

# Crucibles in context

Changes in bronze casting and metal use at the  
Bronze Age – Iron Age transition in southern Scandinavia

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## Abstract

*Bronze casting in Late Bronze Age south Scandinavia was a widespread, varied and often spectacularly performative affair tied to significant rituals. Fragments of casting debris are found in many settlement and burial contexts. In contrast, remains of Pre-Roman Iron Age casting are sparse, despite many excavated settlements. This paper reviews casting debris and their find contexts, with a comparative view on the Late Bronze Age and the Pre-Roman Iron Age. The aim is to identify changes in craft organisation during this transformative period when many classic object types went out of use. Our results, together with previous research on casting technology, demonstrate changes in crucibles, in strategies for melting metal, and in the visibility and setting of casting events. While Late Bronze Age bronze artefact production entertained a variety of social institutions and settings, the Pre-Roman Iron Age bronze working was more concentrated to individual households. The discontinuity highlights the profound social changes of the Pre-Roman Iron Age.*

## Introduction

During the end of the Bronze Age (around 700–500 BC) after centuries of continuity, the production, use and depositions of bronze objects changed drastically in southern Scandinavia. Notably, classic Bronze Age types such as hanging vessels, belt buckles, spectacle fibulas, toilet equipment, spearheads, bronze tools and axes disappeared (Montelius 1885; 1917; Baudou 1960; Sørensen 1989; Jensen

1997; Kaul 2004, 396 f.; Eriksson & Grandin 2008). Many of these types of objects had existed since the Early Bronze Age, and appear linked to various institutions of power and cultic practices with long continuity in south Scandinavian societies (e.g. Levy 1982; 1999; Kristiansen 1983; Håkansson 1985; Sørensen 1987; 1989; Jennbert 1992; Bergerbrant 2007; Nørgaard 2018, 25 ff.). Their

disappearance has therefore been interpreted as signalling profound transformations in the ritual and political spheres (Sørensen 1986; 1987; 1989; Kaul 2004, 399 ff.). While the types and amounts of bronze metalwork clearly diminished with the onset of the Pre-Roman Iron Age, some types of bronze objects also continued to be made after 500 BC (Jensen 1997).

The changes surrounding the repertoire of bronze objects—their production, use and deposition—are therefore keys to understanding the social transformations in Late Bronze Age and Early Iron Age society in southern Scandinavia. During the Late Bronze Age, iron was introduced in at least parts of the area, but seems to have been more commonly used first during the Iron Age (Hjärthner-Holdar 1993; Nørbach 1998; Lyngstrøm & Jouttijärvi 2018; Lyngstrøm 2020; Sörman & Ojala 2022). Iron in itself can therefore not be seen as the main driving force in these changes, as it did not represent a simple mere replacement, and had been used in parallel with bronze for many centuries (Hjärthner-Holdar 1993). Instead, we must find other explanations for why the Late Bronze Age value system and the social and ritual structure upheld by the highly standardised bronzes was abandoned, almost simultaneously, and why these ritual activities do not appear to have been replaced (Sørensen 1989, 465). Only some of the special values and functions of bronze appear to have lived on, notably in the continued production, use and sacrifice of neck rings (Hedeager 1992, 196 f.; Jensen 1997, 164 ff., 179).

Studying how and where bronze objects were cast, and how this changed in this period can reveal how this metal was handled and thus provide insights into the new uses of, and attitudes towards bronze.

## Questions about a changing craft

During the Late Bronze Age and Early Iron Age, bronze was melted in ceramic crucibles, which were heated to the right temperature in a fireplace. The temperature required (at least 1000 degrees) was reached by creating a forced air-stream to increase the incineration. This was accomplished by pumping air from bellows, and leading the air into the fire via a pipe with a ceramic end-piece (Eriksson 2003, 145; 2004; Becker 2005, 262 f.; Jantzen 2008, 206 ff., 299; Eklöv Pettersson 2011, 24; Sörman 2018, 49 ff.). The archaeological remains that this process leaves behind (apart from the objects themselves) are broken moulds and crucibles, and sometimes, metal by-products such as bronze droplets and casting jets.

Residues from bronze casting—in the form of scattered mould and crucible fragments—are often considered vague and elusive during prehistory in northern Europe (e.g. Harding 2000, 232; Jensen 2002, 129, 367; Jantzen 2008, 293, 311). However, for the Bronze Age in the Scandinavian area, excavated sites with traces of casting activities have increased steadily over the last decades (e.g. Thrane 2013, 750). Contrastingly, clear remains of bronze casting from the Pre-Roman Iron Age appear to be rarer. Despite this lack in data, several observations can be made from the finds known so far.

Focusing on southern Scandinavia, mainly Denmark and southern Sweden, this paper will bring together currently known evidence from bronze casting sites that can inform us on how the production of bronze objects changed the centuries around 500 BC. This paper reviews casting debris and their find contexts, with a comparative view on the Late Bronze Age and the Pre-Roman Iron Age. Bronze casting debris, notably crucibles, from excavated sites are assessed in order to understand craft organisation and to evaluate continuity and

discontinuity in the artefact production from the Late Bronze Age to the Early Iron Age. We believe that new insights can be gained by considering Late Bronze Age and Early Iron Age metalworking and metal use together, as materials from different periods otherwise tend to be studied by Bronze Age versus Iron Age researchers respectively.

The questions considered in this study are:

- What residues from bronze casting have been found at excavated Pre-Roman Iron Age sites?
- In which contexts can Late Bronze Age and Early Pre-Roman Iron Age bronze casting debris be found, and does it differ between the periods?
- What are the changes in bronze casting technology from the Bronze Age to the Early Iron Age?
- Can the organisation of metalworking inform about social and political changes in the Late Bronze Age – Early Iron Age transition?

## Material and methods

To study the physical traces of bronze casting, fragments of ceramic moulds and crucibles are the most frequent lead artefacts. While ceramic moulds would crack after practically every cast (Rønne 1993, 86; Sörman 2018, 43; Knight 2022, 139), crucibles could be reused many times and such waste was thus produced more seldom (Eklöv Pettersson 2011). Still, pieces of crucibles often survive better than fragmented moulds in the archaeological record, due to their resistant material composition and high level of sintering. Bivalve stone moulds were also used for certain object types in the Late Bronze Age, but are rarely found in production contexts (Weiler 1993; however more examples have been discovered lately, see Nilsson & Sörman 2015; Linderoth 2016). Warm-smithing

was also used for finishing and shaping some bronze objects. Unlike iron smithing, this process does not result in any concrete archaeological traces such as slags.

Another find type associated with casting, but rarely left behind in archaeological contexts, is the front-piece or nozzle attached to the bellows' pipe conducting air from the bellows down into the hearth and directing it towards the crucible. In the Bronze Age, these were L-shaped ceramic pipes—tuyères—which directed the air stream towards the crucible from above (Eriksson 2003, 145; Eklöv Pettersson 2011, 24; Sörman 2018, 49 ff.). Pieces of such ceramic tuyères, some shaped like horse or animal heads, have been recovered from a few Late Bronze Age settlement sites (e.g. Thrane 2006; Jantzen 2008, 206 ff.; Botwid 2017). We are only aware of one bellows' nozzle dating to the Pre-Roman Iron Age, but in the form of a protective cylindrical disc rather than a tuyère pipe (see section 4.1. and 5. below). A Y-shaped pipe of wood, for leading the air from two bellows, has also been identified in the equipment recovered from the war canoe sacrificed in the Hjortspring bog around 350 BC at the Danish island of Als (Randsborg 1996, 33). It should be noted that the general principle of forced draft through the use of bellows also occurs in iron working.

Casting hearths rarely stand out from other hearths, and might not even be preserved on site (Jantzen 2008, 299; Sörman 2018, 49 ff; see also Schütz 2007). The best indication that a fireplace was used for melting metal are finds of small droplets and other metal spill created when the hot metal was handled—preferably in and around specific hearths (e.g. Söderberg 2002; Schütz 2007; Jantzen 2008, 293, 299), but this is rare. We are typically left only with fragments of the ceramic melting crucibles and moulds. Using such secondary residue to deduce the casting sites and spatial organisation of metalworking obviously poses

Table 1. The Pre-Roman Iron Age sites included in this study mainly consist of materials previously published in the secondary literature. For the Late Bronze Age casting sites, the material is based on the synthesis presented in a previous publication by one of the authors (Sörman 2018).

Site name	Region, country	Site type	Casting finds	Description of context(s) for casting finds	Dating	Reference
Årup	Scania, Sweden	Settlement	Crucible fragments and one small bronze melt	Cultural layer in and around a longhouse, and in a posthole	LBA - early PRIA	Hanlon 2003
Yngsjö	Scania, Sweden	Settlement	Crucible and mould fragments (ceramic moulds and fragments of stone moulds). Some ceramic mould fragments had inprints for pins, one fragmented stone mould had inprint for a socketed axe. Six small metal melts and one probable casting sprout.	Cultural layer and pits within the settlement	LBA Period V - early PRIA	Linderoth 2014
Flansbjerg	Scania, Sweden	Settlement	Crucible fragments, a bronze rod	A series of pits next to a concentration of postholes	PRIA	Samuelsson 1996
Stora Bernstorp II	Scania, Sweden	Settlement	Crucible and mould fragments	In a hearth pit (mould fragment) and cultural layer (crucible fragment)	PRIA	Strandmark & I夫versson 2008
Vitved	Jutland, Denmark	Settlement	Crucible and mould fragments	Large pit, also containing ceramics, iron slag, lithic tools.	early PRIA (c. 500-300 BC)	Andersen & Madsen 1984
Vildbjerg	Jutland, Denmark	Settlement	Crucible fragments	Large pit	mid-late PRIA (c. 300-200 BC)	Winther Olesen 1997
Egebjerg	Zeland, Denmark	Settlement	Crucible and mould fragments and bits of a bellows' nozzle in the shape of a ceramic disc with a central hole. Some of the moulds were for the production of a kronhalsring.	Large pit	late PRIA (c. 200-100 BC)	Kristiansen & Fristed Jensen 2005
Löderup	Scania, Sweden	Burial ground	Crucible fragments	Stone-setting cremation burial, also containing finds dating to the transition between Bronze and Iron Age.	LBA - early PRIA (c. 550-350 BC)	Eklöv Pettersson 2015a; 2015b, 2.
Simris	Scania, Sweden	Burial ground	Crucible and mould fragments	Cremation pit	early PRIA	Stjernquist 1961, 21, 123; Eklöv Pettersson 2015a; 2015b, 2

source critical challenges, as residue might have been replaced, removed and even reused before finally being deposited in pits, cultural layers, mounds of fire-cracked stones, floor layers and other secondary contexts. It thus needs to be subjected to the same analysis as other forms of waste when archaeologically interpreting activities based on their by-products.

