 2002, p. 146). The difference indicates that the producer wanted the crucible to have different abilities from the other ceramic products. These abilities are most probably connected to the type of usage the crucibles had, i.e. heat resistance (Stilborg 2003, p. 146). There was most probably an effort to make better and better crucibles by making them more sustainable. Thus the temper and clay were modified. It seems to me essential to study this connection in order to understand the process behind making a useful crucible.

In order to see how the crucibles from Broåsen were made and to ascertain more definitively how durable they were, the whole and refitted crucibles were studied regarding shape and the sherds were studied regarding temper and clay. Of the 222 sherds, ten were selected that were assumed to represent the variations within the material, in terms of both repairs and differences in temper. These sherds were taken for thin section analysis. From the thin sections it is possible to see at least four different types of temper (Table 1).

In order to further study the durability the analysis continued by replicating the crucibles and using them in as accurate as possible a context to melt and cast bronze. The casting, or pouring of metal, is as important as the melting when investigating durability since the crucible then is taken outside the hearth and put back again during a short interval of time, exposing it to enormous temperature fluctuations. To make as accurate replicas as possible, the shape, clay and temper were replicated as thoroughly as possible. The size of the original whole and refitted crucibles from Broåsen varies in such a way that they can be

Table 1.

	Grain size concentration * (mm.)	Max/Min grain size (mm.)	Percentage	Organic material	Clay type	Number of sherds
Temper 1	0.125–0.5	0.063–1.0	60%		coarse**	1
Temper 2	0.355–1.4	0.063–2.2	60%		coarse**	3
Temper 3	0.5–2.0	0.063–2.2	60%		coarse**	5
Temper 4	0.5–2.0	0.063–2.2	60%	x	coarse**	1

**The intervals in grain size where 75% of the volume of the grains are concentrated. I.e. 12.5 vol% of the smallest grains and 12.5 vol% of the largest grains are removed from the data, making the grain size differ between the 75 vol% of grains that is left.*

** *Diamict* (not sorted) *coarse clay*

divided into three main groups: small (volume of 15–25 cm^3), medium (30–35 cm^3) and large (40–45 cm^3) crucibles. The most frequent size in the studied material was the large crucible, and therefore the measurements of that crucible type was used as model when making the replicas. Regarding temper, one particular type was chosen (temper 3) because it was present in 5 of 10 sherds. Temper 3 was replicated and used when making four copies of the Broåsen crucibles. Furthermore, tempers 1 and 2 were replicated and used to reconstruct an additional three crucibles (one crucible made with temper type 1 and two with temper type 2). Temper 4, present in one of ten sherds, was not replicated due to the time frame of the project. The reconstructed crucibles were divided into three groups depending on the type of temper. Apart from these three groups, an additional crucible was made using a more fine-grained clay and temper type 1 to see if there was any change in durability due to the choice of clay. This crucible was called group 4.

The crucibles in groups 1–3 all show the same pattern; after being used to melt and cast bronze 20 times the majority showed few or no signs of cracks or any other indication that they would soon have to be discarded. Therefore it was concluded that the crucible could be used additional times. The fourth group of crucibles consisting only of one single crucible showed lower durability. After one casting a crack opened in the crucible and after three castings it fell apart in two pieces along the crack.

The fourth group along with earlier experiments show us that high durability is nothing that can be taken for granted. It is obvious that to make a sustainable crucible you need a certain level of knowledge about clay and temper, how they can be combined together as well as their potential heat resistance. It may also be assumed that this kind of knowledge is not something that is obtained overnight, but rather something that you need to experiment with for a long time or simply be taught, as from teacher to pupil. The difference in making, for example, a cooking vessel compared to a crucible is that the crucible has to withstand significantly higher temperatures as well as temperature fluctuations than normal pottery, although they are both made from ceramic material. This requires a new kind of knowledge.

