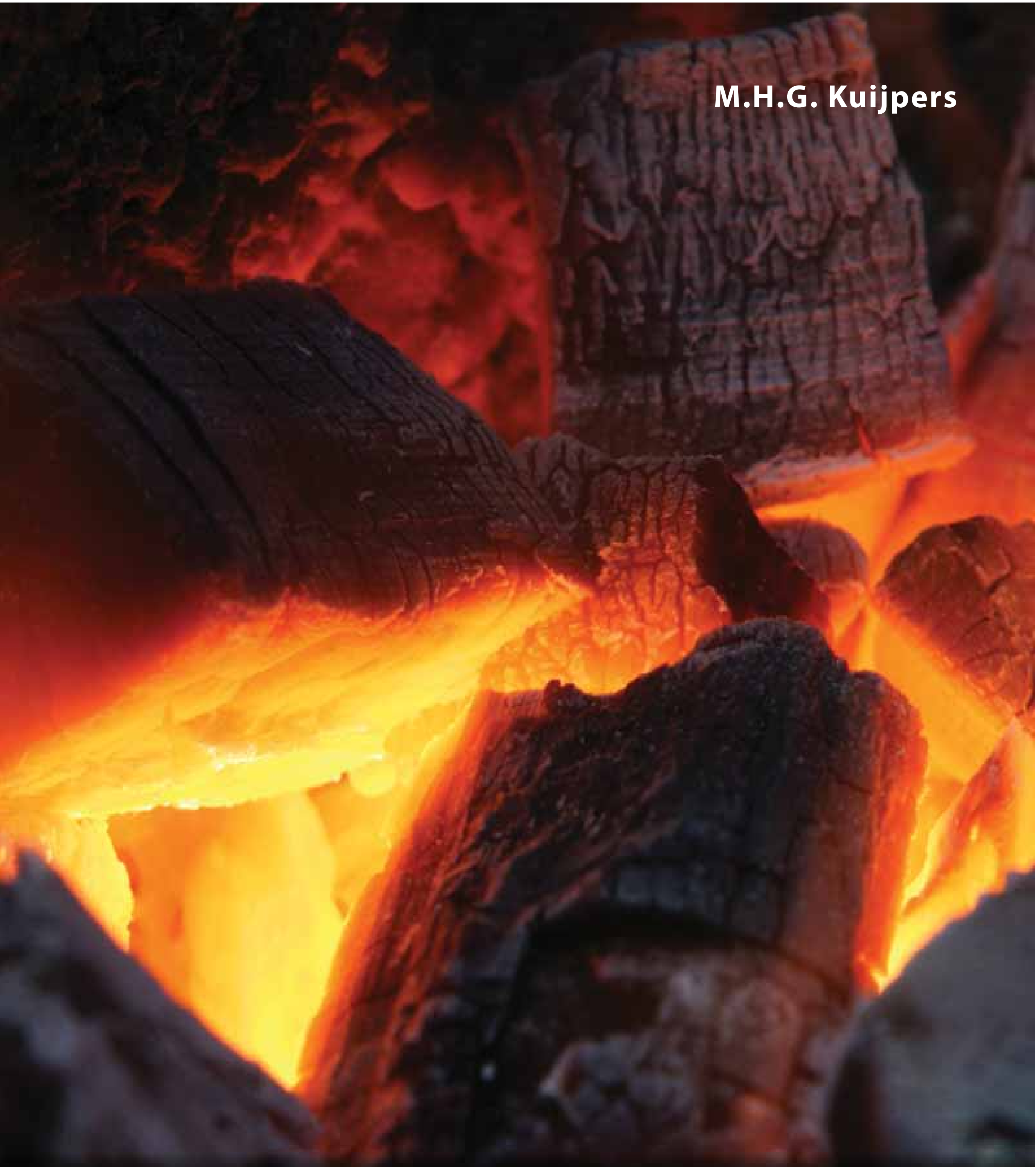
M.H.G. Kuijpers



# BRONZE AGE METALWORKING IN THE NETHERLANDS (c.2000-800BC)

A research into the preservation of metallurgy related artefacts and the social position of the smith

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Sidestone Press

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## A research into the preservation of metallurgy related artefacts and the social position of the smith

**M.H.G. Kuijpers**

Supervisors:
Prof. Dr. Harry Fokkens
Dr. David Fontijn

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Early Farming Communities in North-West Europe
Faculty of Archaeology, Leiden
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(m.h.g.kuijpers@umail.leidenuniv.nl)

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*For my parents*

*As you set out for Ithaca*
*hope your road is a long one,*
*full of adventure, full of discovery.*
*…*
*Keep Ithaca always in your mind.*
*Arriving there is what you're destined for.*
*But don't hurry the journey at all.*
*Better if it lasts for years,*
*so you're old by the time you reach the island,*
*wealthy with all you've gained on the way,*
*not expecting Ithaca to make you rich.*

Konstantinos Petrou Kavafis 'Ithaka'
(translated by Edmund Keeley/Philip Sherrard)

# Contents

# Preface

Thursday 19 december, 2003: I was handed a beautifully crafted Bronze Age sword found in the Meuse near Buggenum (Fontijn 2002, 166ff), during a workshop in the R.M.O.[1] Holding this *Vielwulstschwert* I was astounded by its workmanship. Even after 3000 years, this sword incites an awe that can still be felt. A sword like this lives a life of its own, even up to today, and the bearer of such a sword must have received considerable admiration. But, who was at the beginning of this? Who created such an excellent piece of workmanship that stands out even today? The bronze smith did.

There, my fascination with the subject began. I focused on the Netherlands as here too, bronze objects are found regularly. Most of them have come to us because they have been, curiously, deposited in the Bronze Age; deliberately buried in the ground, not to be recovered again. What was so special about these objects? And if they were so special what about the people that produced them? Were all these bronze objects imported to the Netherlands or is it possible that the Bronze Age may have seen the first Dutch smiths ever? The Netherlands is devoid of any resources of copper or tin, needed to produce bronze, so the Bronze Age smith, if present in the Netherlands, must have had an international trading network in order to supply him with the necessary materials. To try and find answers to these questions I read everything that Jay Jordan Butler, *the* Bronze Age metal specialist in the Netherlands, wrote. Thereafter, I wrote a paper that studied the history of research concerning this topic (Kuijpers 2003). I attended bronze casting experiments and several conferences on the subject. My bachelor thesis dealt with metalworking (Kuijpers 2006). Now, almost four years since I have held the sword of Buggenum, I aim to combine all these years of study on the subject into this final MPhil. thesis. Hopefully, it will cast some light on the persons that have had a pronounced influence in the prehistory of the Netherlands, for: "*A true Bronze Age can only arise with the advent of metallurgists or smiths"* (Childe 1963, 11).

1 The National Museum of Antiquities, Leiden

# PART I

# RESEARCH PROBLEM, FORMER RESEARCH, THEORETICAL FRAMEWORK

# 1 Introduction: looking for the bronze smithy

## 1.1 Introduction

Bronze has been studied in all its facets. The meaning of bronze to Bronze Age people[2], the intriguing depositions of it[3], how it was exchanged and its distribution[4] or responsible for the first 'globalization' of Europe (Vandkilde in press), and of course, how it was produced. On mining and the production from ore to metal[5], composition of the metal, physical and technological aspects[6], socio-cultural aspects of production[7], experimental archaeology on smelting, melting and casting[8] and the tools of the bronze smith[9]. The vast quantities of bronze objects found dominate the archaeological record (*e.g.* the Praehistorische Bronzefunde series[10]) and subsequently the research of that period. The period was even named after the material: the *Bronze* Age.

This thesis will focus on the people responsible for the creation of these objects. It is about metallurgy and bronze casting, but not the famous beautifully crafted bronze objects such as the Nebra disc (Meller 2002; 2004), the Sun Chariot from Trundholm (Gelling and Davidson 1969; Kaul 2004) or the sword from Jutphaas (Butler & Sarfatij 1970; Fontijn 2001). This thesis will focus mostly on the production of simple axes, spears, sickles and other everyday objects which have been made by the thousands, and the production of these objects in the Netherlands.

As mentioned in the preface, I was astounded by the workmanship of the Late Bronze Age sword found in the Meuse near Buggenum (Fontijn 2002, 166ff). At that time, I completely agreed with much of the literature on metalworking: that this must have been a ritual process that commanded considerable respect (*cf.* Bertemes 2004, 144; Budd & Taylor 1995, 140; Piggot 1965, 71; Childe 1963; 1944). However, my perspective has changed much the following four years. Already during the experiments and the writing of my BA thesis I started to doubt this one-sided image of the bronze smith. The complexity of the process of metalworking appeared to me to be less intricate then the assumed big fires and years of apprenticeship, as advocated by Childe (1944; 1963; 1965). Looking at the Netherlands we seem to have evidence of a small-scale production of 'simple' regional objects: mostly axes (Butler & Fokkens 2005; see chapter 4). And production of 'simple', 'everyday', artefacts was, of course, not confined to the Netherlands. Were these simple objects also produced by specialist (itinerant) metalworkers?

Many of the studies concerning bronze production seem to be working in a certain niche. The socio-cultural studies ascribing all kinds of special meaning to metalworking, often disregarding the technological process (*e.g.* Budd & Taylor 1995), while the scholars involved in technological and experimental studies of bronze production seem to perceive the technological process of metalworking as being devoid of social or any other context (Ottoway 2001, 87). As such they all deal with a specific part of the image, but none of them on their own is able to 'reconstruct' the Bronze Age smith. Therefore, I have deliberately chosen to focus both on the social as well

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2 E.g. Bridgeford 2002; Barber 2003; Ottaway & Wagner 2002.

3 E.g. Levy 1982; Bradley 1990; Fontijn 2002.

4 E.g. Butler 1963a; 1987a; Muhly 1973; Northover 1982; Liversage & Northover 1998; Needham 1998.

5 E.g. Coghlan 1975; Craddock 1995; Shennan 1993; 1995; 1999; Timberlake 2001; 2003; in press; O'Brien 2004; Maggi & Pearce 2005.

6 E.g. Northover 1989; Butler 1979; Butler & van der Waals 1964; 1966; Tylecote 1987; Coghlan 1975 and the SAM series (Studien zu den Anfängen der Metallurgie) by Junghans, Sangmeister and Schröder 1966-1974.

7 Childe 1944a; 1944b; 1963; Rowlands 1971; Kristiansen 1987; Levy 1991; Budd & Taylor 1995; Bridgeford 2002; Ottaway & Wager 2002; Barber 2003; Meurkens 2004; Vandkilde 2005.

8 E.g. Drescher 1957; Fasnacht 1999; Ottoway & Seibel 1997; Wang & Ottoway 2004; Timberlake in press,

9 E.g. Hundt 1975; 1976; Ehrenberg 1981; Jockenhovel 1982; Pernot 1998; Armbruster 2001; Rehder 1994.

10 The Praehistorische Bronzefunde series attempts to catalogue all the Bronze Age metalwork in Europe, region per region and one type at a time.

as the technological organization of metalworking. The Bronze Age smith, in my opinion, was 'formed' by both. Nonetheless, dealing with both social and technological factors of bronze is a far too mammoth task for a thesis. As a result, I have tried to narrow down the approach wherever possible, only highlighting the aspects that may have been most important for the bronze smith in the Netherlands.

## 1.2 Research problem

Recently, some metal objects were found at the excavation of Meteren-De Bogen (Butler & Hielkema 2002, 539ff). Most of them are bronzes but also tin and lead are present. Although Butler and Hielkema note in the conclusion that metalworking cannot be excluded, they believe that unambiguous evidence for the production of metal artefacts is lacking and conclude that the objects have been imported (Butler & Hielkema 2002, 545).[11] In this conclusion on the bronze objects from Meteren-de Bogen lies part of the problem I wish to address in my thesis. While metalworking cannot be excluded, there is no *unambiguous* evidence that it did take place. This is not only true for Meteren-de Bogen but relates to the whole of the Netherlands as well. Although it seems to be accepted that the Netherlands did have had a thriving bronze production, as first advocated by Butler (1961) we are still in the dark about where, how and by whom these local artefacts were made. Moreover, the local bronze industry has been surmised almost solely on the ground of 'regional' products.[12] Yet, these 'regional objects' are *indirect* evidence of metalworking (see section 4.4.5) and presently, seem to be a misnomer for objects probably made somewhere in a vast region (Fontijn 2002, 32). Indications other than 'local' products for metalworking are minimal. The latest summary (for the southern part of the Netherlands) has been made by Fontijn (2002, appendix 8) and entails only seven sites with *possible* indications. A discovery like the mould of Oss (Fontijn *et al.* 2002; see appendix 2.1) or the mould from Someren (personal communication H. Hiddink, March 2008; see appendix 2.1), both from a settlement context and directly related to metalworking, remain exceptional finds. Looking at the sheer number of artefacts labelled local by Butler[13], the number of moulds to produce them in (six in total)[14] or other direct evidence for production, is in no comparison. Moreover, the quantity of metal objects produced is always going to be far greater than the number recovered (Roberts in press). If metalworking really took place in the Netherlands, one would expect to find more evidence of it. Moulds, crucibles, melting ovens, hammers, waste products: *direct* evidence of metalworking activities. Yet, we have not, and the workshop of a bronze smith Butler (1961, 199) intended to find is as elusive as it was almost half a century ago.