Despite the large number of excavated Early Iron Age settlements, traces of bronze casting from the Pre-Roman Iron Age remain surprisingly rare in Scandinavia. The decline in the amounts of objects recovered and the disappearance of types probably meant that bronze metallurgy diminished. Part of the explanation might also lay in source critical factors; for example, changes in the handling

of refuse and a tendency in later periods to build in low-lying terrain more exposed to ploughing later on. In addition, typological dating of ceramics within the Pre-Roman Iron Age (Eriksson 2009, 176) and the Late Bronze Age – early Pre-Roman Iron Age (Borsson & Ytterberg 2018, 47 ff.; Stilborg 2021, 391) is challenging in some regions. Casting refuse found associated with ceramics might therefore not be further datable than to the Late Bronze – Pre-Roman Iron Age.

For selecting Pre-Roman Iron Age sites with evidence of bronze working, the point has been to advance examples that can inform us on contexts of bronze working at the Late Bronze Age and Pre-Roman Iron Age transition. To find these sites, different sources have been used for different areas. For reasons of practical advantage and familiarity, we have carried out more profound searches in the Swedish data, including searching for relevant keywords in digitally published excavation reports through the *Samla* database (now *Arkivsök*), the Vitterhetesakademien library's catalogue and general Internet search motors. For the Danish material, we have focused on examples available through secondary literature, such as journal articles and other scholarly works. Future studies of Pre-Roman Iron Age non-ferrous metallurgy will probably reveal other sites that yet remain hidden in the 'grey literature'.

## Background

### *Metal use during the final Bronze Age – Pre-Roman Iron Age*

The bronze object repertoire in the Late Bronze Age included tools, weapons, cultic objects and various personal attributes for body and dress. Several of these items, such as exclusive weapons, large belt attributes and toilet equipment, can be tied to social institutions with a long tradition in the Nordic Bronze

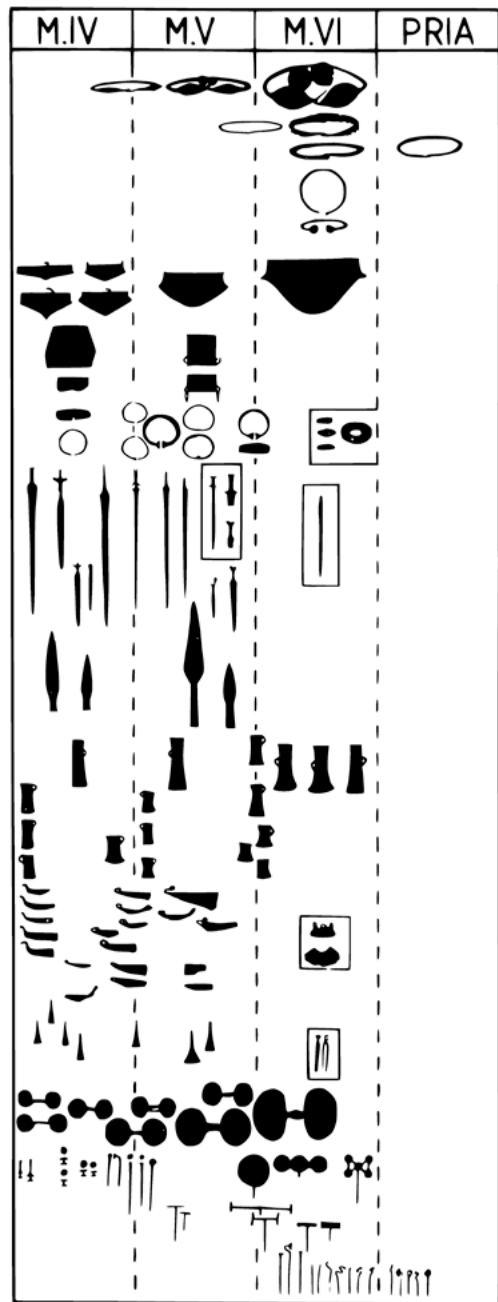


Fig. 1. Schematic illustration of bronze object types recovered from the timespan Bronze Age period VI – late Pre-Roman Iron Age in southern Scandinavia. Illustration from Sørensen 1989. Reprinted with permission.

Age society. Bronze objects from the period are often found in depositions while objects in graves are few and only represent some object types. In addition, complete and identifiable objects are rarer in settlement contexts (e.g. Eriksson & Grandin 2008). Large numbers of bronzes were deliberately deposited in wet and dry contexts in the landscape, both as single objects and as multitype-hoards with various object combinations (Sprockhoff 1956; Baudou 1960; Larsson 1986; Jensen 1997; Kristiansen 2016 [1974]). The last deposits of weapons such as swords and axes, belt attributes such as belt bowls, and spectacle fibulas, and large cult objects occur at the end of Period VI (Sørensen 1989; Jensen 1997).

As the archaeological knowledge of the metal objects from the latest Bronze Age – earliest Iron Age rely almost solely on hoard finds, our insight into the range of object types in circulation is probably limited. The burial customs dominating in this period are characterised by few associated objects in most Scandinavian regions. Deposited objects constitute a selection, i.e. metalwork considered appropriate for sacrifice or other forms of ritualised abandonment or storage. Due to this selection, we can assume that only some of the types of bronze objects that circulated during the period are known today. As an example, a period VI hoard found in Mariesminde in Denmark in 2003 contained four ring types previously unknown in Scandinavia (Thrane & Juottijärvi 2020).

Although depositional practices might not be representative of all object types in circulation, the decrease in object types and the amount of bronze in hoards nevertheless indicate that the quantity as well as the variety of objects diminished at the end of Late Bronze Age Period VI. Only dress pins, neck rings, arm rings and a few other bronze items such as small belt details continued to be cast and used in the Pre-Roman Iron Age (Jensen 1997; Fig. 1). Some of the special value held

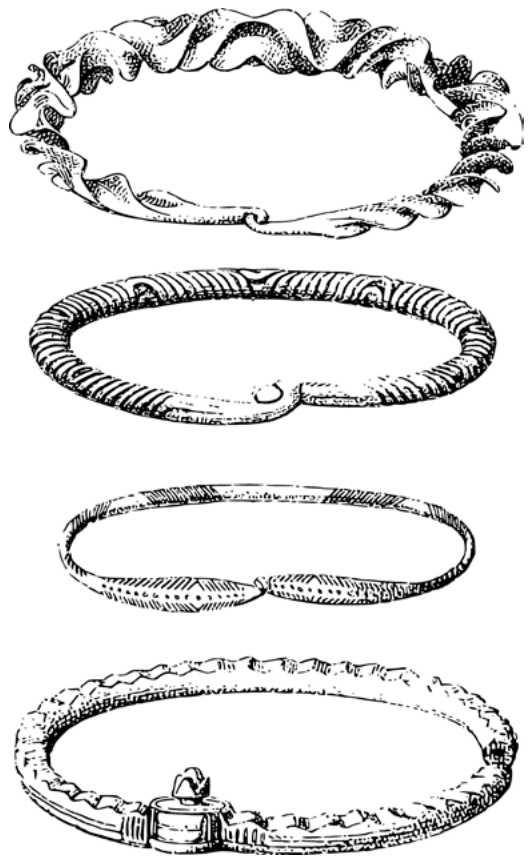


Fig. 2. Examples of neck ring types found in landscape depositions during the Late Bronze Age period VI and the Pre-Roman Iron Age. Illustration from Montelius 1885.

by bronze thus appears to have been preserved or transformed, notably with the continued tradition of casting, wearing, and sacrificing neck rings (Fig. 2; Hedeager 1992, 196 f.; Jensen 1997, 179; Helgesson 2002, 114 ff.).

## New forms and designs enter the stage

At the beginning of the late Pre-Roman Iron Age, around 300–200 BC, new forms of bronze metalwork started to be produced and imported. These are, apart from the continued production and import of

magnificent neck rings, for example, wagon details, belt chains and belt details, and fibulas with a new zoomorphic style, as well as large iron weapons; conspicuous attributes for men and women within a politico-religious elite associated to more manifest burial rites (e.g. Hedeager 1992; Martens 1999; Helgesson 2002, 209; Norlander & Wikborg 2005; Wikborg 2005; Herschend 2009, 118 ff.; Ragnesten 2013). What the decline in early Pre-Roman Iron Age use of bronze represents, hypothetically, is a drastic change in the socio-political and ritual organisation (Sørensen 1986; 1989), with continuity only in certain spheres relating to the wearers of neck rings and dress pins. This was then followed by new or changing expressions for social and ritual institutions in the late Pre-Roman Iron Age.