To conclude, the knowledge that the crucible makers possessed depended on their task. If a person was given the opportunity to learn and work with crucibles for a longer period, perhaps permanently, he or she would obtain a high level of knowledge of clay and temper abilities. On the other hand if there was no a need for highly durable crucibles (as in the case of low-scale production) the crucible maker did not need to attain a high level of knowledge. Since we have both types of production present in the archaeological material (as regards both bronze artefacts and crucibles; e.g. Oldeberg 1943, p. 190; 1960, p. 50; Eklöv Pettersson 2011, pp. 37 f.; Nilsson 2011) the crucible makers (regardless of whether it is the caster, the local potter some any other person) are not to be seen as a homogeneous group of people. Their knowledge is rather to be viewed as depending on their task and position in the society. Their task requires a certain level of knowledge, and thus knowledge and status are linked.

In the case of Broåsen the experiment shows that the crucibles from Broåsen could have been used for 20 or more castings, but it does not prove it. Based on these results exclusively, the crucibles could theoretically have been used fewer times before being discarded. It was clear, however, that the replica crucibles acquired certain traces of use depending on the number of times they were used to melt and cast metal, and that these may indicate the number of castings that the crucibles from Broåsen were used for.

In order to apply these results from the experiments to the archaeological material (crucibles) from Broåsen, the replicas were used as reference material to study and evaluate how many times the crucibles had been used before being discarded. These replicas were used 1, 5, 6 and 20 times and show two clear changes on which to base an estimate of the number of times a crucible was used. First, the ware, which sintered in different zones and to different extents, second the presence and level of copper oxide on the surface and inside the crucible (Eklöv Pettersson 2011 pp. 30).

Using the reference material, it is clear that the crucibles found at Broåsen were used 20 or probably more times before being discarded. The ware is to great extent sintered and the surface inside the crucibles has an even red colour deriving from a layer of copper oxide. They were probably made by a highly skilled craftsperson who had a different type of knowledge from that necessary when making household pottery (not excluding the possibility of the person having a knowledge that craft too).

Who made the crucibles?

So far we can conclude that the crucibles that were discarded in Broåsen had a better durability (indicating a higher level of knowledge of the makers) than previously assumed (Eklöv Pettersson 2011, pp. 9 ff. & 22 f.). Higher durability also tells us that the production probably was higher in terms of the number of objects that were cast. But who were the maker or makers? It could have been the same person that did the casting, but it could just as well have been any other craftsperson. Perhaps this person only made crucibles or he/she also worked with other crafts. However I suggest that the maker of the crucible could have been another person than the caster, linked to but not necessarily present at the production site.

To indicate this I shall present two examples of crucible sherds that may be interpreted differently depending on how they have been repaired; one example from the Broåsen material and one from Löderup 15, Löderup parish, Skåne. Repairs or layers interpreted as repairs are present in almost every assemblage of crucibles in southern Scandinavia. In the Broåsen material nine out of ten sherds have been repaired (e.g. sherd 5951, GAM 5951 G133, fig. 1). The repairs have sometimes been studied and it has been found that they often used a different type of clay/temper (Fig. 2; e.g. Oldeberg 1943, p. 126). One might ask why a crucible was repaired with a different material? If the crucible was initially made of a carefully chosen material, why change a winning concept? One idea is that the person repairing the crucible was not the same as the one who originally made it. If you also consider that it is easy to replicate the shape of a crucible, and that it takes around 1–3 minutes of your time to do so, it is strange why people did not simply make a new one instead of repairing the broken one. The answer is probably that the repair took place somewhere where the crucible maker wais not present. Therefore it was someone else who did it who did not know the correct mix of temper/clay but was also aware of the importance of the correct mix. Having this knowledge, the person tried to repair the "real" crucible rather than just make a new "fake" one. In this way I argue that it is possible to see the crucible maker as a separate person, possibly not directly connected to the casting process itself. When studying the crucible sherds from Broåsen it is clear that after being repaired it seems as if the crucibles were used several more times, probably for around 20 castings. Apparently this type of repair was of high quality as regards durability. In this case the craftsperson behind the crucible would be connected but also probably present at the production site. The second example from southern Sweden is

Fig. 1. The crucible sherd from Löderup 15, Löderup parish. It is clear that the sherd was made out of at least two layers. However, the outer layer is less reddish than the thin copper oxide layer that can be seen in between the two ceramic layers. Photo by P. Eklöv Pettersson.