## 1.3 Research questions

Butler proposed a two-folded way to prove the existence of the "Hunze-Ems industry", which produced the northern regional bronze products (Butler 1961, 199). It involved studying the tangible evidence of the workshops on the one hand and studying the products they produced on

11 The same problem can be found at several other sites, where there is a possible association with metalworking, but no firm evidence to corroborate the hypothesis (e.g. Verhelst 2006, 44).

12 Butler 1961; 1963b; 1973; 1990; 1995/1996; Butler & van der Waals 1966; Butler & Steegstra 1997/1998; 1999/2000; 2001/2002; 2002/2003; 2003/2004; 2005/2006.

13 Around 350 axes have been labelled 'regional' (see appendix 4). Furthermore, spears, urnfieldknives and Omega-bracelets may also have been made locally according to Butler (1969), these could not be counted as they are not catalogued yet as with the axes (see note 12). The total amount of bronzes from the Netherlands numbers around 2400 (Butler & Fokken 2005, 384).

14 Buggenum-Meuse mould (Butler & Steegstra 1997/98, 227, no. 227; Fontijn 2002, 138); Roermond-Meuse mould (Butler & Steegstra 2001/2002, 303, no. 549.); Havelte mould (Butler & Steegstra 2005/2006, 209, no. 772); Oss mould (Fontijn 2003, 138-140; Fontijn *et al* 2002); Cuijk mould (Fontijn 2002, 138-139); Someren mould (H. Hiddink personal communication, March 2008). See appendix 2.1.

the other. Butler succeeded in the latter, which resulted in an extensive corpus of literature on axe typology (fig. 1.1).[15] The former remained difficult however. Butler hoped that evidence of the workshop could give clues as to who the Bronze Age smith was and how and where he worked. Yet, the very few finds that could directly be linked to metalworking were stray finds and thus did not provide much information on the local bronze industries of the Netherlands (Butler 1961, 207).

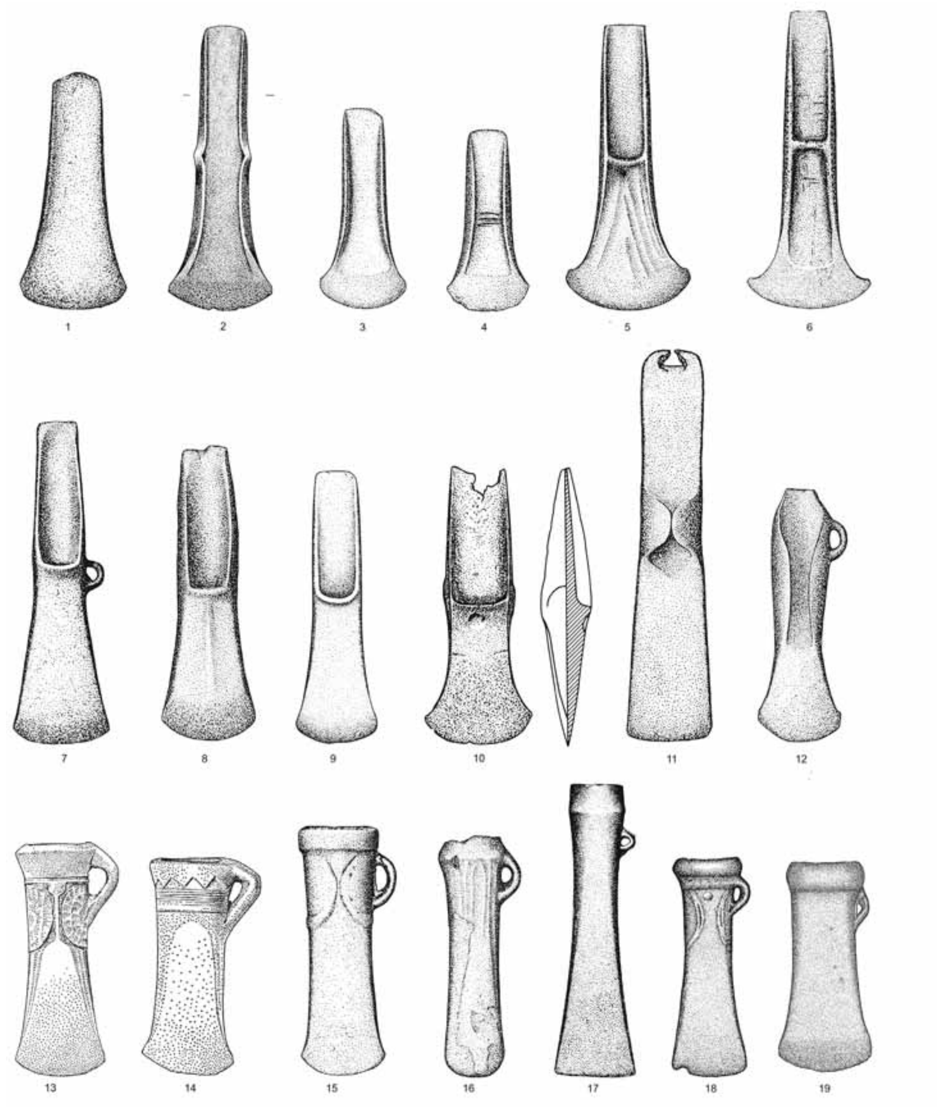


Figure 1.1 Bronze axes from the Netherlands. The local types of axes from the North according to Butler are: 1: low-flanged axe, Emmen type, 4: high-flanged axe, Oldendorf type, Ekehaar variant, 6: stopridge axe Vlagtwedde type, 10: palstave with arches on the side, 13: socketed axe with imitation wings in relief, 14: socketed axe with sawtooth decoration. Local axes from the South are: 16: socketed axe Helmeroth type, 15: socketed axe Nedermaas type, 17: socketed axe Geistingen type. Other axes: 2: *geknicktes randbeil* Sögel type, 3: Oldendorf type, 5: Plaisir type, 7: wide blade, European type, 8: regional type with midrib?, 9: 'plain' palstave, 11:Grigny type, 12: high-winged axe, 15: Plainseau type, 19: Wesseling type. Scale 1:3,5 (after Butler & Fokkens 2005).

15 See note 12.

The whereabouts of the workshop of the bronze smith are presently still unknown and therefore the main goal of this thesis remains exactly the same as the one proposed by Butler (1961, 200): *"het opsporen van de mogelijke overblijfselen der werkplaatsen"* (to trace the possible remains of the workshops). I am looking for the bronze smithy.

One might expect that in the four decades since Butler's aim, much new evidence would have turned up. This is not the case. Only very recently three new moulds have been discovered.[16] Yet, new (regional) bronze objects do keep turning up (*e.g.* Fontijn 2005; Fontijn, Butler & Steegstra 2007, Van Hoof & Meurkens 2008, 91), only increasing the discrepancy between the amount of regional objects and the amount of production evidence. A legitimate question to ask therefore is: are we missing evidence? Stated more clearly: *Why* are we not finding more *direct* evidence of metalworking activities in the Netherlands? Is Butler wrong assuming a thriving bronze industry or are there other reasons that elude the bronze smith's workshop to the archaeologist's eye? I will try to answer these questions by looking at the process of bronze production. How does it work? Which artefacts are needed? What sort of activities are taking place? And, most importantly, how does it manifests itself in the archaeological record? This technical and rather practical approach does not stand on its own. As mentioned in the introduction, there seems to be a divide between socio-cultural and technological approaches of metalworking. The following research questions are however closely associated with each other. While I have narrowed down the latter question to the reconstruction of manufacturing technologies and its manifestation in the archaeological record, technology cannot be seen as devoid from social actors. The role and meaning of a certain craft technology in a society may have had implications on how it was used (Dobres and Hoffman 1994), but also on how production was organized (Costin 2001, 287ff). Hence, I will first look at the possible organization of metalworking. Is metalworking only practised by specialists? Are we dealing with independent or attached craftsmen? Is there a ritual dimension to metalworking? This thesis therefore has two main research questions, which make up part II and III:

1. *Who crafts? How is metalworking organized socially and what is the social position of the smith? Is it likely that several Bronze Age communities in the Netherlands were practising metallurgy or is this confined to a few specific persons?*

2. *How does metalwork production work technically? And, more importantly, how does this process manifest itself in the archaeological record?*

From the second question I hope to be able to constitute a 'toolkit' that is indicative of metalworking and would help archaeologist to recognize metal production evidence during an excavation. Answering the two research questions will provide an image of the bronze smith and Bronze Age metalworking that applies mostly to the Netherlands: a region devoid of any resources for making bronze. Part II on the organization of metalworking may nonetheless also apply for large parts of Western Europe.

The importance of whether metalworking took place in the Netherlands can have pronounced implications for the research of Bronze Age societies in the Netherlands. As bronze objects form an important part of Bronze Age research it is essential to know who produced them, as is explained lucidly by Costin:

> *"In most societies, not everyone crafts. Therefore, it is important to know who crafts, what they craft, and why they craft what they do. Answering such questions becomes all the more imperative as archaeologist recognize social actors and the part of the individual in making technological and*

16 The Oss and Someren mould; respectively discovered in 2001 and 2008, and the mould from Cuijk, a stray find by an amateur archaeologist.

> *aesthetic choices and in creating meaning for material culture. Artisans physically transform raw materials into finished objects with both utility and meaning. As the role of objects in creating social relationships and transforming social organization is stressed, it is important to remember that the artisans are the ones who actively create or capture social meaning and transform it into material objects trough craft production. Even when carrying out the wishes or orders of others, artisans may alter or translate the message to be conveyed. Therefore, if craft objects are to be central in interpretations of social and political relationships, an effort must be made to determine who made them so as to understand the perspective being communicated* (Costin 2001, 279).

## 1.4 Approach

Metallurgy calls for an interdisciplinary approach, in which socio-cultural factors and technological factors of bronze and bronze working do not contradict each-other. Rather they should complement each-other and show possibilities or impossibilities. In this thesis past research, experimental archaeology, ethnographic examples, technological data and archaeological data will be combined in order to surmise an interpretation on metalworking in the Netherlands during the Bronze Age.

The current chapter gives an outline of the research problem, the question raised and the way in which the problem is approached. Problems and limitations of my research are discussed in chapter 2. Experimental archaeology is also discussed for I have made extensive use of information gained from both former experiments as well as experiments I joined myself. A description of one of these experiments is given in the appendix (1). Chapter 3 presents a theoretical discussion on technological organization, involving terms such as 'specialist', 'specialisation', ' knowledge' and 'skill'. Furthermore, as metalworking is often associated with a 'ritual dimension' (*cf.* Meurkens 2004), a critical discussion on 'ritual' is provided here. Because this research is inspired by Butler's work, follows many of his findings, and hopefully will be an addition to it, chapter 4 will discuss his work on the topic, as well as Childe's theory of an itinerant smith. In part II and III (chapters 5-8), I will try to tackle the prevailing image of the bronze smith by reinterpreting the available data, corroborated by experimental archaeology. This is done by researching respectively, the social organization of metalworking and the technological organization of metalworking.

The discussion on the organization of metalworking will focus on the ritual dimension of metalworking and the presumed specialist nature of the smith. Essential to this research is the database from Meurkens (2004) with some additional entries. Around 80 sites with metalworking debris have been collected. They provide the background on which several of the current interpretations on metalworking are 'tested'.

The chapters that form part III are not an in depth research of the use of metalworking tools. I am foremost interested in the archaeological visibility of metalworking (tools). The tools needed and the processes involved are discussed by looking at the archaeological record corroborated with experimental archaeology. Chapter 6 deals with the supply of metal and redefines the term 'ingot' on archaeological premises. In chapter 7 and 8 I will look at melting and casting and the tools that are needed to finish the cast object. The material and conservation, the change of discovery and recognition, and the association with metalworking are subsequently dealt with. This leads to a scheme which shows *what* to expect when looking for evidence of metalworking. Furthermore, I will try to constitute a 'toolkit' that is representative of metalworking.

Chapter 9 brings together the two threads that are followed. Here I will give a synthesis of the findings and place them in a wider context. In the appendices which can be found at the end of this book I have compiled the most important finds from the Netherlands related to metalworking (appendix 2). Furthermore, a database of some 80 sites from North-West Europe with metalworking debris is given (appendix 3), a list of all the regional axes according to Butler (appendix 4) and a describtion of an experiment I joined (appendix 1). A glossary of metallurgical terms is also provided (appendix 5).

# 2 Problems, limitations, source criticism

## 2.1 Introduction

Several problems hamper the study of Bronze Age metallurgy. Ranging from the 'melting-pot' (see below) to the problems encountered trying to provenance metal trough analysis of its composition. The most important problems for my research are touched upon in this chapter. Additionally, experimental archaeology is discussed, because information gained from former experiments, as well as the experiments I joined myself (appendix 1), is used throughout this thesis.