## From bronze to iron – not a revolution, nor a replacement

The Bronze Age metalwork repertoire largely disappeared at the end of Period VI (e.g. Montelius 1885; 1917; Baudou 1960; Sørensen 1989; Jensen 1997). Iron, present since at least Period V in certain parts of Scandinavia (Hjärthner-Holdar 1993; Sörman & Ojala 2022), gradually became more widespread and was used in small quantities in parallel to bronze. In the Late Bronze Age, the use of iron was limited to certain objects such as pins, knives and belt hooks, and as complements in bi-metallic items (Hjärthner-Holdar 1993; Sörman & Ojala 2022).

Judging from archaeological finds, iron did not become the main metal for tools and weapons until around 200 BC (Levinsen 1984; Hjärthner-Holdar 1991, 125). However, there is uncertainty due to issues of deposition and preservation. The number of Nordic bronze weapons decreased drastically in landscape depositions during Period VI

(Baudou 1960; Jensen 1997). This opens for the possibility that iron swords and spearheads were more frequent already at the end of the Bronze Age, but that they are not preserved to be found (as suggested for example by Montelius 1885, 193; Nørbach 1998, 64). The dominance of iron over bronze or vice versa in weapon production remains difficult to evaluate for Period VI of the Bronze Age and early Pre-Roman Iron Age.

During the 20<sup>th</sup> century, it became clear that decline in bronze and the rise of iron does not simply reflect a replacement where bronze items were instead made in iron. Instead, iron partially filled other roles in society in the Early Iron Age than bronze had previously done (Sørensen 1989, 465). Many bronze object types were never produced in iron. Later, when the use of iron became more widespread, in the late Pre-Roman Iron Age, it largely replaced tools that were previously made in antler, bone, stone and flint (Levinsen 1984).

## Where?

### *The organization of bronze casting during the Late Bronze Age*

Before turning to the early Pre-Roman Iron Age bronze casting, we will present the first part of this study: a synthesis of the organisation of bronze casting in southern Scandinavia during the Late Bronze Age. This forms a basis for the analysis, as they are the key insights against which the Pre-Roman Iron Age casting sites will be compared.

## Interpretative model for Bronze Age metalworking

In Bronze Age research, the link between bronze crafting and the elite is a long-standing interest. This mirrors a larger archaeological and anthropological field of study regarding how metalworking has been organised in

relation to institutions of power. Several Bronze Age scholars have suggested that we might expect a concentration of casting at larger settlements or in elite-attributed workshops, as centralisation of prestige goods production would have been controlled by political centres (e.g. Herner 1989; Jensen 2002, 365f; Kristiansen & Larsson 2005, 225ff; Thrane 2015). Against this, a backdrop of simpler household production, reflecting either the activity of independent amateurs or itinerant specialists, has often been evoked (e.g. Oldeberg 1960, 50; Björhem & Magnusson Staaf 2006, 166; Goldhahn 2007, 323; Jantzen 2008, 300 ff.; Nilsson 2011). However, systematic studies testing these hypotheses against the actual casting remains have been missing (for critique see Wrang 1982; Levy 1991; Sørensen 2015).

With the increasing number of excavated sites in the recent decades, it has become evident that Late Bronze Age bronze casting in southern Scandinavia was probably a rather widespread practice (e.g. Levy 1991; Björhem & Säfvestad 1993, 80; Eriksson 2003, 143; Björk 2007, 54 f.; Thrane 2013, 750). Archaeologists in several regions of south Scandinavia have noticed that residue of bronze casting occur on a large number of settlements, but in varying amounts; often seen as reflecting a hierarchical variation with centralised, specialised casting versus simpler household production (e.g. Björhem & Säfvestad 1993, 80; Jensen 2002, 365 f.; Eriksson 2003, 143; Björk 2007, 55; Jantzen 2008, 300 ff.; Karlenby 2011, 168; Nilsson 2011; Thrane 2013, 750).

## Results from new analysis of Bronze Age casting sites

A recent study by one of the authors presented a full-covering mapping of casting finds in central Sweden, with comparisons to

excavated sites in south Scandinavia (Sörman 2018). The following account builds primarily on this study. It will be limited to the Late Bronze Age, both due to the focus of this paper, and also because casting finds from the Late Bronze Age are more numerous and well-known than those from the Early Bronze Age.

By synthesising the casting debris from excavated sites, several interesting differences have been revealed; both ‘vertically’, in terms of variations between small and large sites in a settlement hierarchy, and ‘horizontally’ as in the heterarchical variation within more complex sites (Sörman 2018).

Firstly, bronze casting appears at various types of settlements: small farmsteads as well as larger settlement complexes with both dwelling and burial areas. In what could be interpreted as lower strata of society we find a few smaller, single-farms<sup>1</sup> which, in some cases, have yielded evidence for casting of socketed tools (Sörman 2018, 174 f., 200; see also Nilsson 2011; Björk & Wickberg 2012; Nilsson & Sörman 2015; Linderöth 2016). The smaller settlements are characterised by little or no associated burial arena or cult house, relatively short use-time and a dwelling area covering only a few thousand square metres.

Remains of casting also appear on most of the larger, more long-lived settlements. These are often associated with ritual arenas, such as areas with burials and cult houses (Sörman 2018, 134 ff, 174 f.; see also Goldhahn 2007). In this group, casting debris appears in a variety of contexts. Casting is attested in dwelling areas, longhouses, open areas of other buildings, as well as by nearby burial grounds or in relation to cult houses in the mortuary arena (Sörman 2018; 2019; see also Victor 2002, 147 f.; Goldhahn 2007). Settlements and ritual areas with cult house(s) are often found adjacent to each other, at least in Central Sweden. They constitute complex sites covering tens of thousands of square metres, taking profit of different topographical



locations for various activities (e.g. Karlenby 2011; Sörman 2018, 91 ff., 134 ff.). The large variety of settings, and the presence of casting remains at more than one area within several of the larger complexes, indicate that Late Bronze Age casting technology was mobile in nature, and that the melting hearths with bellows were set up in various indoor and outdoor settings.

These findings appear to confirm previous hypotheses about a hierarchical organisation of production, and difference in crafting between smaller and larger settlements.

## Interpretation of the character of Late Bronze Age bronze casting

Due to the widespread presence of casting activities in domestic and ritual arenas, and due to debris often being recovered from exposed and visible settings at these sites, it has been argued that bronze casting could sometimes be played out as a performative and public affair (Sörman 2018). This interpretation can be further placed in perspective when considering the motivations behind the production of many cast objects. Possessions like swords and exclusive personal attributes were markers of social hierarchies and institutions tied to various ranks, roles and genders. The casting of such objects therefore probably directly linked to social transformation rituals of wider importance in the community (Sörman 2017; 2018, 176 ff.; see also Goldhahn & Oestigaard 2008, 231). This is supported by the fact that casting moulds for such objects (notably swords and spear heads) have been recovered from cult houses, large burial grounds and large settlements, interpreted as functioning as intermittent assembly places (Sörman 2018, 118 ff., 153 ff., 170; 2022; see also Thedéen 2004, 156; Mikkelsen 2015, 86, 90; Melheim *et al.* 2016).

In the Late Bronze Age, the link between an

object's social role and its production therefore appears to have been of a very direct nature, and the casting event itself an integrated part of social rituals such as initiations (Sörman 2017, 2018). The various settings for crafting metalwork could thus mirror the adaptation to various clients and contexts. Late Bronze Age bronze casting was organised to enforce and demonstrate hierarchies, institutions and social order at various levels of society.

## Where?

### *Bronze casting in the Pre-Roman Iron Age*

Contrary to the interest for metalworking in Bronze Age research, bronze and bronze working has been given limited attention in previous research regarding the earliest Iron Age (however see Rundkvist *et al.* 2007; Eklöv Pettersson 2014). One important reason is probably that relatively few bronze casting sites from this period have been identified in the archaeological record. The sites with probable or demonstrated casting from the Pre-Roman Iron Age in southern Sweden and Denmark studied in this article can be found in table 1.

## Settlement contexts

Several settlements with finds of casting debris fall within the timespan final Bronze Age – early Pre-Roman Iron Age (Hanlon 2003; Onsten-Molander & Wikborg 2006, 57, 141; Linderoth 2014; 2016). It is therefore difficult to determine if the casting can be linked to the Late Bronze Age or the Pre-Roman Iron Age, or if it might indicate a continuity. This is the case at the Scanian settlements Årup (Hanlon 2003) and Yngsjö (Linderoth 2014) where casting debris was found spread in and among longhouses. Crucible finds possibly indicating casting at Pre-Roman Iron Age settlements are