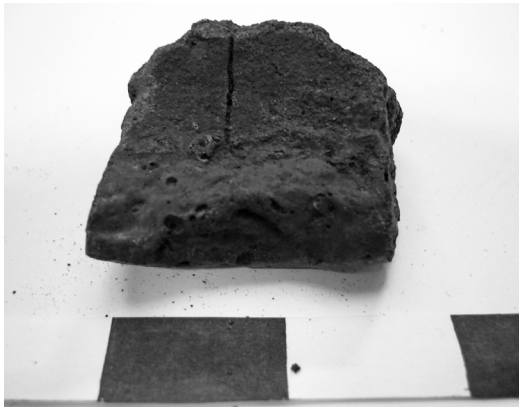

Fig. 2. Thin section of sherd GAM 5969 G140 from the Broåsen material. It is clear both from ocular assessment and from looking at the thin section that the sherd is made out of two different layers. The thin section also tells us that a different type of temper was used to make the extra layer. Scale thin section: 1 mm. Scale sherd: 1 cm. Photo by P. Eklöv Pettersson.

a sherd from Löderup 15 (LUHM 29064:1). In between the two ceramic layers of which the sherd is made it is possible to see a thin layer of copper oxide, something that cannot be seen on top of the outer layer. This, together with the difference in the level of sintering between the ceramic layers, inclines me to conclude that the crucible from which the sherd derives was used multiple times, repaired, used only a few more times and then discarded. In this case the material fits with the theory presented above of an itinerant craftsperson. What is interesting about the two examples is the difference in the rate of usage after being repaired but the similarity in the rate of usage of the original crucible before being repaired. What these two examples might represent is the presence of a skilled craftsperson making the original crucible in both cases, and this craftsperson's presence/absence during its usage.

Using the examples and the experiments to view bronze craft in southern Sweden, a certain picture emerges, where bronze production is conducted with a high level of technological knowledge, where sub-producers of specialized tools were connected, and possibly a financing party was present, having control over objects and raw material exported and imported from the workshop (as discussed by e.g. Welinder 1977, pp. 162 ff.; Earle 1997, pp. 167, and Nordquist 2001, pp. 246).

However, there is also another side of the bronze artefact production that is presented in the literature (Oldeberg 1960, p. 50; Nilsson 2011), according to which the bronze casting may have been done on a smaller scale, performed by persons who were not full-time bronze casters. This kind of low-knowledge production could also be seen in the ceramic material connected to bronze casting. One example is the crucible sherd from Östra Vemmerlöv (13:5) parish (LUHM 29077:42), Skåne (Fig. 3). This sherd is the only one in the material. The fabric of the sherd is thin-

ner and contains a lower amount of temper than the crucibles found at Broåsen. It does not seem to have been used more than five times at a maximum. This is due to the colour of the ware (no visible traces of copper oxide) and the level to which it has sintered (not at all) shows us that this sherd was never exposed to high temperatures or only a few times, or during a short period. To make this estimate the crucible replicas from the abovementioned experiments were used as reference material for use traces (Eklöv Pettersson 2011, pp. 30 ff.). The low degree of usage indicates that the crucible from Ö. Vemmerlöv 13:5 was discarded earlier than the ones from, say, Broåsen. Two theories come to mind: either the crucible may have been used by a person who only needed to do so many castings, or the crucible was made of such poor material that it cracked and fell apart after just a few castings. Regardless of which interpretation is correct, it is possible to say that this sherd may indicate low-scale production. Perhaps the crucible maker in this case did not possess the knowledge needed to produce a crucible of the same quality as in Broåsen, and perhaps this person did not need to.