Firstly, the distinction between smelting and melting, a terminological problem, has to be dealt with, as it explains some of the difficulties encountered in this thesis. Secondly, the 'melting-pot' and the implications of re-melting are explained. It will be argued that re-melting may have been a far more common practice and that deposition *prevented* the objects from going into the melting-pot. Additionally, I will discuss the data on which interpretations on metalworking are postulated. These are of course the bronze objects found by archaeologist, but as these objects most often represent deliberate deposition we must consider their 'special' meaning and the implications this has on our view of the Bronze Age. The last section will confer on experimental archaeology and the reasons why, and how, I make use of it in my research.

## 2.2 Smelting and melting: confusion in terminology

When producing Bronze Age metalwork there are two very important processes that need to be distinguished: smelting and melting.

> *"Melting is, of course, changing a metal from the solid to liquid state; smelting is an entirely different process by which a metallic ore is converted to metal through the agency of heat and chemical energy"* (Coghlan 1975, 27).

There appears to be some confusion in terminology, because scholars do not always seem to make a clear distinction between the two processes. Authors dealing with the practical, technological side of metal production are particularly interested in smelting (*e.g.* Forbes 1950; Craddock 1995; Henderson 2000; Rehder 2000), which is unlikely to have taken place in areas where metal is not available trough natures resources (*i.e.* ore). In contrast to pottery, bronze production has several stages in which (semi-) finished products may move around allowing for production at centres far distant from the sources of raw material (Miller 2007, 242). Scholars who do realize that smiths in areas devoid of ore would have dealt with metal in a different manner mainly focus on the social aspect of metalworking and do not seem to make a distinction between the two processes (*e.g.* Rowlands 1971; Budd & Taylor 1995; Meurkens 2004). It is important to know whether smelting or melting took place; both processes can clearly be segregated both in knowledge and skill as well as spatially (Miller 2007, 242). Availability of resources also must have had implications as to the organization of Bronze Age metalworking (Costin 2001, 286).

S*melting* is the extraction of the actual metal from the ore, in order to produce a usable and tradable metal (an ingot).[17] It involves crushing and beneficiation of the ore and, if sulphide ores are delved, like at Ross Island (O'Brien 2004) or Mitterberg (Shennan 1995), roasting of this ore in order to oxidise it. Subsequently, smelting would take place in an oven, possibly with the use of a flux

17 For a brief and simple introduction on smelting see Miller 2007, 152ff

and under reducing circumstances.[18] *Melting* on the other hand, is the (re)melting of the ingot (or scrap metal), in order to cast a new bronze object. This process is technologically a much simpler action requiring only a crucible, a small furnace and the right temperature (around 800 - 1000 $^{0}$C depending upon the alloy). Therefore, it is especially important to distinguish between smelting and melting on terms of knowledge. The complex process of smelting is much more likely to demand specialist knowledge. Furthermore, smelting only took place in a restricted region where there was a supply of ore. Consequently, metallurgical skills on smelting may have been restricted, either intentionally or because of the relatively small area in which the process was carried out. This would not have been the case for melting, for which only pyrotechnical capabilities are needed, which were around already several thousands of years (Roberts in press).[19] One of the most important differences – archaeologically – in both activities is the appearance of slag. Smelting produces slag, the material remaining after the metal is won from the ore. Melting however is the secondary production of metal and does not leave any traces in the form of slag. If an ingot is melted everything will be used. Even the redundant metal that is cut of the produced object, waste products such as runners, but also the metal droplets that fell next to the mould, can and probably will be melted down eventually (see section 2.4.1). It is unlikely that anything more than just some small droplets will be left in the ground (Bachmann 1982; Miller 2007, 159-161; see section 7.7). Hence, much of the literature on the technological aspects of metallurgy[20], if projected on the Netherlands, becomes less well applicable, for it mostly deals with smelting. I think we can safely assume that smelting would not have taken place in the Netherlands. There are no copper or tin deposits in the ground and it is highly unlikely that raw ore was transported to the Netherlands in order to smelt it locally.[21] This, however, also means that ideas on the organization of the smith, which are mainly based on areas in which both smelting and melting took place, have to be used cautiously when projected on the Netherlands. Communities in the mining areas would have dealt with metal in a completely different manner than the regions without these resources, such as the Netherlands.

## 2.3 The 'melting-pot' and what it has obscured

A particularly innate and problematic aspect of metallurgy is the fact that metal can be reused – at any time:

> *"A million ancient silver coins - the second-largest hoard ever found - is likely to be melted down to make tourist trinkets because nobody wants to buy them"* (Keys 1994)[22]

Metal can be re-melted and reformed and thus, in contrast to other materials, a whole new object can be made from scrap. Unsurprisingly, this has consequences for several aspects of archaeometallurgical research.

The observation that – at least in the Middle and Late Bronze Age – re-melting took place indicates that metal-analysis cannot directly link objects with the ore sources. This has led to a general concern about the usefulness of metal-analysis. Northover (1982, 45) acknowledges that the use of scrap can be demonstrated in all periods, but argues that metal-analysis can still provide important conclusions. In a worst-case scenario, a large scale programme of metal analyses can still tell us about changes in refining techniques, alloying practices, the number and nature of sources,

18 Flux and reduction are not a necessity but produce more and better (i.e. purer) copper (O'Brien 2004).

19 Being able to melt a piece of bronze does not mean also being able to cast a good object from it. I am arguing that the knowledge for melting was widely available though, not necessarily the skill. See section 3.3.3 for a brief discussion on the difference of knowledge and skill.

20 Forbes 1950; Coghlan 1975; Tylecote 1987; Craddock 1995; Rehder 2000; Henderson 2000.

21 Although Jovanovic (1988) argued that movement of ore is not infeasible.

22 From an article in *The Independent,* London, April 26, 1994.

and metalworking practices (Northover 1982, 46ff). One problem remains though; while it is clear that metal was re-melted, archaeologist have no clue as to how many times bronze objects were re-melted and recast. Circulation and use of bronzes may have been more intense than visible from the archaeological record (*i.e.* depositions), but this is difficult to surmise. Theories that try to involve re-melting as important part of the circulation of metal (*cf.* Needham 1998) rely heavily on assumptions.

The estimates that are made on the amount of copper extracted from mines, even if these are grossly overestimated, still exceed the amount of bronze objects found by far.[23] Large amounts of bronze are therefore 'missing'. They simply have not been found (yet) by archaeologist. However, it should also seriously be considered that a large part of the Early Bronze Age bronze objects are 'hidden' in later artefacts. It is easily conceivable that copper, mined at the start of the Bronze Age, was still being used in the Iron Age and maybe even later. Re-melting is by no means confined to the contemporary period in which the metal circulated. Copper extracted and first used in the Early Bronze Age may easily be found as Late Bronze Age artefacts.

Sites like Eigenblok or Zijderveld clearly show that the wooden posts used to build houses were shaped with the use of bronze axes (Meijlink *et al.* 2002; Jongste & Knippenberg 2005, 106-113, fig 7.26, 7.28).[24] Although intensive use have been made of metaldetectors, not a single axe was found on these sites. While this might be the implication of depositional practises (*cf.* Fontijn 2002), it may also be explained as the outcome of regular re-melting. Clearly, bronze was not discarded but either deposited or re-melted. This will be elaborated below.

## 2.4 Sacrificial economy and pars pro toto sacrifice

The metalwork known to archaeologists mainly originates from deliberate depositions (*e.g.* Bradley 1990; Fontijn 2002). Archaeologists have long tried to make sense of these depositions (Fontijn 2002, 13ff). All the approaches however appear to – implicitly or explicitly – make a distinction between ritual and profane. Hoards that have long been seen as traders' hoards therefore oppose a problem, because the two approaches of profane trade of commodities (short-term exchange) seem to clash with the ritual deposition (long-term gift exchange) of the bronzes. Fontijn (2008, 6) argues that this is an epistemological problem of our own making.

'Profane trade' and 'ritual' deposition may have been much more closely linked than usually assumed. Fontijn's theory that bronzes circulated in a *sacrificial economy,* in which a part of the supply was deposited (*pars pro toto sacrifice)* is worked out in his 2002 dissertation and recently, he has applied this theory to explain the Voorhouten hoard[25] (Fontijn 2008). This hoard, described as an almost paradigmatic example of buried trader's stock (Butler & Steegstra 1997/1998, 185; Van den Broeke 205, 662), appears to be a permanent (ritual) deposition. It was deposited in a boggy hollow in peat, which would make retrieving the material very hard (Fontijn 2008, 11). Hence, it is unlikely that this is buried traders' stock. However, Fontijn reconciles both approaches by arguing that the Voorhouten hoard was a *pars pro toto* sacrifice of an 'alien' traders stock in order to make the rest of the stock acceptable for its role in society (*Op. cit* 2008, 15; *cf.* Fontijn 2002, 247ff). Most of

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23 For the Kargaly mine alone, in the Ural Mountains, it is calculated that 1.5 to 2 million tons of copper were extracted (Fontijn 2002, 33). Some estimates for mines in Europe are: at least 40.000 tons from Grimes Graves (O'Brien 1996, 48) and around 4000 tons from Mount Gabriel (*Op. cit*, 37). Shennan (1995, 301-2) argues (using several calculations) that, although these guesstimates are full of imponderables, there is nothing impossible about the Mitterberg-Pongau region having been a major source of copper, to the level of at least several tons per year, from the later Early Bronze Age onwards. These are only a few of several discovered mines, let alone the undiscovered (destroyed) mines archaeologist expect in areas like the Harz or Erzgebirge (Bartleheim *et al.* 1998; Niederschlag & Pernicka 2002).

24 Several of the posts found at this Middle Bronze Age / Iron Age settlement at Zijderveld show traces of having been worked. The traces are so evident that it can even be deducted that a flat, very sharp, bronze axe of around six centimeters was used (Jongste & Knippenberg 2005, 106-113).

25 This hoard comprises eighteen bronze axes and a chisel (Butler 1990, 78-84).

the material would have been re-melted and re-shaped in a form that was appealing to the people involved (Bradley 1990, 146; Fontijn 2002, 246ff), part of it was deposited.

How does this theory have implications for the research on metalworking? If we accept the theory of a *sacrificial economy* it implies that far more bronzes were available in the Netherlands. Metal circulation must have been voluminous and large amounts of 'alien' objects were traded, as in shown by some shiploads like the Langdon bay hoard (Muckelroy 1981) or Cape Rochelongue (Huth 2003). Metal was clearly also traded to the Netherlands: in the form of axes (*e.g.* Voorhouten; Butler 1990, 78-84) or as scrap (*e.g.* Drouwen; Butler 1986). If these indeed show a deposited part of a larger stock, we can thus logically infer that a steady and systematic importation of bronze from abroad took place (Fontijn 2008, 14) which was re-melted in the Netherlands. It also means that these depositions mostly seem to represent the objects that were *prevented* to disappear in the melting-pot because they were given a different meaning.[26] We must therefore also consider that these objects may present a skewed image of the metalwork actually produced, used, and in circulation, during the Bronze Age. They represent the long-term, rather than short-term exchange (Fontijn 2002, 33).

### 2.4.1 The cultural biography of an axe and how re-melting may be the most common practice in this biography

As argued above, axes appear to have been traded as a supply of metal and re-melted into desirable 'local' objects. Nonetheless, axes were also deposited either in large amounts or as single objects in watery places. Fontijn (2002, 246ff) has tried to work out the 'cultural biography' of an axe. Figure 2.1 shows such a cultural biography. At some point the axe would have been at the end of its use-life either by loss or by deliberately terminating the biography of the axe. There is only scarce evidence for loss. Bronze objects that were probably lost are those that are occasionally found on settlement sites (*e.g.* Butler & Hielkema 2002), although these may also represent deliberate deposition on a settlement site (Jongste 2002).[27] For deliberately terminating the biography of an axe or other bronze object there are three alternatives: they were discarded, melted down or deposited (Fontijn 2002, 250). There is ample evidence for deposition. Almost *all* the objects found in the Netherlands appear to belong to the group of deliberate deposited objects. Nonetheless, I agree with Fontijn (*ibid.*) that the most common practice may have been to re-melt a worn axe and form a new object from it. Re-melting is invisible in contrast to deposition. Deposition however, does not tell us how the object was produced, used, traded or recycled. The final state of an object determined its interpretation and any recycling or re-melting is lost the archaeologist. It tells how the object was perceived when it was deposited which need not be the same when it was used (Roberts in press). Moreover, there is an unavoidable bias in perception of metal use towards regions or objects where deposition occurred rather than recycling (Roberts in press). Although there was a steady supply of bronzes (as argued above and in chapter 6) it may still have been a scarce good. This may also be founded by the fact that almost no (discarded) bronzes are found at settlement sites in the Netherlands. Even large-scale excavations such as Oss hardly yield any bronzes, although a mould was found (Fontijn *et al.* 2002). It is very likely that the economic attitude towards bronze was indeed one in which discarded objects and tiny pieces of scrap re-entered the melting-pot (Fontijn 2008, 14). This theory is corroborated by ethnographic evidence: Costin states that in most non-industrialized craft production, raw materials were recycled or exhausted and minimal debris was generated (Costin 2001, 294).