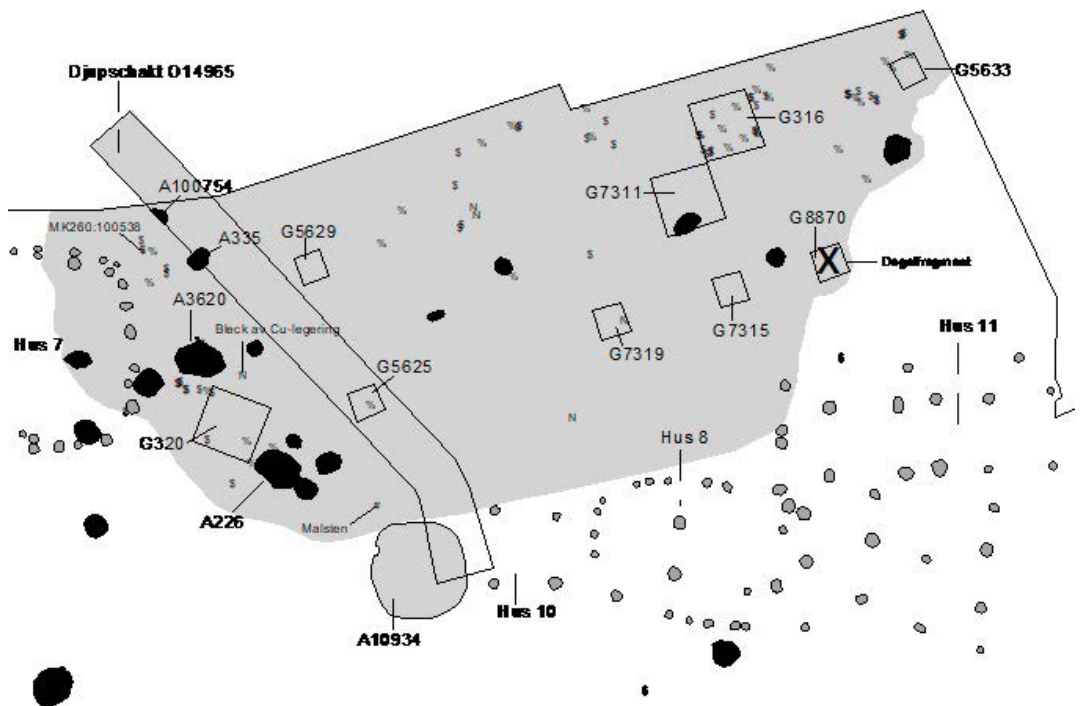


Fig. 3. Plan of the Late Bronze Age – Early Iron Age settlement at Stora Bernstorp II. Location for the crucible find marked with an X. Illustration: Malmö Kulturmiljö. Reprinted with permission.

also known from settlement pits at Flansbjerg (Samuelsson 1996) and Stora Bramstorp II (Strandmark & Ifversson 2008, 27 ff.; Fig. 3) in Scania.

Finds of casting debris in more well-dated settlement contexts are known from Denmark. One important case is the early Pre-Roman Iron Age bronze casting refuse at Vitved at mideastern Jutland (Andersen & Madsen 1984). Crucible and mould fragments were found in a large pit with ceramics, iron slag and some stone tools. The ceramics could be stylistically dated to the Pre-Roman Iron Age I, c. 500–300 BC (Andersen & Madsen 1984, 92). The imprints in the casting moulds could not be identified by type, but the shapes hinted at ‘smaller objects, e.g. dress-pins or pieces of jewellery’ (Andersen & Madsen 1984, 99, authors’ translation).

Two similar, but younger finds throw light on casting carried out in the later

Pre-Roman Iron Age. Vildbjerg, in central Jutland, featured casting residue in a large settlement pit at an Early Iron Age settlement with longhouses and several other pits (Winther Olesen 1997). Pottery shards found together with the casting debris could be dated to the mid-late Pre-Roman Iron Age, c. 300–200 BC, and the casting might thus be contemporary with the oldest settlement phase (Winther Olesen 1997, 31). Similarly, in Egebjerg in Zealand casting debris turned up in a large pit in a settlement (Kristiansen & Fristed Jensen 2005). The pit contained pottery fragments, a crushing stone, iron slags, crucible and mould fragments and bits of a bellows nozzle in the shape of a ceramic disc with a central hole [Swedish *blåstermunstycke*, Danish *blåsebalgsbeskyttere*] (Kristiansen & Fristed Jensen 2005, 6 ff.). Some mould fragments had been used to produce a *kronhalsring* (English *crown shaped*

*neck ring*) – a neck ring type from the late Pre-Roman Iron Age mainly found in Denmark, northern Germany and Eastern Europe (Kristiansen & Fristed Jensen 2005, 10; see also Jensen 1997, 171 f.). The Egebjerg find shows that the making of this remarkable object had taken place in a settlement context. The ceramic types in the pit concords with the dating of the neck ring, and places this casting at Egebjerg around 200–100 BC (Kristiansen & Fristed Jensen 2005, 10).

## Burial contexts

Paul Eklöv Pettersson has recently drawn attention to two finds of casting debris in Late Bronze Age to early Pre-Roman Iron Age burial contexts in Scania (Eklöv Pettersson 2015a). One of these is from the Löderup burial ground which has been used from the Middle Neolithic to the Migration period, and was partially excavated in the 1950s–1970s (Strömberg 1975). Eight crucible fragments were recovered from a stone-setting cremation burial, also containing finds dating to the transition between Bronze and Iron Age (Strömberg 1959; Eklöv Pettersson 2015a). Eklöv Pettersson performed new analyses on some of the melting pots as well as <sup>14</sup>C-datings on charcoal encapsulated in ceramic sherds found in the grave, and one of these gave the result 545–355 BC with 2 sigma or 485–365 BC with 1 sigma (Eklöv Pettersson 2015a; 2015b, 2). Another example is known from Simris, where crucible and mould fragments were found in a cremation pit (grave 75) dated to the early Pre-Roman Iron Age (Stjernquist 1961, 21, 123; Eklöv Pettersson 2015b, 2).

Eklöv Pettersson suggested that these by-products from casting had been employed as grave goods (Eklöv Pettersson 2015a, 9). We would rather like to point to the similarities with scattered fragments of casting debris occasionally found under, around or in grave

constructions at Bronze Age burial grounds (Goldhahn 2007; Sörman 2018, 133). Such finds should be seen as redeposited remains of casting activities within the mortuary arena, rather than as purposeful ritual depositions (Sörman 2018, 133). Arguments for this are that the fragments of crucibles or moulds do not appear as specially selected nor intentionally deposited, and that bronze casting at some burial grounds is well-attested (through bronze drops and probable casting hearths). There are, as far as we are aware, no well-dated graves or burial grounds from the late Pre-Roman Iron Age with remains from contemporary casting.<sup>2</sup>

## Interpretation of the character of Pre-Roman bronze casting

To sum up, the Pre-Roman Iron Age casting finds are mainly recovered from pits and cultural layers at settlements. Dating these finds is challenging, and many of them fall into the general timespan of the Late Bronze Age to the earliest Iron Age. The refuse probably represents debris cleaned out after various castings at the direct vicinity of the pits within these settlements. We also lack finds and a fuller picture of the structures on these sites in order to further assess the difference in size or importance of the different settlements. At several sites (Vitved, Egebjerg and Flansbjerg), we can note the presence of iron slag, indicating a spatial overlap between bronze casting and iron working. There are also finds from burials potentially suggesting that the Late Bronze Age tradition of casting in burial grounds continued in the early Pre-Roman Iron Age. Casting bronze in association to burials might have come to an end in the late Pre-Roman Iron Age. Finally, we note that the cult houses and bronze working associated with these in the Late Bronze Age seems to have no continuation in the Pre-Roman Iron Age.

## How?

### *From Bronze Age to Early Iron Age crucibles: changes in technology*

Apart from the changes in spatial and social context of casting, we would also like to draw attention to transformations in casting technology during the Pre-Roman Iron Age. As previously discussed by other scholars, several Pre-Roman crucible-finds demonstrate other designs and sintering patterns compared to the Late Bronze Age material (Winther Olesen 1997; Eklöv Pettersson 2011; 2014).

The specimens from Vitved, Egebjerg and Vildbjerg resemble Late Bronze Age crucibles in shape, but differ by featuring a ceramic 'coating' (Fig. 4). After being produced, pre-burnt and filled with metal, these crucibles would have been coated with an extra layer of ceramic clay encapsulating most of the vessel and leaving only a small opening by the spout. Such a layer has never been found intact, but some crucible pieces from both Vitved and Vildbjerg have remains where the layer continues a few centimetres over the rim (Andersen & Madsen 1984, 94 ff.; Winther Olesen 1997, 25 ff.; Fig. 4). In the Swedish material we so far, to our knowledge, lack clear examples of 'coated' or sealed crucibles from the Pre-Roman Iron Age. It could be mentioned that the crucible from Scanian Stora Bernstorp II is described as a 'small bowl' with convex sides and flat base, but its dimensions with a diameter of 4 cm and a height of c. 3,5 cm (Strandmark & Ifversson 2008, 21 f.) is approaching the cylindrical shape.

The change in crucible design is followed by a change in sintering patterns *i.e.* indicating a shift in the way the airflow was directed into the fireplace. Late Bronze Age specimens have their heaviest sintering along the rims (e.g. Eriksson 2007, 18 f.; Eklöv Pettersson 2011, 61). The Iron Age crucibles from Vitved had notable sintering at the back, opposite of the spout (Andersen & Madsen 1984, 101).

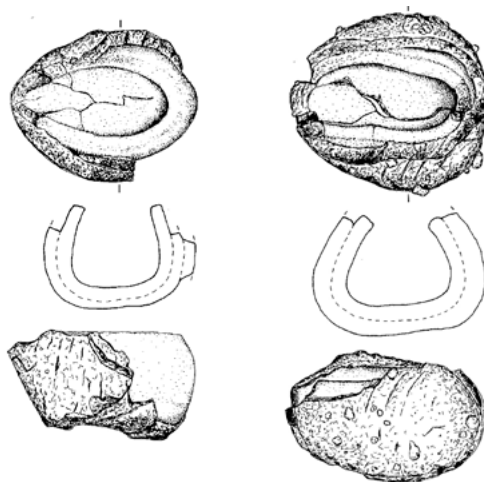


Fig. 4. Crucibles from the Pre-Roman settlement at Vildbjerg. Illustrations by Jens Jørgen Kjærgaard, Museum Midtjylland. Reprinted with permission.