By way of comparison it is interesting to study the single crucible sherd that was found at Löddeköpinge 23:3 Löddeköpinge county (LUHM 30657:16; fig. 4). This sherd seems to have been used more times than the previously mentioned sherd from Östra Vemmerlöv 13:5. Referring to the discussion above, it is possible to imagine that since the sherd from Löddeköpinge 23:3 was used more times before being discarded, this sherd more probably represents the presence (in one way or another) of a highly skilled craftsperson. What is clear is that these two sites both represent low-scale production in the sense of being single finds, but differ in the number of times the crucibles were used. Perhaps further studies may show us what made this difference.

Fig. 3. The sherd from Flackarp 13:1 A, Flackarp parish (LUHM 30019:13). Photo by P. Eklöv Pettersson.

Fig. 4. The sherd from Löddeköpinge 23:3 (LUHM 30657:16). Photo by P. Eklöv Pettersson.

How was their status in comparison to others?

In the text above I have been trying to sum up some of my thoughts about bronze casting during the Bronze Age in Halland (using the material from Broåsen) with comparative material from Skåne. As stated above, we might have to look at knowledge as linked to status. Having this in mind we can also begin to discuss whether the people who made the crucibles that were discarded in Broåsen enjoyed high status or not. Due to the high durability, which previous studies have shown is not something to be taken for granted but rather something indicating high knowledge of clay and temper capabilities, we are talking about high-skilled production. Regardless of the presence/absence of a financier, the maker of the crucibles at Broåsen did such a good job preparing the clay and temper he/she must have been doing this not as a project on the side but rather during a major part of their lives. Otherwise the craftsperson would not have been able to learn such a craft to that extent (e.g. Apel 2000, pp. 144 f.).

Another way of looking at it is to study the moulds discarded at the same cairn, suggesting that they were used at the same time. Brita Svensson (1940) did an analysis of the material uncovered by the excavation at Broåsen and found remains of moulds for casting two spearheads (with sockets), one sword, a button and a bronze collar (although the last item is uncertain). Svensson also writes that most of the sherds are hard to interpret and therefore, she also adds, the rest of the objects are unrecognizable but possibly (due to the context) sherds of moulds for casting knives or jewellery. The recognizable objects are thought to date from the earlier Bronze Age (Svensson 1940, pp. 102 ff.). Once again the idea of a skilled group of craftsmen comes to mind, people who can make these products that are thought to have been intended for the upper strata of society, and therefore probably had been doing this for a long time. Since the craftsmen who left us the debris at Broåsen seem to have been hard to replace, having this specialized knowledge, this group should have been able to climb the ladder of society a little higher than the average person. The question is which other specialized skills were involved in the bronze casting craft? How did this differ geographically, chronologically and between different societies?

Summary

This study has focused on the debris of bronze production found at Broåsen, Grimeton parish, Halland, looking mainly at the crucibles. The high durability of the crucibles together, with the composition of the mould debris, indicates that this is the debris from bronze artefact production by highly skilled craftsmen. Also, the person who made the crucibles is to be regarded as a highly skilled or specialized craftsperson. Some crucibles from other sites in Sweden show us that they were used fewer times before being discarded in comparison to the crucibles from Broåsen. This indicates the other kind of production, mentioned and discussed by earlier authors where the production scale is smaller and the producer did not necessarily require a high level of knowledge about the craft of melting and casting bronze. The crucibles would in this case have been used fewer times and perhaps also made locally by a person who was not, by trade, specialized in making crucibles. In both scenarios the producer of crucibles was linked to the production of bronze artefacts, but not necessarily participating in the casting of objects.

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