26 They were essentially transformed from a commodity to a gift. See Fontijn 2002 for a thorough discussion on the subject.

27 See Fontijn 2002, 141 Appendix 9 for an overview of metalwork from settlements in the southern part of the Netherlands. See also Arnoldussen (2008).

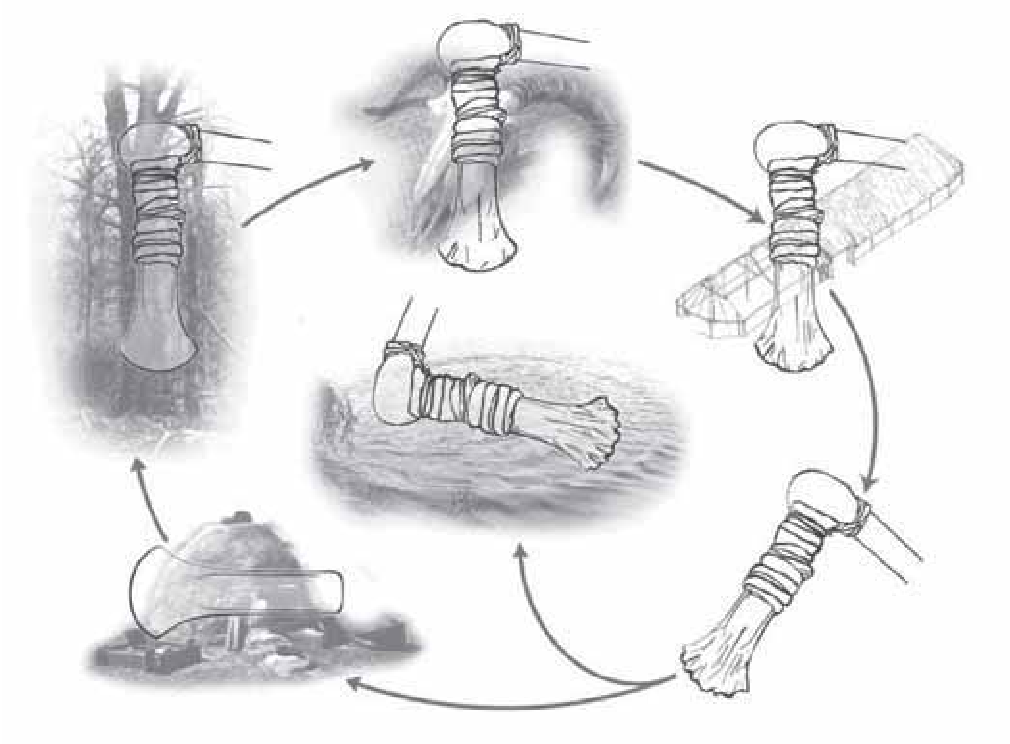

Figure 2.1 The cultural biography of an axe. It is used until it is either re-melted and starts a new life-cycle or is deposited (taken from Fontijn 2002).

Re-melting took place for two reasons: to transform 'alien' metal to a more accepted form and to 'regenerate' worn down objects. In my opinion we may even assume that, at least for the later Bronze Age, metalworking is *characterized* by the constant re-melting of objects. The problem however is that re-melting is hardly visible in the archaeological record. While the cultural biography of an axe (fig. 2.1) may have seen several re-melting phases it is only the deposition, that is visible for archaeologists. The image we have for the Bronze Age may then be based on anomalies (the depositions), which might explain the one-sided approach to ritual, specialist, symbolism and elites. This will be elaborated on in the following chapters.

## 2.5 Final remarks on (re-)melting and its implications

The quantities of copper extracted from Bronze Age mines show us that a considerable amount of bronze that circulated in Bronze Age is missing and that the amount of objects produced is far larger than the amount recovered. Furthermore, the objects that have come down to us represent the objects that were finally *not* re-melted, but deposited. Objects from the Late Bronze Age can easily contain copper originally mined and first used in the Early Bronze Age. Therefore, two important conclusions can be made at the end of this section:

- Theories on the Bronze Age smith may be severely skewed since they have been build on the bronzes found, that may not have representative use-lives for Bronze Age metal or the actual metal present in a region in the past.
- The most probable 'cultural biography' of a bronze object in the Bronze Age may have been to end up in the melting-pot. As such, paradoxically, finding evidence of a Bronze Age smith is severely hindered by the deconstructive nature of his job: re-melting.

## 2.6 Experimental Archaeology

Archaeometallurgical research is substantially aided by experiments (*e.g.* Drescher 1957; Ottoway 1997; Wang & Ottoway 2004, Kuijpers 2006; Timberlake in press). This thesis also comprises information taken from experimental archaeology on metal production. Although useful, it is often questioned whether knowledge gained from experiments can be used scientifically. Many forms of experimental archaeology indeed can be flawed. Nonetheless, I do think that 'experiencing' can be of great value for scientific research. This will be advocated more thoroughly in the following sections.

### 2.6.1 A good experiment?

Building on Coles´ (1979) handbook on experimental archaeology, Reynolds (1999) wrote a key article on the theory of a "good" experiment. I do not agree with Reynolds definition of a good archaeological experiment, however. In Reynolds opinion, the experiments I joined (casting bronze artefacts in Archeon, see appendix 1), is part of 'experiencing'. Applying a past technology in order to discover, learn and experience how this technique was used (Reynolds 1999, 157). Interesting nonetheless, but not useful in scientific research. According to Reynolds (*ibid.*) an experiment is by definition a method of establishing an initial hypothesis, by trial or test and these experiments have nothing to do with 'living in the past' or 're-enacting the past'. This false view of experiments within archaeology originated through the entanglement of three different topics: experimenting, experiencing and education (Reynolds 1999, 156).

The theory of a good experiment, as advocated by Reynolds (1999, 157), can be reduced to the following scheme (fig. 2.2). Archaeological data is interpreted by an archaeologist. On the basis of these finds a hypothesis is deducted. An experiment is established which aims at investigating this hypothesis. The data from the experiment is directly compared to the archaeological data. If they match, the hypothesis may be accepted. If they disagree with the known archaeological data then the hypothesis is rejected and replaced by a new one. It is important that experiments are not changed, even when during the implementation it becomes clear that they are not correct.

An archaeological problem is actually approached in the same manner as how problems are dealt with in the beta-sciences. I do agree with Reynolds that this approach is more scientifically sound. However, this positivistic approach denies the usefulness of experimental archaeology at several other aspects of archaeological research. Furthermore, this manner of testing a hypothesis raises some doubt, for the hypothesis made by the archaeologist is actually an *interpretation*, based on

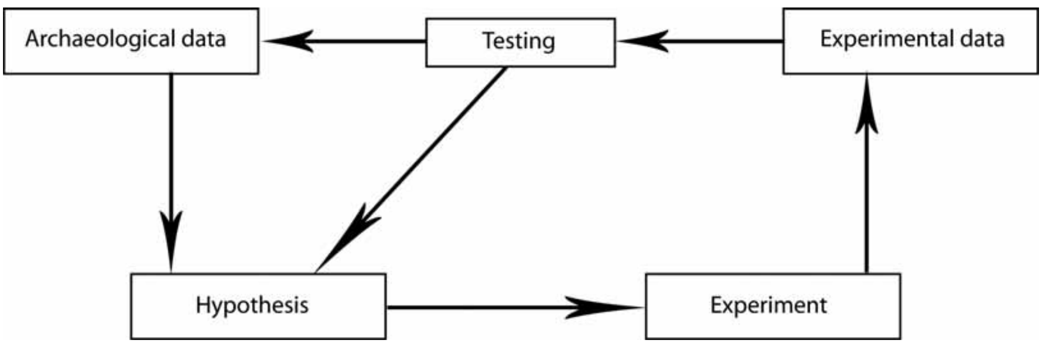


Figure 2.2 Schematic approach of Coles' theory on experimental archaeology.

a dataset gathered in a subjective way. The information that archaeologist gather from the record, is, after all, dependent upon their knowledge. Hence, if experimental archaeology supports the interpretation this does not have to mean that the interpretation is the right explanation. Another problem concerning metallurgical experiments and Reynolds' approach is that in some cases it is impossible to perform the best possible experiment. Experiments on casting arsenical bronze (an alloy used in the Early Bronze Age) are not possible, because it is forbidden to use arsenic in experiments.

Experimental archaeology should not only be applied to verify or enfeeble an interpretation, but also to inspire (new) questions. Possibly, it should raise more questions than it answers. Archaeologists can improve their insight of a process and certain aspects of it. With this insight in the back of their minds research and excavations can be carried out in a more purposeful way. In the next paragraph a few examples are given to enforce my point.

### 2.6.2 From experiment to archaeological theory, some examples.

One example that shows that non-scientific use of experimental archaeology can also be of great importance is the 'simple' test done by Drescher (1957). For a long time, archaeologist did not believe that bronze objects could be cast in bronze moulds. Interpretation was thus that a wax or lead axe was made in these bronze moulds, to use as a model (see fig. 2.3). When Drescher decided to simply try this (Reynolds would define this experiment as 'experiencing'), he came to the conclusion that bronze axes could be perfectly cast in bronze moulds. Even at an 'industrial' like level, casting several objects per hour (Drescher 1957, 74-75).[28] This 'discovery' meant that many archaeologists had to revise their thoughts and interpretation on these bronze moulds.

A second example: Childe (1936, 9) argued that melting, because of the intense fire and smoke, took place outside the settlement. However, one of the first things I noticed during the melting and casting experiments in Archeon, was the place of the activities. The furnace used to melt the bronze was placed inside a hut with a thatched (!) roof. This is all the more striking if one realizes that in order to melt bronze temperatures of around 1000 °C are needed. The fire is controlled to such an extent that this normally does not cause any problems.[29] As small as this observation looks, I think it is a good example on how experimental archaeology can help archaeologist to broaden their scope. Former archaeologists (following the ideas of Childe) might have been looking for large fireplaces or ovens for metalworking. Nowadays archaeologists are more aware that the evidence of metalworking is minute. The application of experimental archaeology can be very fruitful in enhancing knowledge on a certain technological process. I do not assume that the experiments I have looked upon for this thesis give a true image of the process of metallurgy in the Bronze Age, but they can show us the problems, solutions and possibilities that might have occurred.

One final example: through regular re-melting of bronze the tin slowly evaporates. Tin oxidizes much faster and especially at higher temperatures it disappears quite rapidly. Eventually only pure copper will remain. This means that, if it was common to re-melt metal in the Bronze Age several times, the prehistoric smith would have needed an extra supply of tin in order to keep his bronze of decent quality. This assumption raises yet other questions: was there a supplementing trade in tin next to the trade of bronze objects? And in what form was tin traded?

When applying the scheme (fig. 2.2) of Reynolds theory on my research, the square with 'archaeological data' is rather empty. This is precisely the problem in the Netherlands. There are a lot of

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28 Drescher (1957, 74-75) calculated that a smith with a single bronze mould could produce either 30 - 40 palstaves, 50 sickles or 12 - 15 socketed axes.

29 Nonetheless, hot particles did escape from the furnace, but a very natural 'solution' to this problem was found; spider webs in the top of the farm catch the particles, preventing them from igniting the thatched roof. Although this observation has little value for archaeological research, it does show that a technology or activity can involve aspects which archaeologist would never think of and are completely invisible in the archaeological record.

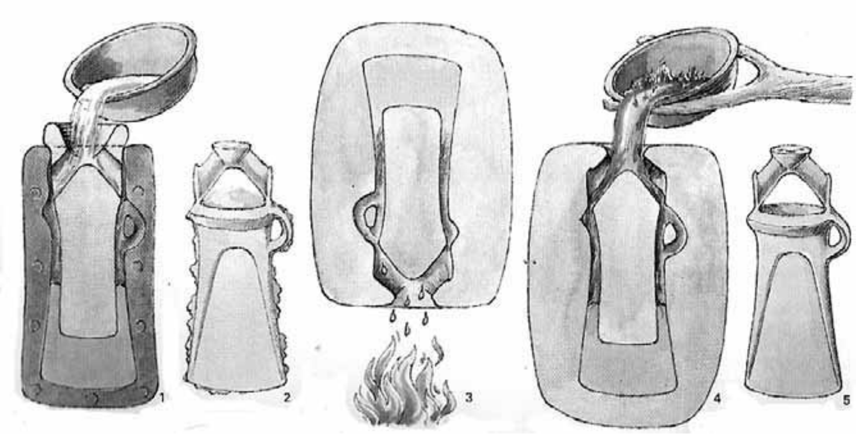


Figure 2.3 The manner in which scholars used to think how bronze moulds were employed: 1: a wax model is cast in the bronze mould, 2: this model is used to make a mould in clay, 3: the clay mould is heated and baked while the wax model melts, 4: bronze can be poured in and a newly cast bronze axe is made. Nowadays, thanks to experimental research, it is clear that bronze axes can be cast directly in the bronze mould (taken from Bloemers *et al.* 1981).

artefacts indicating indigenous metallurgy *indirectly*, but almost none are directly linked to it. Partially through experimental archaeology I aim to study whether the absence of evidence results from the process of bronze casting, or whether archaeologists have faulty expectations or are unable to recognize the evidence.