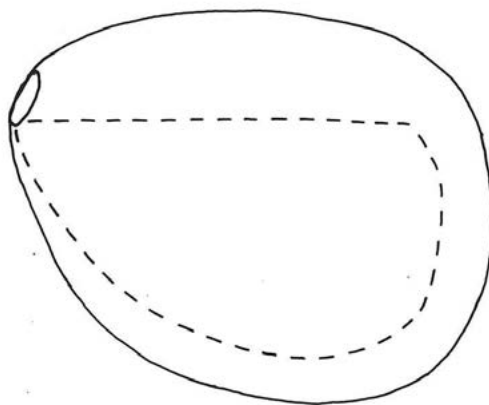


Fig. 5. Some of the crucibles from the Pre-Roman Iron Age settlement at Vildbjerg were slightly tipped backwards. Illustration by Jens Jørgen Kjærgaard, Museum Midtjylland. Reprinted with permission.

A similar sintering pattern has been noted on Iron Age crucibles from Helgö (Stillborg 2008, 211 ff.). The Egebjerg crucibles had signs of strong heating both from above and below (Kristiansen & Fristed Jensen 2005, 8). Additionally, in Vildbjerg, the crucibles' bases were not flat but tipped slightly backwards

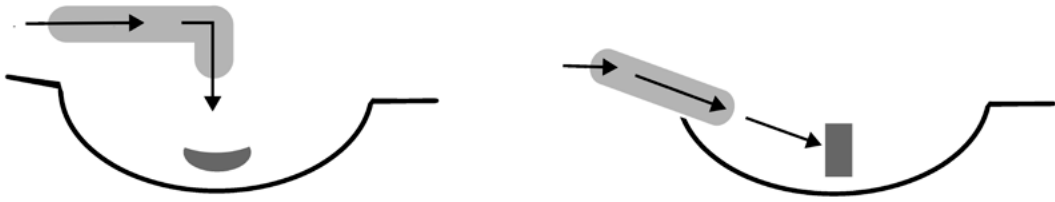


Fig. 6. Principles for melting metals in crucibles of Bronze Age type versus Iron Age type respectively. The types are not mutually exclusive, particularly not in the Iron Age. Some Pre-Roman Iron Age finds presented here could represent the transition phase from the Bronze Age to the Iron Age type. Illustration redrawn and simplified after Eklöv Pettersson 2011, fig. 16.

(Winther Olesen 1997, 24, 28 f.; Fig. 5), possibly indicating a first step towards the taller and more cylindrical crucible designs that followed later in the Iron Age. This fits well with the fact that this casting site belongs to the later phase of the Pre-Roman Iron Age.

The shift from open to closed crucibles observed in the Pre-Roman Iron Age in Denmark, would have had consequences for the position of the tuyère/bellow nozzle and the construction of the casting hearth. A study of sintering patterns on Mid and Late Iron Age crucibles demonstrated that these were now heated from the side (Stilborg 2008, 213; see also Hjärthner-Holdar *et al.* 1999, 21). These issues have also been studied by Eklöv Pettersson, who has made important observations about the construction, use and durability of Bronze Age and Iron Age melting pots based on experimental studies and ceramic analyses (Eklöv Pettersson 2011; 2013; 2014). The difference between Bronze Age crucibles (normally wide, flat and open) and Iron Age crucibles (often narrow, tall and closed/lidded<sup>3</sup>) indicate a new way of heating the metal and consequently also introducing changes to the fireplace construction (Eklöv Pettersson 2011, 22 ff.; Fig. 6).

The changes observed in melting pots also indirectly indicates a shift from L-shaped

tuyères to flat bellows' nozzles with a central hole [Swedish *blästermunstycke*, Danish *blæsebælgsbeskyttelse*]. The nozzles of bellows would have been placed at the hearth's side, as the crucible was now heated from the side or below instead of directly from above. The use of round bellows' nozzles or bellows' protection discs have previously been associated with the Roman Iron Age and onwards (Stilborg 2002, 150). Sintering patterns on some of the Pre-Roman crucibles, as well as the fragments of a cylindrical bellow nozzle from 200–100 BC at Egebjerg (Kristiansen & Fristed Jensen 2005), shows that this invention was already in use in the Pre-Roman times, at least in some regions.

The reasons behind this change have not been studied in detail, but suggestions include: influence of crucible designs more suitable for melting gold and silver, the tendency to cast smaller objects and thus melting smaller quantities than in the Bronze Age, and possibly, the introduction of iron tongs (Eklöv Pettersson 2011, 35 with references). To this, we could also add the influences from iron smithing and the construction of forges—experiences and solutions which would also have fed back into non-ferrous metalworking.

## Discussion

### *Continuity and change in bronze casting at Bronze Age to Iron Age transition*

The comparison of bronze casting debris in Late Bronze Age and Pre-Roman Iron Age contexts highlights certain similarities but also notable differences. Together with the previously noted shifts in metalwork types, and in the bronze casting technology at this time, this gives new clues to how and why society changed.

## Where?

### *Changes in spatial organization of Pre-Roman bronze casting*

Casting bronze objects within dwelling areas is observed throughout the Bronze Age in Scandinavia (Sörman 2018), and seems to have continued in the Pre-Roman Iron Age. Bronze casting at Pre-Roman Iron Age settlements thus followed the tradition of metalworking in or in the vicinity of longhouses during the Bronze Age (Sörman 2018; 2019). Due to new and different ways of treating refuse on settlements in the Early Iron Age, as compared to the Bronze Age (e.g. Eriksson 1997, 38 f.), it is not possible to reconstruct the specific casting sites in Pre-Roman Iron Age settlements in more detail. Finds are recovered from refuse pits rather than found accumulated at activity areas or by specific hearths or buildings. However, the making of bronze objects (and also potentially some of iron objects, as indicated by slag finds at several of the sites) can in several cases be linked to the direct vicinity of longhouses.

Based on the finds so far recovered from the Pre-Roman Iron Age it is not possible to interpret crafting in relation to settlement hierarchy. Status differences in the settlement structure in the early Pre-Roman Iron Age are difficult to distinguish. Social inequality in the

settlement structure becomes more tangible again with the emergence of extremely large longhouses, more than 40 metres in length, in the late Pre-Roman and early Roman Iron Age (e.g. Løken 2001; Fagerlund 2007; Artursson 2008). Interpreting the organisation of bronze casting in relation to socio-political status in the early Pre-Roman Iron Age is thus difficult. Only the 'kronhalsring' produced at the settlement site at Egebjerg can provide a clue that this settlement hosted inhabitants of notable wealth and socio-political/ritual influence.

Apart from the neck ring in Egebjerg, determinable moulds have only been found at Vitved 'smaller objects, e.g. dress-pins or pieces of jewellery' and moulds for pins of Late Bronze Age or early Pre-Roman date at the Yngstrup settlement in Scania. We can therefore assume that Early Iron Age neck rings and small dress attributes of bronze were sometimes produced at settlements. This production of rings in and by longhouses have parallels in the Late Bronze Age material. For example, a period V–VI farm with two contemporary longhouses in Danish Fragtrup featured casting moulds for arm or ankle rings by a hearth at the yard between the two houses (Draiby 1985). Another example is the casting mould for an ankle ring found with ceramics and parts of a tuyère in a pit at a period VI settlement at Flademosegård (Thrane 1980; Jensen 1997, 74 ff.). The casting of dress pins have also been attested at several Late Bronze Age settlements in central Sweden (Sörman 2018, 136). The production of rings and certain dress attributes by the farm thus appear to have continued after 500 BC.

There are also locations and settings where bronze casting did not continue or continued in diminished form after the Bronze Age had come to an end. There are indications of bronze casting by early Pre-Roman Iron Age graves or burial grounds, following the Bronze Age practice. We have found no

	LBA	early PRIA	late PRIA
In/near longhouse	X	X	X
Burial ground	X	X	
In/near culthouse	X		

Fig. 7. Different settings for bronze casting indicated by finds of crucible and/or mould fragments, Late Bronze Age versus early and late Pre-Roman Iron Age.

examples from the late Pre-Roman Iron Age and after the third century BC this seems to be a part of the production that came to an end. Furthermore, the production of bronze objects at cult houses and complex ritual arenas found at large Late Bronze Age grave and settlement complexes discontinued as these ceased to be used (Fig. 7). The cult house phenomenon does not appear to have any direct counterpart in the Early Iron Age.

Considering the suggested role of Late Bronze Age casting as part of social transformations when acquiring new objects (Sörman 2017; 2018), it is tempting to suggest that these abandoned spaces, and the ritual practices and bronze casting that disappeared with them, should be understood in relation to the structural changes in metalworking. Perhaps this spatial reorganization mirrors the disappearance of traditional social institutions represented by belt plates, toilet equipment, spearheads, spectacle fibulas and other emblematic bronze object types.

## How?

### *Changes in Pre-Roman bronze casting technology*

After centuries of continuity, the casting technology underwent several changes in the Pre-Roman Iron Age, including new ways to construct crucibles and methods for melting the metal (e.g. Andersen & Madsen 1984;

Winther Olesen 1997; Eklöv Pettersson 2011, 22 ff.). This includes a successive abandonment of the L-shaped tuyères. The fact that Bronze Age tuyères were sometimes shaped as animal or horse heads also suggests that the process of melting and casting bronze was understood through metaphors from mythologies, as the horse had an important role in Bronze Age cosmology (Thrane 2006; Engedal 2009; see also Kaul 2004). Like the horse-shaped tuyères, many other expressions of these myths and central symbols dissolved on a broad scale around the Bronze Age to Iron Age transition (Kaul 2004, 405 ff.). The disappearance of tuyères underlines the profound practical and conceptual reformations in bronze casting set in motion at this time. The centuries after 500 BC shows openness to and adaptations of new techniques in the craft.