# 3 Theoretical framework: the ritual aspect and social organization of craft production.

## 3.1 Introduction

With regards to the socio-economic significance of metallurgy and of metals in general, the social position of the metallurgist in Bronze Age society has often been discussed since Childe, who regarded smiths as socially independent, traveling tradesman (Childe 1930, 4; *cf.* Trigger 1980, 68; see section 4.3). The nature of his job was considered to involve "abstruse" knowledge (Childe 1966, 120). Since then, metalworking has often been associated with rituals: Budd and Taylor's (1995) article being the most prominent example. This view is corroborated by ethnographic examples in which it is often the case that metalworking is seen as much a ritual practice as a skilful practical one (Helms 1993; Bekaert 1998; Bisson 2000). Nonetheless, explaining metalworking as 'ritual' or claiming that metalworking may have been a 'specialist' job appears to have been done regularly, without actually defining what is meant by 'ritual' or 'specialist'. In this chapter, I will therefore focus on the theoretical issues of 'ritual' and 'specialist'. What do these terms mean and how can they be used?

## 3.2 The use of 'ritual' as an analytical tool

One of the main problems within the archaeological discourse is that ritual is defined as non-functional and irrational and that this designation is used to identify 'ritual' archaeologically (Brück 1999, 313). However, these conditions of ritual are very ambiguous and may differ from person to person. There are no rules to determine when something is 'irrational' enough to be labelled 'ritual'. Moreover, there is no reason to assume why rational and functional acts would not be ritual. Many of the supposedly diagnostic properties of ritual practice may with equal validity reflect secular actions (Brück 1999, 315). The opposition of the ritual / symbolic versus the practical / technological is a modern Western distinction and hence, one could question its usefulness.

> *"the problems we face in analyzing ritual, as well as the impetus for engaging these particular problems, have less to do with interpreting the raw data and more to do with the manner in which we theoretically constitute ritual as the object of a cultural method of interpretation"* (Bell 1992, 16-17).

Because these *a priori* definitions of ritual (irrational, non-functional, repetitive etc.) create conditions by which to recognize ritual practices in the archaeological data, 'ritual' is made into, and used as, an analytical tool to survey the data. Yet, our conditions on which to define ritual are most likely not the same conditions as made by the people studied; *if* they see ritual as a separate category at all (see below). Consequently, one could argue that these conditions, and thus the concept ritual, do not exist (Bell 1992, Brück 1999). Most recently, Bradley (2005) has opted that ritual should be seen as being intertwined with the domestic. He argues that ritual often transcends from the domestic and is completely interwoven with it. Indeed, it is the western Cartesian world view (culture - nature, mind – body, object – subject) that opposes ritual against the secular (domestic). However:

> *"where people do not draw such a categorical distinction between the sacred and the profane, ritual action may not be spatially or temporally distinguished from more 'mundane' or secular activities"* (Brück 1999, 319).

Bradley (2005) is right when he sees 'ritual' acts happening in the domestic realm and vice versa. This *could* mean that no clear distinction was made between ritual and profane. However, as valid as his observations may be, I doubt whether his conclusion is helpful. It creates a single category in which everything remains ambiguous. I have tried to visualize the problem and conclusion sketched by Bradley (2005) in figure 3.1.

As mentioned above, Brück also doubts whether we can use the term ritual as a distinct category of practice. She argues that the conception of ritual is a product of post-Enlightment rationalism (Brück 1999, 313). In line with Bell (1992) she argues that archaeologist and anthropologist are using ritual wrongly (*i.e.* as an analytical tool). Her solution is as followed:

> *1) The question 'how do we identify ritual practice archaeologically?' is redundant. In fact, by pursuing this aim, archaeologists have blinded themselves to a much more fundamental issue, namely: 2) What can past actions tell us about the nature of prehistoric rationality?* (Brück 1999, 327).

What seems ritual to us can be perfectly rational (practical) to people that are studied. Brück proposes that we should rather look for the *rationalities* of prehistoric actions; recognizing categories that were made by them. I agree that we cannot use our definition of ritual to screen archaeological data. Abandoning our categories completely however, does not solve the problem. As with the interpretation given by Bradley (2005), that everything is interwoven, the risk exists of lumping everything in one big category in which everything remains ambiguous. Furthermore, the approach forwarded by Brück, to completely jettison the term 'ritual' and look at the 'rationalities' of prehistoric people partly just replaces the problem. The problem does not lay in the *term* 'ritual' but in the recognition and interpretation of it. To look for 'rationalities' instead, essentially still revolves about recognition and interpretation of certain patterns or acts in the archaeological data. Archaeologists should rather look for categories made by the people that are studied. This 'emic approach' tries to recognize specific practices of social action that are distinguished from other activities as a separate 'field of discourse' by the people involved (Fontijn 2002, 21). Whether these practices are termed 'ritual' or 'rationalities' is essentially of no significance. A good example of this 'emic approach' can be found in Fontijn's 2002 research on selective deposition.[30] Fontijn is interested in patterns that occur in the deposition of bronzes ('rationalities' according to Brück (1999)), without taking a stance in the ritual debate beforehand. In his concluding chapter on depositions, he can then ascribe these depositions neither to the theory that ritual is a meaningless, traditional behaviour, nor to the theory that ritual permeates all fields of life (Fontijn 2002, 276). He can only state that depositions

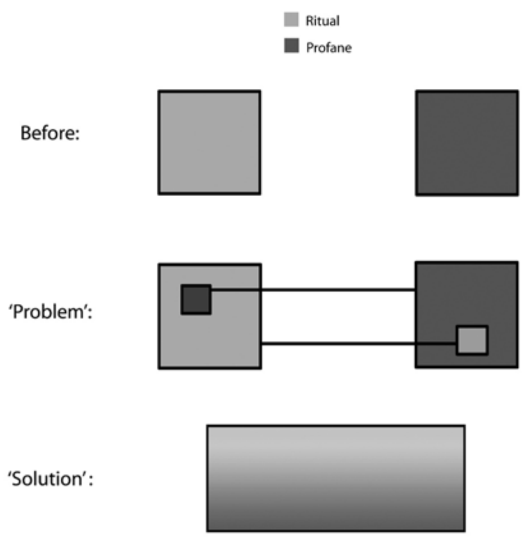


Figure 3.1 A schematic impression of Bradley's (2005) theory. Archaeologist try to determine what is ritual and what is profane (before). However, Bradley sees rituals in the domestic sphere and vice versa ('problem') and argues that the ritual and domestic should be seen as interwoven ('solution').

30 Note the choice of words in his work; *selective* depositions in contrast to the so often heard *ritual* depositions.

are 'ritualised', but explicitly note that there is no evidence that this reflects the profane-ritual dichotomy (*Op. cit,* 277).

Using this emic approach prevents us from using 'ritual' as an analytical tool. Nonetheless, even if we achieve to identify categories that were also used by prehistoric people[31] we will never be able to interpret it in the same manner. An interpretation by us will always be etic. In this way however, I am content with the use of the *term* ritual, for it is not employed as a tool. A concept with *a priori* definitions to it (and thus certain conditions) used to screen the archaeological data. Part of the problem remains, though. With the use of our words, our terminology and our interpretations we will not be able to explain a completely different worldview, in which dichotomies such as culture – nature, mind – body and ritual – secular are perhaps not made. Use of another term such as 'odd', 'rationalities', 'different' or showing the interwoveness (Bradley 2005, xiii) only replaces or veil the problem.

## 3.3 Recognizing ritual, concealing and revealing at the same time

Although axes seem to be *the* symbol of agricultural settlement (Bradley 1990, 48) in which it functioned as a tool for cutting down trees, building houses, or as generally accepted form in which metal was traded as a commodity; axes also appear to function in less mundane activities. They were deposited either individually or in the hundreds (Fontijn 2002, 248). The 'act' encountered by the archaeologist is the deposition and thus only represents a single event that marks the end of a, possibly very long, biography of the axe (fig. 2.1). This act of depositing an axe is fundamentally different from using it to cut down trees. However, they were conceptually linked. It was an object's life that mattered and during its use-life it became entangled with the live of the people that used it (Fontijn 2002, 23ff) which ultimately leads to deposition. By then the axe has undergone a transformation from commodity / practical object to gift or ritual object for deposition. The same goes for the axes used in trade: at some point commodities (short-term exchange) were transformed to gifts (long-term exchange) (*Op. cit*, 246ff).

Another example: many societies make offers to ensure, or thank for, a good harvest (Bradley 2005, 123ff). This 'act' of making an offering is fundamentally different from the act of harvesting itself. Even *if* people believe that one cannot happen without the other and thus see both as equally practical, they still are two distinct actions. *We* would describe only the cutting down of a tree or the harvesting as practical, and the deposition of the axe or offering as 'odd', 'irrational', 'non-functional' or indeed 'ritual'. We can also *describe* (albeit not truly understand) it as practical, interwoven (Bradley 2005, xiii), or ritualised (Fontijn 2002, 277) if we work from an emic basis. This would be better, but would not undeniably make it more comprehensible. Because these two acts, the offer and the harvest or the trade and the deposition, are conceptually connected, one could indeed argue that they are interwoven. However, I do not want to go as far as to say that trade, or harvesting, is consequently a ritual activity or that the offering, or deposition, is thus a mundane activity. We are capable of making the distinction between both actions and because it is *us* who want to understand, we can also choose to explain both separately. The explanation depends on the level and the context in which the interpretation is made.

Harvesting, for the prehistoric people involved, is offering to the gods *plus* the act of harvesting itself; interpretation on this level would thus lead to the conclusion that the offering is mundane for it is part of an everyday, mundane practice (the ritual and secular are interwoven). However, if the act of offering is singled-out in this 'harvesting process' or the act of deposition is singled out in the process of trade, something which often happens within archaeology, we would come to the

31 Wentink (2006) is another example in which this approach is used. By means of metrical, spatial and functional analysis on TRB flint axes, patterns are explored that shed light on the actions performed by people in the past. With this approach Wentink is able to study emic categories.

conclusion that the offering is ritual and use it to show the 'ritual dimension' (*cf.* Meurkens 2004, 37). Both interpretations are legitimate and both produce a conclusion that is partly revealing, partly concealing. Singling-out the offering reveals an intriguing action, but at the same time, conceals the wider framework of the harvesting process in which it should be placed. Singling out the deposition of the axe reveals an interesting, ritualised practice, but is not an act on its own. It should be seen in the context of a wider, mundane, practice of trade and use of this axe. The problem is that, no matter what terms are used, or in what way we will try to explain (as two separate activities or as one activity encompassing both acts), the conclusion will be partly revealing and partly concealing.[32]

To conclude, I think the archaeological record should be engaged in an emic way as much as possible, but we are limited to explain it on etic accounts; it is *us* who want to understand. Clear patterns in the archaeological data may reflect deliberate choices or categories made by prehistoric people. If so, these emic categories should be studied and interpreted. Many acts or categories can be called 'ritual' if singled-out, but can equally validly be interpreted within the process (often mundane) of which it is part. The single (ritual) act does not make the process ritual nor does the (mundane) process make the offer or deposition a mundane act. How this has consequences for the way in which Bronze Age metallurgy is perceived is shown in chapter 5.

## 3.4 Organization of production

Several organizational terms are used to describe Bronze Age metalworking. 'Specialisation' and the smith as a 'specialists'; 'attached' or 'independent', and (the control over) 'skill' and 'knowledge' are reoccurring themes.[33] All these terms seem to be used indiscriminately and often without a transparent definition which leaves many questions open. Can specialisation be discerned from the amount of production or labour efficiency? Is standardization evidence for specialisation? On what grounds is the distinction between specialist and non-specialist made? When is someone skilled? In the following sections the terminology will be discussed briefly. Furthermore, I will try to formulate clear and transparent definitions as to the use of these terms in this thesis, in order to prevent foggy interpretations.

### 3.4.1 Specialist and specialisation

Although specialisation based on the possession of superior technical skill is commonly known and would make the person who possessed it a specialist (Rowlands 1971, 218), I argue that specialist and specialisation should better be seen as two different concepts that are likely, but not necessarily, associated with each other. While both terms are extensively used and discussed in archaeological research (*e.g.* Brumfeld and Earle 1987; Wailes 1996; Milliken & Vidale 1998) they appear to lack a well defined, commonly accepted definition. Whether specialisation and/or specialist are recognized appears to be extremely depended on the premises[34] of the archaeologist as to the terminology, rather then its actual archaeological visibility.