The changes in crucibles and melting would also have affected the way the melting and casting was perceived by potential onlookers. Visible access to the liquid metal as the crucible was manipulated would have been more restricted than before, as most of the vessel was now covered. The abandonment of the (animal shaped) tuyère, in combination with the innovation of more covered and closed crucibles could indicate that less importance was invested in visual qualities and symbolic embellishment at the casting performance. Bronze casting seemingly became less of a spectacular and public affair than it had sometimes been in the Bronze Age (Sörman 2018). This interpretation is also supported by the craft's disappearance from visible, central or elevated positions at dwellings or cult sites.

A similar tendency from open Late Bronze Age shapes to more closed designs in the Early Iron Age has been observed in contemporary Scandinavian ceramics (Eriksson 2009). Thomas Eriksson has noted that the variety of open vessels for serving and consuming food and drink, characteristic of the Scandinavian

Late Bronze Age, disappeared during the course of the Pre-Roman Iron Age. It was being replaced by simpler vessels, while bowls with handles were no longer produced (Eriksson 2009, 175 ff., 189). When finer drinkwear reappeared in the end of the Pre-Roman Iron Age and Roman Iron Age, the vessels were more closed in shape (Eriksson 2009, 189). Eriksson has interpreted this as a sign of ruptures in the drinking rituals and social contexts of consumption, shifting from a collective to a more private character in the Early Iron Age society (Eriksson 2009, 178). In western Sweden, a similar shift in ceramic traditions has been observed around 200 BC at the transition from early to late Pre-Roman Iron Age, when 'Bronze Age traditions' such as the wide, low open bowls disappeared (Brorsson & Ytterberg 2018, 57). These ancient vessel forms, and their use in communal drinking, came to an end.

The functional and stylistic changes in the ceramic, the restructuring of ritual activities as indicated by the abandonment of cult houses, the disappearance of bronzes tied to long-lived Bronze Age social institutions and the changes in bronze casting organization can all be seen as interlinked expressions of rupture in social and ritual order.

## For whom?

### *Socio-political aspects of Pre-Roman bronze casting*

The Late Bronze Age production of bronzes appears to have been linked to important social transitions such as initiations of persons with special roles in the community (Sörman 2017; 2018); was this also the case during the Pre-Roman Iron Age?

As Nathalie Becker has pointed out, Iron Age bronzes also 'symbolized social codes, which communicated identity and social ties, about sworn commitments and alliances,

confirmed by, for example gift-giving' (Becker 2005, 298, authors' translation; see also Becker 2005, 258). The production of objects like neck rings and dress pins might still have linked to social transitions of larger importance for the community in Pre-Roman Iron Age society. We must also keep in mind that many new or changed object types were successively made of iron, such as axes and weapons (e.g. Wikborg 1998, 25 ff.). However, the changes in bronze casting suggest that the casting event itself was less exploited as a means for passing social messages than before, or that this message was now more directly linked to the household. This understanding is in line with the interpretation of the Bronze Age 'collapse' of old social and ritual institutions as marking the transition to a new social organisation, moving from more collective kin-based forms of ownership and power to smaller household units and nuclear families as an organising principle in society (e.g. Sørensen 1989, 472; Björhem & Magnusson Staaf 2006, 202; Friman 2008, 116 f.).

Towards the end of the Pre-Roman Iron Age, new, more embellished and exclusive forms of metalwork types came into circulation, such as wagon and belt details, zoomorphic fibulas and ornaments on neck rings and foreign metal vessels (e.g. Lønborg 1986; Jensen 1997, 174; Martens 1999; Norlander & Wikborg 2005; Wikborg 2005; Ragnesten 2013). These expressions are seen in the same period as exceptionally long longhouses emerged at certain farms in the late Pre-Roman and Roman Iron Age (e.g. Løken 2001; Fagerlund 2007; Artursson 2008; Martens 2010, 246), and the development of a new burial rite with wealthy, furnished graves (Nicklasson 1997; Wikborg 1998; Martens 2002). This emerging 'agrarian elite', as Bo Friman has named them (Friman 2008, 117), appears to have embodied both sacred and political power (Martens 1999).

While the metalworking organisation in



the Late Bronze Age indicates that bronze workers entertained a broad variety of ritual and political institutions, the Early Iron Age finds imply a singularisation or concentration where the political and ritual value of bronze was expressed in other ways. At this point in time, the political and ritual institutions changed, and as its regalia changed or disappeared, so did the rituals that surrounded its production. Further studies into the production of objects in bronze during the Early Iron Age—notably neck rings, dress pins/Early Iron Age fibulas, belt chains and horse or wagon gear—is one aspect that can inform us of where and how institutions of ritual and political authority continued to operate after 500 BC.

## Concluding summary

This study has discussed three significant shifts in bronze crafting practices at the Late Bronze Age to Early Iron Age transition—socio-politically, technically and spatially. Socio-politically, a majority of the Bronze Age bronze objects types, and thereby also their users, disappeared after 500 BC (Baudou 1960; Sørensen 1989; Jensen 1997). Technically, the wide, low crucibles heated in open hearths successively gave way to taller, narrower crucibles heated in closed hearths (Winther Olesen 1997; Stilborg 2008; Eklöv Pettersson 2011; 2014). Spatially, as our brief review of casting remains have demonstrated, the making of bronze objects became concentrated to settlements, whereas the wide variety of arenas and sites for casting in Late Bronze Age burial and cult sites successively disappeared. This allowed for bronze metallurgy to become adapted to new needs, functions and clients, emerging in the late Pre-Roman Iron Age society.

The changed role of metalworking is at the heart of the transformations of socio-

political and ritual organization in the mid millennium BC. This has implications for how we interpret and understand the role of the craft and crafters in society, and its links to ritual and social hierarchies. It also has consequences for method and fieldwork; where to anticipate casting debris during excavations of Pre-Roman Iron Age sites, the importance of closer studies to identify changes in crucible design and further investigations into the relation between the continued bronze crafting and the growing practice of iron working.

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## Notes

- 1 This category of sites is probably underrepresented in the dataset as 1) sites of smaller size with no remains visible above ground are less likely to be discovered, and 2) small-scale casting results in less refuse (Sörman 2018, 188).
- 2 Examples of casting debris close to graves with possibly late Pre-Roman Iron Age casting debris from a cultural layer under Late Iron Age boat grave at Skamby in the region of Östergötland has been raised in a paper by

Rundkvist *et al.* (2007). Fragments of lidded crucibles were recovered from a cultural layer associated with carbon dated to 190–40 BC, however, the crucible type points to the first mid millennium AD (Rundkvist *et al.* 2007, 279 f). The find is thus probably later in date. The same appears to be the case for possible casting mould fragments found around a 8-shaped hearth within a cremation-urn cemetery from the Pre-Roman and Roman Iron Age at Linneberga, less than 1 km from Skamby (Hörfors 1994; Stilborg 2006). Although the hearth has not been dated, its shape resembles casting hearths found at Helgö (Stilborg 2006). Rather than the earliest Iron Age, these finds instead point towards the mid – Late Iron Age (Rundkvist *et al.* 2007, 280).

- 3 Although the closed/lidded crucibles of cylindrical shape seem to dominate from the Roman Iron Age onwards, it should be noted that there is variation and that occasional finds of open crucibles are also known from this period (e.g. Hjärthner-Holdar *et al.* 1999, 20 ff).

## References

- Andersen, S. H. & Madsen, H. 1984. Et førromesk bronzestøberfund fra Vitved i Østjylland. *HI-KUIN* 10.
- Artursson, M. 2008. Storgårdar och bebyggelse i Skåne och på Själland: perioden 500 f.Kr.–150 e.Kr. In Calie, A. (ed.), *Öresund – barriär eller bro? Kulturella kontakter och samhällsutveckling i Skåne och på Själland under järnåldern*. Lund.
- Baudou, E. 1960. *Die regionale und chronologische Einteilung der jüngeren Bronzezeit im Nordischen Kreis*. Stockholm.
- Becker, N. 2005. Metallhantverk och specialisering. In Carlie, A. (ed.), *Järnålder vid Öresund. Bd 1, Specialstudier och syntes*. Lund.
- Bergerbrant, S. 2007. *Bronze Age identities: costume, conflict and contact in Northern Europe 1600–1300 BC*. Lindome.
- Björhem, N. & Magnusson Staaf, B. 2006. *Långhuslandskapet: en studie av bebyggelse och samhälle från stenålder till järnålder*. Malmö.
- Björhem, N. & Sävestad, U. 1993. *Fosie IV: bebyggelsen under brons- och järnålder*. Malmö.
- Björk, T. 2007. Kring förfädernas bopålar: om bronsålderns och den äldre järnålderns bosättningar i Vätland. In Artursson, M. (ed.), *Vägar till Vätland: en bronsåldersbygd i nordöstra Skåne 2300–500 f.Kr.* Stockholm.
- Björk, T. & Wickberg, Y. 2012. *Degeberga 23:6, Degeberga sn. Arkeologisk undersökning 2011*. Kristianstad.
- Botwid, K. 2017. *Understanding Bronze Age life: Pryssgården (LBA) in Sweden from an artisanal perspective*. Lund.
- Bronsson, T. & Ytterberg, N. 2018. *Stil, kronologi och struktur: Bohusläns keramik i långtidsperspektiv*. Uddevalla & Lund.
- Draiby, B. 1985. Fragtrup – en boplads fra yngre bronzealder i Vesthimmerland. *Aarbøger for Nordisk Oldkyndighed og Historie* 1984.
- Eklöv Pettersson, P. 2011. *En hållbar utveckling? – Hållbarheten för bronsålderns deglar*. Unpublished master thesis. Department of Archaeology and Ancient History, Lund University.
- 2013. Social status through crucibles. *Lund Archaeological Review* 18.
- 2014. *På jakt efter den legering som flytt – En studie av legeringsmetaller använda för Cu-legeringar i Skåne under perioden yngre bronsålder – äldre järnålder*. Lund.
- 2015a. *Bronze casting refuse in Grave 1 (1957), Löderup 15:2–3*. Lund.
- 2015b. *Datering av keramik från Grav 1 (1957), Löderup 15*. Lund.
- Engedal, Ø. 2009. Verdsbilete i smeltedigelen. In Brattli, T. (ed.), *Det 10. nordiske bronsealder-symposium. Trondheim 5.–8. okt. 2006*. Trondheim.
- Eriksson, T. 1997. Boplatser i ett makroperspektiv. In Frölund, D. (ed.), *Boplatser i Uppsala och Västmanlands län, del II: rapport över ett FoU-projekt*. Uppsala.
- 2003. Gjuterifynden i Apalle. In Ullén, I. (ed.), *Arkeologi på väg: undersökningar för E18. Bronsåldersboplatsen vid Apalle i Uppland: Uppland, Övergrans socken, Apalle RAÄ 260*. Stockholm.
- 2007. Specialregistrering av keramik och gjuterifynd. In Frölund, P. & Schütz, B. (eds), *Bebyggelse och bronsgjutare i Bredåker och Gamla Uppsala: arkeologisk undersökning, fornlämnning 134, 596 & 599, Uppsala socken, Uppland*. Uppsala.
- 2009. *Kärl och social gestik: keramik i Mälardalen 1500 BC–400 AD*. Uppsala.