*Specialisation*

Recently, Costin (2001; 1991) has critically discussed the research of specialisation. Depending on the definition, specialisation may be found in all societies (Costin 2001, 275). What is needed, according to Costin, is:

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32 Cf. Bazelmans (1999) on gift and commodity and the philosophy of Saussure on signs.

33 Childe 1956; 1963; Torbrugge and Uenze 1968, 26; Rowlands 1971; 1976; Kristiansen 1987; Budd & Taylor 1995; Bradley 2007, 232.

34 A good overview and critical discussion of these premises can be found in Costin (2001).

> *"a fairly simple definition of specialisation that can be operationalized archaeologically[…]The core idea is that "fewer people make a class of objects than use it"[…]Such a definition is broadly applicable to societies of all sizes and degrees of socio-political complexity. It does not presuppose units of analysis"* (Costin 2001, 276).

Although this definition indeed does not associate categories as full-time/part-time or household/ workshop with the appearance of specialisation, I believe it to be too broad to be helpful. Producing more metal objects than oneself uses does not entail working day in day out. As Drescher showed; a single bronze smith would have been able to cast 30-40 palstaves or 12-15 socketed axes a day in a bronze mould (Drescher 1957, 74-75). According to Costin this could be regarded as clear proof for specialisation. On these terms, specialisation would be common in the Bronze Age. Nonetheless, I would like to make a distinction between sites such as Cannes-Écluse (Gaucher & Robert 1967) or Choisy-au-Bac (Blanchet 1984), that have yielded vast amounts of debris, and the production of a few axes by a single (or group of) farmer(s)/bronze smiths. Both, in essence, represent specialisation because fewer people make the class of object than use it, but are fundamentally different in my opinion. Concerning my research I would therefore add that specialisation is the separation of tasks within a social system. The people involved are compensated for their work (*i.e.* the produced objects are 'paid' or traded) and it may lead to a full-time practice in which smiths provide themselves solely by the trade of their goods for food and other materials. Hence, the smith that haphazardly produced a couple of axes before returning to his fields is not regarded as involved in specialisation, even if more objects are produced then he himself needs.[35]

Still, even if well-defined, measuring specialisation seems impossible, but 'levels' or 'degrees' may be distinguished from each other (*e.g.* weakly specialized, highly specialized; *cf.* Costin 1991).

### *Specialist*

The distinction between specialist and non-specialist centers around three criteria according to Costin (2001, 279): (1) intensity (the amount of time spent crafting), (2) compensation (both types and amount derived from crafting) (3) skill (mastery of a set of knowledge and/or motor habits that confer special ability. The first premise and partly the second are also often used to determine specialisation, which may be the reason why specialisation and (being a) specialist are interchanged frequently. I would formulate the distinction on specialist and non-specialist primarily on skill. Firstly, because the distinction between specialist and specialisation can be made more easily; in contrast to specialisation, specialism is than defined by technical rather that social means (Kristiansen 1987, 33). Being a *specialist* is about a certain level of skill and experience that separates the master from the common craftsmen.[36] Secondly, intensity and compensation is extremely difficult to analyse from the archaeological record (see section 5.4).[37] That means that archaeologist can only 'measure' specialism according to the third premise: skill. Costin (2001, 282) is right though, that evaluating skill on the 'quality' of an object is a highly subjective assessment. While no methodological practice can be established to make absolute measurements on specialism, I do think that distinguishing skill relatively from each other may help archaeologist in their research. Next to the subjective 'measurement' of technological skill (the technological difficulty to produce an object); which objects were regarded as more skilful than others may be inferred from the way they are treated (their context). The Jutphaas sword (Butler & Sarfatij 1970/1971) for instance, may then be regarded as highly specialist because of its technological complexity (Fontijn 2001) as well as its context (*i.e.* deliberate deposition; Fontijn 2002, 104).

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35 As such, my definition does entail a distinction between large-scale (workshop) and small-scale (household) production.

36 It is important not to confuse skill with knowledge (see section 3.4.3).

37 For a more thorough discussion on the theoretical and methodological difficulties of assessing intensity and compensation from the archaeological record alone, see Costin (2001, 280-281).

### 3.4.2 Individual and workshop

As I am following Butler's research question as to locating the 'workshop' of the smith (Butler 1961, 199) it is necessary to determine what exactly a workshop is. Butler himself does not give a definition. Costin (2001, 296) sees the term as the constitution of production units, which is mostly based on size and workgroup composition. A distinction is made between individual (small scale) production and workshop (large-scale) production. Hence, 'workshop' implies a certain size (large) of workgroup composition and a non-domestic context (*ibid.*). Using this definition, the archaeological record is devoid of any 'workshop' beside possible exceptions such as Rathgall, Ireland (Tylecote 1987; Raftery 1976). This site clearly shows a certain area that is used for metalworking (supra-household/non-domestic) and the amount of debris found may be indicative of a large workgroup. As the term 'workshop' clearly entails a priori definitions on the organization, I would refrain from using it. Instead, following Costin (2001, 296), the more neutral term *production locus* is used.

### 3.4.3 Knowledge and skill

Skill should not be confused with knowledge. To have the knowledge of a certain process does not mean that you are also skilled. Turning knowledge into skills always takes a learning period, from a couple of minutes to several years (Siguat 2002, 430). While I may have the knowledge how to paint, this does not mean that I have the skill to produce a nice painting. Accordingly, the most important point I want to address here is that metalworking, *because of* the skilful objects, has often been regarded as a confined knowledge (Childe 1963; Kristiansen 1987). Yet, this causal relation is by no means proven.

## 3.5 Conclusions

Metalworking is often associated with a form of specialism, specialization and described as an arcane practice involving confined knowledge and rituals. Before studying whether these associations are a reality (see chapter 5) it was necessary to look upon their meaning and use. How can we recognize 'ritual' metalworking and when is someone a 'specialist' metalworker?

*Ritual*

The recognition of 'ritual' practices in the archaeological record proposes several problems. Most importantly, archaeologist should be aware not to use 'ritual' as an analytical tool to survey the data. Defining ritual beforehand means that etic categories are constructed and one can doubt whether these tell anything about how prehistoric people perceived their world. The domestic and ritual are by no means two separate categories, rather they appear to be interwoven with each-other. Technology in small-scale societies is often regulated and organized by what we would call rituals. Nonetheless, to the people involved both the ritual as well as the functional acts are all part of one process. This does not mean that archaeologist cannot use the term ritual. If a specific act is singled out we may well describe it as a ritual. However, this 'act' should be placed in its context, which often is a mundane practice. Depending on the level (context) on which the interpretation takes place, it will be partly concealing and partly revealing. The archaeological record should be engaged in an emic way as much as possible for the categories that were made and meant something to prehistoric societies are the most informative for archaeologist. Interpreting patterns will remain an etic practice however, because it is done by us.

### *Specialism, specialization, knowledge and skill*

The core idea of specialization is that fewer people make a class of objects than use it. Hence, specialization may be found in almost every society. To be able to make a distinction between the haphazard production of a couple of axes for a community and mass production of objects for trade I have added to this definition that specialization is also about the separation of tasks within a social system. I make a distinction between the household (small-scale production) and the workshop (large scale production). Specialization is not to be confused with specialism. An unskilled smith, only producing regular tools, can work full-time, which represents specialization. In the archaeological record specialization is extremely difficult to surmise from artefacts alone. 'Measuring' specialization seems impossible but different degrees of specialization may be distinguished.

Specialism revolves mainly around skill. Costin advocated two other criteria to make the distinction between specialist and non-specialist (intensity and compensation) but as these cannot be easily deduced from archaeological data and are also related to specialization, I will not use them to verify specialism. To determine the skill or quality of an object is a highly subjective assessment. Hence, no methodological practice can be established to make absolute measurements on specialism. Nonetheless, it is possible to distinguish objects relatively from each other. Producing a functional axe requires less skill than the production of a ceremonial sword.

That brings us to the final point of this chapter. There is no a priori causal relation between skill and knowledge. Knowledge may be widely available but skill can only be learned.

# 4 Bronze production in the Netherlands; former research

*"Wat beteekent dit nu anders als dat zoo'n reizend koopman klaarblijkelijk zijn tocht een enkele maal naar hier heeft uitgestrekt; als er dan ook hier en daar in onzen bodem nog een aantal van dergelijke bijlen of andere werktuigen los in den grond gevonden zijn, dan mag men daar toch zeker niets meer uit besluiten, dan dat zulke handelsreizen niet geheel zonder succes zijn geweest"* (Holwerda 1925, 71)[38]

## 4.1 Introduction

Dealing with the production of bronze, metalworking and the Bronze Age smith, there is a general divide between those that follow a technical approach (the archaeometallurgist) and those that study their topic from a socio-cultural approach (socio-cultural archaeologist) (Budd & Taylor 1995, 134). Beside this dichotomy, the overall changes taking place in archaeological theory, from pre-WW II to New Archaeology and post-processual archaeology, also have had their implications. The scientific approach of the New Archaeologist meant, for instance, that several tens of thousands metallographic analyses were made on metals (the SAM series). Rowlands' (1971) article is another New Archaeology 'marker' in metallurgical studies. It introduced anthropological examples of metalworking and, based on analogies to these examples, argued against Childe's ideas of a nomadic smith. Another 'marker' can be found in Budd & Taylor (1995) whom opt for, what I believe is, a post-processual view towards metalworking related studies. In the following sections, the former research on metalworking, related to the Netherlands, is reviewed and discussed. Especially Butler's work will be addressed as his theory on locally produced axes provided the starting point of my research.

## 4.2 Before Butler

At the time when Butler is getting involved in the archaeology of the Netherlands, the Bronze Age is generally seen as a period of material poverty in which the only advantage was that the exchanges routes (Rhine, Meuse) ran trough our country (De Laet & Glasbergen 1959, 114 following Byvanck 1940). Main reason to adopt this stance was the lack of bronzes in burials. Research at that time was mainly concerned with the excavation of burial mounds and the presence of bronze was thought to signify wealth. However, as we now know, most bronzes did not accompany the dead but were deposited in swamps, lakes, rivers and other 'selective' places (*cf.* Bradley 1990; Fontijn 2002). Metal found in the Netherlands was, at that time, automatically ascribed to itinerant smiths, properly in line with Childe's theories, as is shown by the two citations below:

*"in de buurt van Voorhout in Zuid-Holland is een aantal bronzen bijlen gevonden, blijkbaar de voorraad van een reizenden koopman"* (Byvanck 1940, 161)[39]

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38 "What else could it mean: that such an itinerant merchant evidently extended his journey to here; and if some of those axes and other tools are also found then, as stray finds in our ground, than nothing more can be concluded from that, than that the travels of such a merchant were not without success."

39 "in the neighbourhood of Voorhouten in South-Holland, a number of axes have been found; apparently the stock of a travelling tradesman."

> *"De Bronstijd [….] waarin af en toe een reizende bronsgieter-handelaar uit een van de centra van metaalbewerking elders van nederzetting tot nederzetting trok"* (de Laet & Glasbergen 1959, 114).[40]

For the Late Bronze Age, when the archaeological record produces more bronze artefacts and richer hoards are found, the explanation is simply adjusted to the fact that itinerant smiths visited this region more often (De Laet & Glasbergen 1959, 148). Even the artefacts that should have aroused some speculation on local production, such as the casting jet and bronze mould from Havelte, were without hesitation accredited to an itinerant smith. They are explained as proof that now and then some objects were cast in these regions by smiths *visiting* the Netherlands (De Laet & Glasbergen 1959, 141). These are exactly the same artefacts that Butler (1961) uses to show the existence of a local bronze industry in the Northern-Netherlands, as we shall see in the following sections. After the '60's when Childe's model was discredited and the first articles on bronze production by Butler are published, the opinion of Dutch archaeologists changed. There is some acceptance of the possibility of local production but the concept of an itinerant smith is not dismissed. Brongers and Wolters , for instance, believe that the local smith himself was itinerant, thus combining the two theories, and see it as a stage before being a "full" smith (Brongers & Wolters 1978, 96). Nowadays it is widely accepted that local production of bronzes existed although a bronze smithy needs still to be found.

## 4.3 Childe and the detribalized smith

Inextricably tied to the study of the prehistory of Europe and almost every topic within that frame is Gordon Childe. Childe was one of the first to deal with metal production, bronze smiths and the metal trade and his ideas have had profound implications on how the Bronze Age is perceived.[41] For instance, the idea that specialisation is generally associated with the rise of complex societies can be traced to the works of Childe (Costin 2001, 273).

In his book '*The Bronze Age*' (1963 [1930]) Childe introduced his theory on the travelling smith. Childe sees the discovery of metallurgy as so abstruse and complex that it is "fantastically improbable" to have had several independent origins (Childe 1963, 10). The Bronze Age is, according to Childe, a period in which massive social changes took place (Childe 1951, 24-25). To him, technological advances imply social and moral progress of society and therefore the Bronze Age is a crucial era in the prehistory of Europe (Childe 1944b; 1958a; 1963; 1965). The techniques needed to produce metal artefacts were complicated to such an extent that only a full-time smith would have been capable to perform these processes (Childe 1963, 4; 1965, 136). This specialist position, consequently, gave the smith a position outside society.

> *"It is, indeed, quite likely that miners and smiths constituted distinct crafts or even castes, membership of which implied initiation but conferred some degree of immunity from bondage of the tribal system"* (Childe 1963 , 10).

Herewith, the idea of the detribalized smith is born. These bronze smiths would travel and provide their services to communities. In Childe's (1963, 3-7) opinion the Bronze Age is a period of primitive science and capitalism. In fact, he saw the travelling detribalized smith as the first capitalist, standing at the brink of what later would become European liberalism and capitalism. This is a remarkable conclusion from a life-long Marxist.

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40 "The Bronze Age [....] in which an itinerant metal- worker/trader from on of the metal producing centres elsewhere, travelled from settlement to settlement."

41 A good synopsis can be found in Trigger (1980, 67ff).

Childe takes the view, in accordance with the *ex oriente lux* perspective of Montelius[42], that the first metalworking took place in the Near East. Spreading from this region, the first European civilization to come into contact with metalwork would have been the Minoan society. The Aegean area is considered to be the core area of metalworking in Europe. Childe believes Aegean prospectors sailed European seas, looking for new sources of metal. Consequently, they incorporated "barbarian" societies into their trading networks, thus bringing them into contact with this new material (Childe 1958a; 1963, 38-41).

> *"Peoples develop at unequal rates and the effective demand for and use of metal is only possible when a certain stage of development has been reached"* (Childe 1963, 9).

The trading networks operating at that time were used to provide the Aegean market with goods. Societies near these trading routes, the "Amber-road" (Childe 1958a, 162ff) came into contact and developed a demand for metals while the rest of Europe was still "dwelling in the late Neolithic" (*Op. cit*, 163). The first use of metals in European societies is therefore, according to Childe, due to their Aegean contacts. Childe never considered whether a local metal production could have sprung up somewhere else, probably due to the way he perceived the bronze smith as being itinerant. Knowledge of metalworking would have been guarded as a professional secret by the masters who practiced the craft (Childe 1963, 4; 1965, 136). He even argues that the more accessible veins or alluvial ores could have been mined by the local people, yet the process of turning them into artefacts could only have been done by professionals (Childe 1963, 10-12). The ores mined in the Eastern Alps and Slovakia were used to supply the itinerant merchants and smiths involved in the amber trade (Childe 1958a, 160). Although he does state that these smiths from Syria and the Aegean must have had their disciples in Europe (*Op. cit*, 166), his opinion on the bronze smith did not change. These smiths too would – in due time – become detribalized and travel as smiths / traders. One of the main arguments behind this theory is the absence of smith's graves. According to Childe this absence clearly shows that the metalworker stood outside society and thus must have been itinerant. Furthermore, he argues, no village would have been big and wealthy enough to support a smith of their own (Childe 1958, 168). On the basis of these ideas Childe declares most depositions of metal objects as traders or founders hoards belonging to travelling smiths. They were entrusted to the earth in times of social unrest or war. The smith would bury his trading goods in times of danger, only to come back later and collect them again. He supports this interpretation by analysing the distribution of the traders hoards, arguing that on the map they, most frequently, could be seen at places were one would expect social unrest (Childe 1963 , 44-45).

Childe's idea in a nutshell: Only after large scale reorganization had taken place, in which a surplus economy was needed, there would have been the opportunity for a full-time smith to exist. Because of his specialisation, the smith would become isolated from his own community and was therefore *detribalized*. Freed from community bounds he could travel and stay wherever he could find a market for his products and craftsmanship.

### 4.3.1 Criticism on Childe's ideas: death of a salesman[43]

Until the end of the '60's, Childe's arguments were strongly represented in almost every work dealing with the Bronze Age. With the arrival of the New Archaeology, a completely new view on the Bronze Age developed and Childe's model was strongly criticized. The development of $^{14}C$ dating

42 Montelius argued that all the attributes of civilization, from stone architecture to metal weapons, had spread or "diffused" to Europe from the Near East by trade or migration of people. Although Childe argues that Europe also must have had indigenous development, he does accredit all the major changes to Near Eastern influences (Renfrew & Bahn 2000, 34)

43 Title taken from Gibson (1996).

lead to a new chronological framework (Renfrew 1973, 84-108) and the fundamentals of Childe's diffusionistic explanation of the European Neolithic and Bronze Age did no longer hold. Besides this criticism a reassessment of the role of the smith in the Bronze Age was made. For the first time it was suggested that the importance of metal was not situated in its technical superiority, but rather as prestige goods (Renfrew 1973, 190).

Rowlands (1971), in line with New Archaeology's search for a middle range theory, used anthropological examples "*to examine general assumptions made by archaeologists as to the organization of metalwork production"* (Rowlands 1971, 210). According to the 'best fit' method of Ucko (1969), the known alternatives for the social position of the smith, coming from ethnography, are tested against the available archaeological data and theories. Childe's theory on the itinerant smith was accordingly dismissed. Rowlands sees virtually no ethnographic parallels for the existence of a free, detribalized, travelling smith. Furthermore, the concept of an itinerant smith does not correspond with evidence for distinctions in the style of metalwork correlating to distinctions in other aspects of material culture. Nor does it explain the local differences in different regions (Rowlands 1971, 215), unless these itinerant metalworkers were indeed able to adapt to the local style, as advocated by Childe (1940, 166 cited in Rowlands 1971).

Another assumption, that metalworking is a specialist's job and would mean a full-time occupation, made by Childe (1958a, 78) and (later) several other archaeologists (*e.g.* Kristiansen 1987), is discarded by Rowlands as well. A normal smith rarely spends all his time on metalworking because demands would fluctuate strongly (Rowlands 1971, 212). One could comment that exactly this could be a good reason for a smith to travel from town to town, looking for places to sell his products and/or skills.

The associations that Childe (1963; 1965) makes between metallurgy, specialisation and social complexity, are also quite problematic. Costin surmises three reasons why technological complexity cannot be used to infer organizational complexity. (1) Relative complexity of one technology over the other is biased and subjective (2) studies of technology often only consider part of the matter (*e.g.* materials but not knowledge and processes), and (3) there is little theoretical or empirical evidence to support the association between technological and organizational complexity (Costin 2001, 288-289).

A final argument worth mentioning here is the refuted detribalization of the smith. Rowlands sees exactly the opposite happening, arguing that being a skilled metalworker would cause a stronger integration within society and more obligations towards it. For instance; in the Celebes, Indonesia, the smith needs the help of the community to build a workshop (Marschall 1968, 149). Rowlands states his point very clearly on the itinerancy of the smith:

> *"there is no more reason to assume that Irish smiths travelled on the Continent to learn the techniques of making sheet bronze buckets and cauldrons than that such influences were transferred trough normal exchange and culture contact"* (Rowlands 1971, 215). [44]

Nonetheless, Childe's itinerant smith has not died yet, as proclaimed by Gibson (1996), and many still find the concept of an itinerant smith attractive (Gibson 1996, 108). With respect to the Gelidonya shipwreck (Bass 1987), Sherratt argued that this may be clear evidence of a travelling bronze smith, ready to melt down his scrap and turn out metal artefacts to orders (Sherratt 2000, 87).

44 Rowlands (1971) looks at a number of other ethnographical examples of metalworking and the role of the smith in a society, on the basis of which he offers several more arguments to refute Childe's theories.

## 4.4 Butler's view on Bronze Age metalworking; an indigenous production?

Beside Butler's work on Bronze Age connections (Butler 1963a; 1987a)[45] and the enormous task of cataloguing all the Bronze Age metal from the Netherlands[46], Butler focused on the subject of an indigenous metal production in the Netherlands (Butler 1961; 1963b; 1966; 1969; 1987b). In contrast to his tutor Childe, Butler does see a local industry developing in the Netherlands. At first sight this looks like a completely different interpretation but the contrast to Childe's ideas is not as evident as it seems.

Butler first suggest local metal production in the Netherlands in his '*Vergeten schatvondsten uit de Bronstijd*' (Butler 1959). In this publication he describes the hoard found in Wageningen. The fragmented pieces of copper in this hoard are interpreted by Butler as 'ingots' and their presence indicates that the hoard belonged to someone who was capable of, at least, a simple form of etalworking (Butler 1959, 126). The typical flat axe and halberd, according to Butler, suggest an Irish connection and thus this hoard must have belonged to an Irish itinerant smith. This interpretation is perfectly in line with the ideas of Childe. However, Butler's interpretation differs in the fact that he argues that this Irish smith *introduced* bronze production in the Netherlands (*Op. cit*, 128). Several axes, according to Butler, may have been derived from the Irish-type and point at a small local industry started by the itinerant Irish smiths (*ibid.*). In his 1961 article Butler published the argumentation based on which he deduced a local industry. He tackled the issue by (1) looking at the evidence of production in the Netherlands; *i.e.* the workshop of the smith and (2) by studying the axe types and their distribution (Butler 1961, 199-200). Later he elaborates on the latter point and adapts two means to determine whether an axe is a local product or not: (1) the axe must be clearly distinguishable from known types of axes elsewhere and (2) the study area has to yield enough examples of the axe to surely state that we are dealing with a local product, rather than a single deviating find (Butler 1963b, 181). It remains unclear how many local products Butler needs to safely assume a local bronze industry.

His theory of local bronze production is mainly based on the recognition of local types of axes. In addition to the axes, Butler is also interested in other bronze artefacts which could have come from these local southern Niedermaas and northern Hunze-Eems industries. The Omega bracelets, as well as Urnfield knives with one cutting edge are also, based on their style, ascribed to a local bronze smith somewhere in the North of the Netherlands (Butler 1969, 97ff).

As my goal is to find the workshop, or better, the production locus of the claimed bronze industries by Butler, I will first have a look at these industries and the products that were produced locally according to Butler. These local products may also provide a good starting point for my research. Although I am concerned with *direct* evidence for local metal production, these regional products, *indirect* evidence, do show concentrations on the map (see appendix 4) which might reflect increased metalworking activities in that area.

In the following sections, Butler's ideas on an indigenous production are presented and discussed. I will not chronologically follow the articles written by Butler, but rather use the archaeological periodization. For each period, from the Bell beaker to the Late Bronze Age, first the isolated finds related to metalworking are reviewed, followed by the regional axe types of that period. For an overview of the axe typology as used by Butler, see appendix 4. The last section provides a discussion on Butler's theories and the use of 'regional' axes as indicators for a local bronze industry.

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45 Butler's PhD research was on Bronze Age connections across the North Sea (1963a).

46 The '*Bronze Age metal and amber in the Netherlands*' series published in Palaeohistoria (Butler 1990, 1995/1996, Butler & Steegstra 1997/1998, 1999/2000, 2001/2002, 2003/2004, 2005/2006)

### 4.4.1 The Bell Beaker period

At a time when many other scholars had doubts about the Bell Beaker folk as introducers of metallurgy[47], Butler endorses Childe's hypothesis and tries to prove that Beaker people were indeed responsible for bringing metallurgy to the Low Countries (Butler & Van der Waals 1966, 42). In contrast to other countries, the link between Bell Beaker smiths and the introduction of metallurgy is seen as rather well established in the Netherlands. Evidence to support this theory are the two Bell Beaker graves from Lunteren and Soesterberg (fig 4.1 & 4.2). The two graves contain objects that relate to some form of metalworking.[48] Cushion stones, hammer stones, a whetstone and a copper awl are the main indicators to ascribe these graves to a smith (Butler & Van der Waals 1966, 63ff). Including stray finds a total of nine cushion stones have been found, all in the Veluwe area. This is corroborated by analyses of the metal objects and some stray finds of anvils (Butler & Van der Waals 1966, 122ff). Considering whether the cushion stones indeed could have been used as metal-hammering implements Butler and Van der Waals (1966, 69) opt that (1) hammering played an important role in the metalworking of the Bell Beaker people and (2) that it is reasonable to surmise, in view of the special composition of the Bell Beaker metals in the Netherlands, that Bell Beaker people in this country practiced metalworking. Accordingly they conclude that:

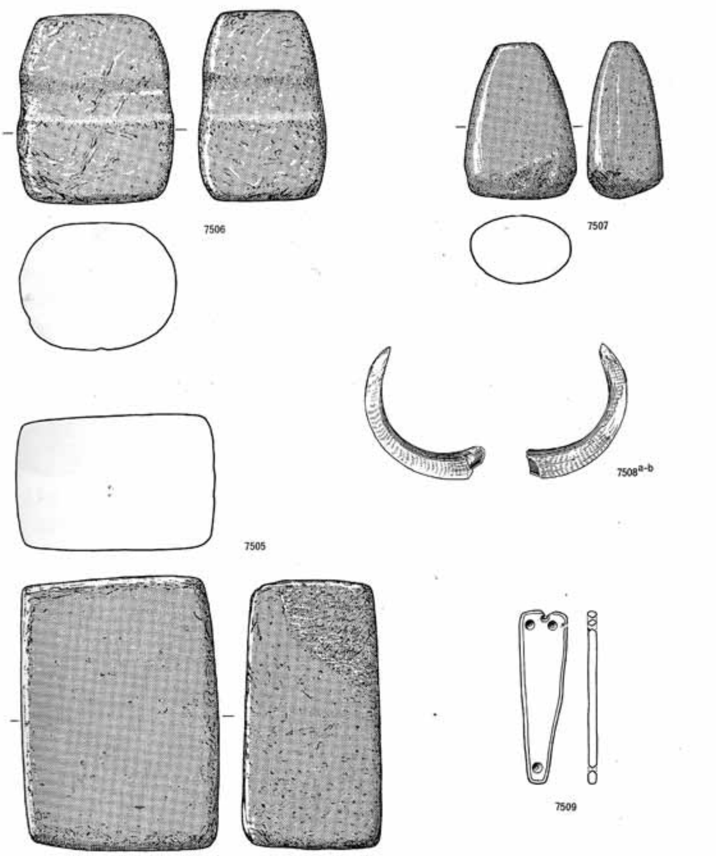


Figure 4.1 Part of the Soesterberg find: above are two stone hammers. The groove in 7506 was probably used to haft the stone with the use of whitties. Below left is a small cushion stone. Scale 1:4 (taken from Butler & Van der Waals 1966).