- Eriksson, T. & Grandin, L. 2008. Brons – den gyllene metallen. In Hjärthner-Holdar, E., Eriksson, T. & Östling, A. (eds), *Mellan himmel och jord: Ryssgården, en guldkimrande bronsåldersmiljö i centrala Uppland*. Uppsala.
- Fagerlund, D. 2007. Stora hus från äldre järnålder i Mälardalsregionen. In Göthberg, H. (ed.), *Hus och bebyggelse i Uppland: delar av förhistoriska sammanhang*. Uppsala.
- Friman, B. 2008. *Att stå på egna ben: centrala funktioner och lokal utveckling under yngre bronsålder och äldre järnålder i Mellanbyn, Skåne*. Malmö.
- Goldhahn, J. 2007. Dödens hand – en essä om brons- och hällsmed. In Goldhahn, J. & Oestigaard, T. (eds), *Rituelle specialister i brons- och järnåldern*. Gothenburg.
- Goldhahn, J. & Oestigaard, T. 2008. Smith and death – cremations in furnaces in Bronze and Iron Age Scandinavia. In Chilidis, K. (ed.), *Facets of archaeology: essays in honour of Lotte Hedeager on her 60th birthday*. Oslo.
- Håkansson, I. 1985. *Skånes gravfynd från äldre bronsålder som källa till studiet av social struktur*. Lund.
- Hanlon, C. 2003. Årup: boplatser och bebyggelse lämningar från senpaleolitikum, tidigmesolitikum och yngre bronsålder. *Skåne, Ivetofta socken, Väg E22 Gualöv-Bromölla, Årup 1:1*. Lund & Kristianstad.
- Harding, A. 2000. *European societies in the Bronze Age*. Cambridge.
- Hedeager, L. 1992. *Iron-age societies: from tribe to state in northern Europe, 500 BC to AD 700*. Oxford.
- Helgesson, B. 2002. *Järnålderns Skåne: samhälle, centra och regioner*. Stockholm.
- Herner, E. 1989. *Spiral decoration in early Bronze Age Scandinavia: a technical and qualitative analysis and study of production*. Oxford.
- Herschend, F. 2009. *The Early Iron Age in South Scandinavia: social order in settlement and landscape*. Uppsala.
- Hjärthner-Holdar, E. 1991. The transition from bronze to iron in the Late Bronze Age. *Lab Ark* 5.
- 1993. *Järnets och järnmetallurgins introduktion i Sverige*. Uppsala.
- Hjärthner-Holdar, E., Larsson, L., Englund, L.-E., Lamm, K. & Stålborg, O. 1999. *Järn- och metallhantering vid en stormannagård under yngre järnålder och tidig medeltid: Husby, Glanshammars sn. Närke*. Uppsala.
- Hörfors, O. 1994. *Linneberga Å: fornlämning nr 85, Linneberga Å sn, Vikbolandet, Norrköpings kommun, Östergötland. Arkeologisk undersökning, april 1994*. Linköping.
- Jantzen, D. 2008. *Quellen zur Metallverarbeitung im Nordischen Kreis der Bronzezeit*. Stuttgart.
- Jennbert, K. 1992. Changing customs: reflections on grave gifts, burial practices and burial rituals during period III of the Bronze Age in Southeast Scania. *Meddelanden från Lunds universitets historiska museum* 1992.
- Jensen, J. 1997. *Fra bronze- til jernalder: en kronologisk undersøgelse*. Copenhagen.
- 2002. *Danmarks Oldtid. Bronzealder: 2000–500 f.Kr.* Copenhagen.
- Karlenby, L. 2011. *Stenbärarna: kult och rituell praktik i skandinavisk bronsålder*. Uppsala.
- Kaul, F. 2004. *Bronzealderens religion: studier af den nordiske bronzealders ikonografi*. Copenhagen.
- Knight, M. G. 2022. *Fragments of the Bronze Age: The Destruction and Deposition of Metalwork in South-West Britain and its Wider Context*. Oxford & Haverton, PA.
- Kristiansen, K. 1983. Kriger og høvding i Danmarks bronzealder. Et bidrag til bronzealdersværdets kulturhistorie. In Stjernquist, B. (ed.), *Struktur och förändring i bronsålderns samhälle: rapport från det Tredje nordiska symposiet för bronsåldersforskning i Lund 23–25 april 1982*. Lund.
- 2016 [1974]. *En analyse af yngre bronzealders Depotfund (Periode IV–V) i Danmark: kildekritik, kronologi og tolkning*. Gothenburg/Academia.edu.
- Kristiansen, K. & Larsson, T. B. 2005. *The rise of Bronze Age society: travels, transmissions and transformations*. Cambridge.
- Kristiansen, A. M. & Fristed Jensen, T. 2005. Kronehalsring. *Skalk* 2005 (3).
- Larsson, T. B. 1986. *The Bronze Age metalwork in southern Sweden: aspects of social and spatial organization 1800–500 B.C.* Umeå.
- Levinsen, K. 1984. Jernets introduktion i Danmark. *Kuml* 1982–1983.
- Levy, J. E. 1982. *Social and religious organization in Bronze Age Denmark: an analysis of ritual hoard finds*. Oxford.
- 1991. Metalworking technology and craft specialization in Bronze Age Denmark. *Archaeo-materials* 5 (1).

- 1999. Metals, symbols, and society in Bronze Age Denmark. In Robb, J. (ed.), *Material symbols: culture and economy in prehistory*. Carbon-dale.
- Linderoth, T. 2014. *Yngsjö 219:351: fornlämning 166 och 167 Åhus socken, Kristianstad kommun, Skåne län*. Kristianstad.
- 2016. En kustnära pionjärbosättning med bronsgjutning från yngre bronsålder/förromersk järnålder vid Yngsjö. *Ale* 2016 (1).
- Løken, T. 2001. Oppkomsten av den germanske hallen – Hall og sal i eldre jernalder i Rogaland. *Viking* 61.
- Lønborg, B. 1986. Bronzestøbning i dansk jernalder. *Kuml* 1986.
- Lyngstrøm, H. 2020. Early iron and ironworking in Denmark. In Brumlich, M., Lehnhardt, E. & Michael, M. (eds), *The coming of iron: the beginnings of iron smelting in Central Europe*. Rahden.
- Lyngstrøm, H. & Jouttijärvi, A. 2018. Failing arguments for the presence of iron in Denmark during the Bronze Age Period IV: regarding the razors from Kjeldbymagle and Arnitlund and a knife from Grødby. *Danish Journal of Archaeology* 7 (2).
- Martens, J. 1999. En halsring med fugleformede endstykker fra Nordre Rør, Øsfold: om betydningen af de zoomorfiske udsmykkede genstande fra afslutningen af den yngre førromerske jernalder. *Universitetets Oldsaksamling Årbok* 1999.
- 2002. The Introduction of the weapon burial rite in southern Scandinavia during the late Pre-Roman Iron Age: new perspectives in the light of recent chronological research. In von Carnap Bornheim, C., Ilkjeer, J., Kokowski, A. & Luczkiewicz, P. (eds), *Bewaffnung der germanen und ihrer nachbarn in den letzten Jahrhunderten vor christi geburt: Akten der Internationalen Tagung in Naleczow, 23. bis 25. September 1999*. Lublin.
- 2010. Pre-Roman Iron Age Settlements in Southern Scandinavia. In Meyer, M. (ed.), *Haus – Gehoft – Weiler – Dorf Siedlungen der Vorrömischen Eisenzeit im nordlichen Mitteleuropa: Internationale Tagung an der Freien Universität Berlin vom 20. –22. März 2009*. Rahden/Westf.
- Mikkelsen, M. 2015. Brobakken – en lokalitet, der rejser væsentlige spørgsmål til vores forståelse af bronzestøbning i yngre bronzealder In Boddum, S., Mikkelsen, M. & Terkildsen, N. (eds), *Bronzestøbning i yngre bronzealders lokale kulturlandskab*. Viborg & Holstebro.
- Montelius, O. 1885. *Om tidsbestämning inom bronsåldern med särskildt afseende på Skandinavien*. Stockholm.
- 1917. *Minnen från vår forntid: 1 Stenåldern och bronsåldern*. Stockholm.
- Nicklasson, P. 1997. *Svärdet ljuger inte: vapenfynd från äldre järnålder på Sveriges fastland*. Stockholm.
- Nilsson, A. 2011. Making a Simple Tool: Bronze Casting for Personal Use in the Latter Part of the Scandinavian Bronze Age. *Lund Archaeological Review* 17.
- Nilsson, P. & Sörman, A. 2015. En gjutform av täljsten från den yngre bronsåldern – spår av bronsantverk vid Rambodal i Norrköping. *Fornvännen* 110.
- Nørbach, L. C. 1998. Ironworking in Denmark From the Late Bronze Age to the Early Roman Iron Age. *Acta Archaeologica* 69.
- Nørgaard, H. W. 2018. *Bronze Age Metalwork: Techniques and traditions in the Nordic Bronze Age 1500–1100 BC*. Oxford.
- Norlander, Å. & Wikborg, J. 2005. Ett förromerskt vagnsbeslag: Nerthus på besök i Holmsmalma . In Karlenby, L. (ed.), *Tidens resenärer: Arkeologiska händelser längs vägen mellan Köping och Kolsva*. Stockholm.
- Oldeberg, A. 1960. *Skälbyfyndet: en boplatsslämning från den yngre bronsåldern*. Stockholm.
- Onsten-Molander, A & Wikborg, J. 2006. *Trekanten och Björkgården: boplatsslämningar från brons- och järnålder vid Fullerö: undersökningar för E4, RAÄ 601 & 602, Gamla Uppsala socken, Uppland*. Uppsala.
- Ragnesten, U. 2013. En förromersk bältekedja av brons från Änghagen i Torslanda, Göteborg. *Fornvännen* 108.
- Randsborg, K. 1996. *Hjortspring: warfare and sacrifice in early Europe*. Århus.
- Rønne, P. 1993. Problemer omkring bronzealderens metallhåndverkere. In Forsberg, L. & Larsson, T.B. (eds), *Ekonomi och näringsformer i nordisk bronsålder: rapport från det 6:e nordiska bronsålderssymposiet, Nämforsen 1990*. Umeå.

- Rundkvist, M., Stilborg, O. & Williams, H. 2007. Copper alloy casting at Skambo in Kuddby parish, Östergötland. *Fornvännen* 102.
- Samuelsson, B.-Å. 1996. *Flansbjerg: rapport över arkeologisk slutundersökning 1991. Burlövs sn, M-län, Sk. Malmö*.
- Schütz, B. 2007. Ett bronsgjuteri från yngre bronsålder. In Frölund, P. & Schütz, B. (eds), *Bebyggelse och bronsgjutare i Bredåker och Gamla Uppsala: arkeologisk undersökning, fornlämnning 134, 596 & 599, Uppsala socken, Uppland*. Uppsala.
- Söderberg, A. 2002. Metalliska spår efter gjuteriverksamhet – en skiss till en arkeologisk fältmetod. *Fornvännen* 97.
- Sørensen, M. L. S. 1986. Materiel kultur og kulturel forandring: et forslag til diskussion af lokalt særpreg udtrykt gennem bronzerne fra periode V og VI. In Mikkelsen, E., Stensdal Hjelvik, D. & Welinder, S. (eds), *Det 4. nordiske bronsalder-symposium på Isegran 1984*. Oslo.
- 1987. Material order and cultural classification: the role of bronze objects in the transition from Bronze Age to Iron Age in Scandinavia. In Hodder, I. (ed.), *The archaeology of contextual meanings*. Cambridge.
- 1989. Period VI reconsidered: continuity and change at the transition from Bronze to Iron Age in Scandinavia. In Sørensen, M. L. S. & Thomas, R. (eds), *The Bronze Age – Iron Age transition in Europe: Aspects of continuity and change in European societies c. 1200 to 500 B.C.* Oxford.
- 2015. Forankring af metallproduktion – betydningen af bopladsfundene. In Boddum, S., Mikkelsen, M. & Terkildsen, N. (eds), *Bronzestøbning i yngre bronsalders lokale kulturlandskab*. Viborg & Holstebro.
- Sörman, A. 2017. A place for casting? Late Bronze Age metalworking in southern Scandinavia and the issue of workshops. In Brysbaert, A. & Gorgues, A. (eds), *Artisans versus nobility? Multiple identities of elites and ‘commoners’ viewed through the lens of crafting from the Chalcolithic to the Iron Ages in Europe and the Mediterranean*. Leiden.
- 2018. *Gjutningens arenor: metallhantverkets rumsliga, sociala och politiska organisation i södra Skandinavien under bronsåldern*. Stockholm.
- 2019. Casting in the Longhouse: The Organization of Metalworking at Late Bronze Age Settlements in South-eastern Sweden. *Current Swedish Archaeology* 27.
- 2022. Made in Håga: om bronsgjutning vid kultus och om metallhantverkets organisation under bronsåldern. In Ojala, K. & Østgård, T. (eds), *Bronsålderns Håga: fornlämnningar, fynd och förbindelser*. Uppsala.
- Sörman, A. & Ojala, K. 2022. Iron in the Nordic Bronze Age and Early Pre-Roman Iron Age – Visibility, Colour Contrasts and Celestial Associations. *Norwegian Archaeological Review* 55.
- Stilborg, O. 2002. Blåstermunstycke. In Lindahl, A., Olausson, S. & Carlie, A. (eds), *Keramik i Sydsverige: en handbok för arkeologer*. Lund.
- 2006. *Gravkeramik och gjutformar? Kuddby Å. RAA 85:2, Linneberga, Å sn. Vikbolandet, Östergötland*. Lund.
- 2008. A technological study of crucibles from Helgö and Bäckby. In Clarke, H. & Lamm, K. (eds), *Excavations at Helgö XVII: Workshop part III*. Stockholm.
- 2021. Bilaga 11: Keramikanalys. In Evertsson, E., Lagerstedt, A. & Sörman, A. (eds), *Storgårdar, gravar och heliga hållar – kronologiskt blandade boplatser i åkermark i Skarplöt och Haninge, med lämningar från senneolitikum, bronsålder och äldre järnålder*. Upplands Väsby.
- Stjernquist, B. 1961. *Simris 2: Bronze age problems in the light of the Simris excavation*. Lund.
- Strandmark, F. & Ifversson, P. 2008. *Stora Bernstorp II – arkeologisk slutundersökning av Stora Bernstorp industriområde, etapp II inom fornlämnning RAA 58 Burlöv socken i Burlövs kommun. Skåne län. Malmö*.
- Strömberg, M. 1959. Ein bronzzeitliches Brandgrab mit Schmelztiegelfragmenten bei Löderup in Schonen. *Meddelanden från Lunds universitets historiska museum* 1959.
- 1975. *Studien zu einem gräberfeld in Löderup*. Lund.
- Sprockhoff, E. 1956. *Jungbronzezeitliche Hortfunde der Südzone des nordischen Kreises: Periode V*. Mainz.
- Thedeen, S. 2004. *Gränser i livet – gränser i landskapet: generationsrelationer och rituella praktiker i södermanländska bronsålderslandskap*. Stockholm.
- Thrane, H. 1980. En boplads fra bronsalderens slutning fra Flædemose på Stevns. *Historisk Samfund for Præstø Amt. Årbog*, 1979.

- 2006. »Figurinen» fra Pryssgården – et alternativt tolkningsforslag. *Formvænner* 101.
- 2013. Scandinavia. In Fokkens, H. & Harding, A. (eds), *The Oxford handbook of the European Bronze Age*. Oxford.
- 2015. Kirkebjergbopladsens støbeaktiviteter. In Boddum, S., Mikkelsen, M. & Terkildsen, N. (eds), *Bronzestøbning i yngre bronzealders lokale kulturlandskab*. Viborg/Holstebro.
- Thrane, H. & Juottijärvi, A. 2020. A New Bronze Age Hoard from Mariesminde at Langeskov. *Acta Archaeologica* 91 (2).
- Victor, H. 2002. *Med graven som granne: om bronsålderns kulthus*. Uppsala.
- Weiler, E. 1993. *Innovationsmiljöer i bronsålderns samhälle och idévärld: kring ny teknologi och begravningsritual i Västergötland*. Umeå.
- Wikborg, J. 1998. Den äldre järnålderns vapengravar i Mälardalen – internationellt och på det lokala planet. In Andersson, K. (ed.), *Suionum hinc civitates: nya undersökningar kring norra Mälardalens äldre järnålder*. Uppsala.
- Wikborg, J. 2005. En krigares grav – förromersk begravning i Holmsmalma. In Karlenby, L. (ed.), *Tidens resenärer: Arkeologiska händelser längs vägen mellan Köping och Kolsva*. Stockholm.
- Winther Olesen, M. 1997. Smeltedigler fra den tidlige jernalder – en bronzestøbergrube i Vildbjerg. *FRAM – Fra Ringkøbing Amts Museer* 1997.
- Wrang, L. 1982. *Bronze Age workshops: aspects of metallurgical production in southern Scandinavia*. Unpublished Bachelor thesis. Department of Archaeology, Uppsala University.

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