47 See Butler 1966, 42 for an overview.
48 It is debatable whether these small anvils were used for working gold, relatively pure copper or bronze.

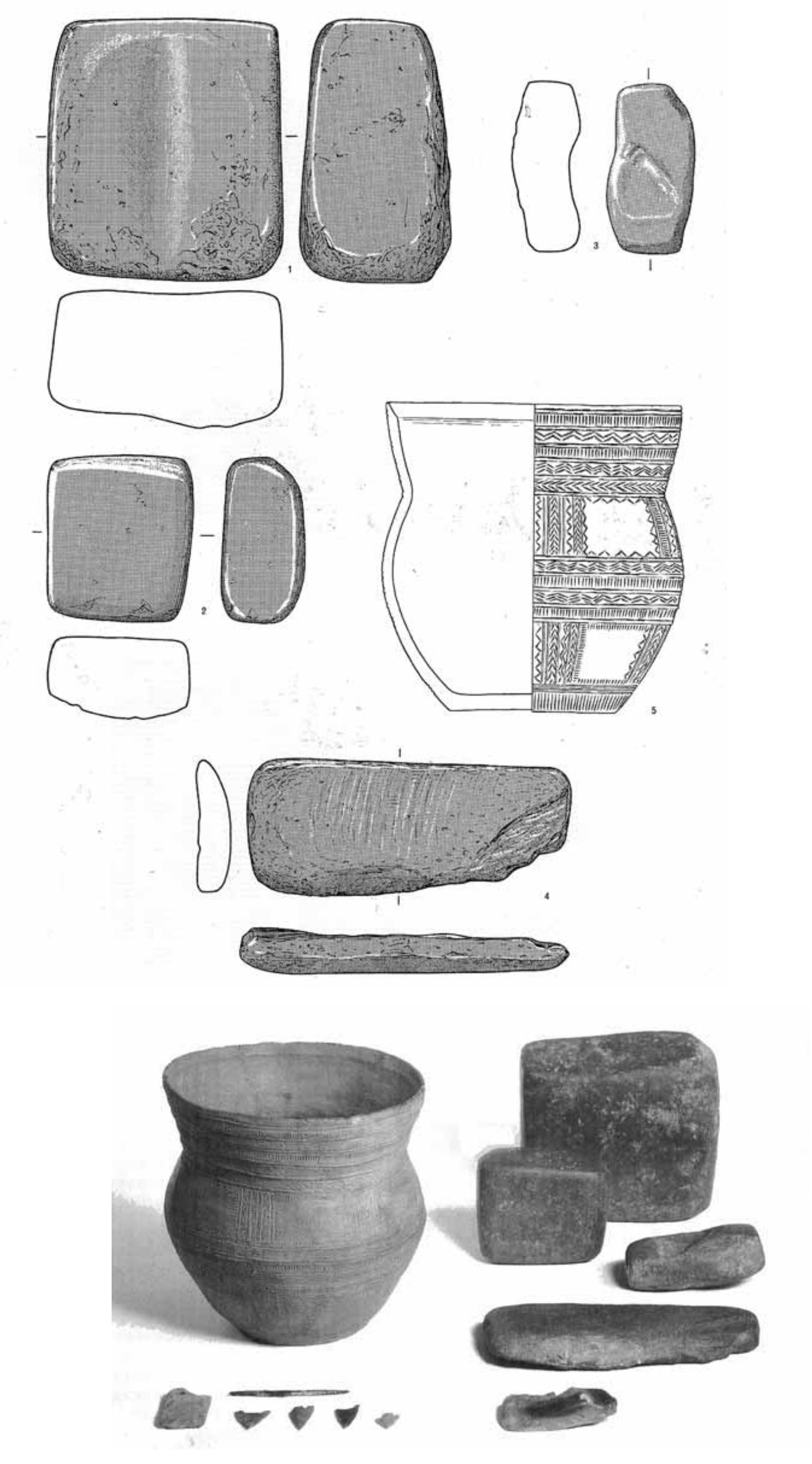

Figure 4.2 The Bell Beaker grave frome Lunteren containing two beakers (one is lost), cushion stones, a wetstone, arrowheads a copper awl and a wristguard. Drawing scale 1:4 (taken from Butler & Van der Waals 1966).

> *"...despite the Breton affinities of the Dutch Bell Beaker metal, it would not be unreasonable to suppose that Bell Beaker metallurgy reached the Netherlands from the Central European area"* (Butler & Van der Waals 1966, 100).

### 4.4.2 The Early Bronze Age

Butler has argued that based on typology and associations, as well as the metal analyses there could not have been any significant contacts between Bell Beaker metallurgy and that of the Early Bronze Age (Butler & Van der Waals 1966, 100). In the Early Bronze Age there is evidence for the first true bronze[49] smith in the Netherlands, represented by the Wageningen hoard. This hoard, discovered in 1844, contains only one artefact, the halberd, which has a parallel in the Netherlands. Butler therefore reasons that if all these objects were foreign, the owner must have been so too (Butler 1963b, 186) and that this hoard is

> *"sufficient to suggest that such travelling bronze smiths from the British Isles provided the Netherlands with its earliest metal industry"* (Butler 1963a, 202).

In addition to the halberd, the hoard contained a dagger, unfinished rivets, an awl, a thin bracelet, a piece of twisted metal (which Butler considers to be an ingot), a bronze axe and a flint axe (fig. 4.3). After analysis of the metal composition, which showed that none of the artefacts had a definite 'Irish' composition, Butler revaluates his former interpretation, but is consistent on the origins of the smith. Five of the artefacts are made of Singen-metal, including the 'Irish' axe.[50]

> *"The absence of tin and of Irish metal and the predominance of Singen metal in the assembly indicates that the smith did not bring metal from the West with him (or had exhausted his original supply) but depended (at least at the time of the hoard's assembly) on metal acquired locally, which was predominantly of Central European origin"* (Butler & Van der Waals 1966, 81- 2).

Figure 4.3 The Wageningen hoard (photo courtesy of the RMO).

49 Earlier finds are almost pure copper implements. The objects in the Wageningen hoard, and later bronze objects, are made from either arsenical bronze or tin bronze.

50 'Singen-metal' or 'A-metal' is provenaced to the region around Singen (South-Germany). It consists of copper with high impurities of arsenic, antimony, silver and nickel (Butler and Van der Waals 1966).

Although Butler, with his ideas on regional production, deviates from Childes perspective, it seems that in this case he strongly adheres to Childe. This hoard provides information on *how* metalworking was introduced in these regions; the Irish industry being developed to such a degree, that it allowed migratory smiths to set up shop in the Netherlands (Butler 1963a, 210). These itinerant metalworkers would settle here and could have had local apprentices. They would have become the first indigenous bronze smiths (Butler 1963b, 187). This interpretation on the introduction of metalworking in the Netherlands is, however, heavily lacking evidence to support it. Therefore, the idea of an itinerant smith has lost much appreciation among archaeologist. Although Butler now sees the Wageningen hoard as an isolated find, he does not abandon the idea that this hoard suggests "*a visitor to the region, perhaps a travelling smith, or a trader along the Rhine route*" (Butler 1990, 68). Currently, there is still no good alternative to explain the composition and origins of this hoard (Butler & Fokkens 2005, 377).

Beside the Wageningen hoard Butler postulates an Early Bronze Age axe-type that is of local origin. He first mentions the axes as being 'pseudo-Irish' (Butler 1963b, 190). These imitations of the Irish flat axes are later categorized as the Emmen type (Butler & van der Waals 1966, 78; Butler 1969; Butler & Steegstra 1995/1996). There are currently 14 examples of this early axe-type known in the Netherlands (of which 4 are variants of the Emmen type) (Butler & Steegstra 1995/1996). They are regarded to be part of the 'northern industry', with their main distribution focused on Drenthe (see appendix 4).

### 4.4.3 The Middle Bronze Age

According to Butler (1969, 118-119) an unambiguous indication of Middle Bronze Age metalworking is the Ommerschans hoard. This hoard comprises a range of tools, such as bronze chisels, an awl and facetted stones that are "often" found in founders hoards elsewhere. Beside two Russian examples, no others are given. These tools and the scrap metal accompanying it suggest metalworking, although other handicrafts may be implied as well (Butler 1990, 91). Yet another hoard, the Voorhouten hoard, is also described as typical example of an itinerant metalworker's /trader's stock as it contained scrap metal and a lugged chisel (Butler 1959, 131-134; 1961a, 201; 1969, 92; 1990). By interpreting this hoard as such Butler is explicitly following Childe's interpretative framework. Later he modifies this slightly:

> *"This brings us close to belief in an itinerant bronze-caster; although this model has been discredited by Rowlands on the ground of African ethnological parallels. If we exclude this itinerant smith, we are left with the possibility that imported prototypes were used as a pattern for mould manufacture by local smiths"* (Butler & Steegstra 1997/1998, 184).[51]

Another indication of indigenous bronze production, and one of the few finds that Butler uses to discuss the workshop of the smith, is a fragment of a bronze mould dredged from the river Meuse in the neighbourhood of Buggenum (Butler 1973, 322; Butler & Steegstra 1997/1998, 227-8 Cat. No. 323; see appendix 2.1). The type of palstave that could be cast with this mould is very rare in the Netherlands. Butler therefore argues that there is no evidence to suggest that it was actually employed and that we are dealing with a piece of scrap metal intended to be re-melted (Butler 1997/1998, 271).

For the Middle Bronze Age, Butler recognizes a considerable number of local axe-types. He argues that that 71 % of the palstaves are local products (*Op. cit*, 270)

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51 Fontijn (2008) proposes a completely different approach and argues that this hoard is a permanent deposition of a part of the trade stock (see section 2.3).

*"The heavy predominance numerically of palstaves types with a limited, regional distribution constitutes plausible evidence for the production of these types in the region in which they occur"* (Butler & Steegstra 1997/1998, 271).

This causal relation between region of occurrence and production is nonetheless debatable (see section 4.4.5). Appendix 4 lists all the different local varieties that make up group IV (the regional group) in Butler's catalogue on palstaves (Butler & Steegstra 1997/1998, 202ff). Beside palstaves, other axe-types from this period also have regional variants. For the flanged axes these are a derivate from the Oldendorf type, namely the Oldendorf – Ekehaar variant or Ekehaar type (Butler 1995/1996, 204ff). The regional variant of stopridge axes is represented by the so-called Vlagtwedde type (*Op. cit*, 230ff).

### 4.4.4 Late Bronze Age

In 1961 Butler tries to demonstrate the existence of a Late Bronze Age 'Hunze-Eems Industry'. At that time four finds were known that Butler could relate to a metalworking workshop; three hoards (Havelte, Deurne and Berg-en-Terblijt) and a single find (Havelte mould) (Butler 1961, 203ff). Three of the finds are discussed by him.[52] The hoard from Deurne, comprises a gouge and two chisels. The hoard from Havelte consist of two axes, a broken knife and a casting jet (Butler 1961, 268; fig 4.4). Regarding the Deurne finds, Butler mentions that comparisons are easily found in Late Bronze Age hoards from other countries and that they have formed the personal belongings of a craftsman, maybe a bronze smith (*ibid.*). No examples of such hoards used as parallel are given. Concerning the half bronze mould from Havelte, Butler argues that only a bronze smith would possess such an item (Butler 1961, 204). He even infers from this find that the workshop must have been somewhere in the neighbourhood (*ibid.*). However, as with the mould from Buggenum, the axes produced by this mould are of a type that is common in Britain and Ireland but almost unknown in the Netherlands. Hence, he concludes that this mould cannot shed much light on the 'Hunze-Eems industry' (Butler 1961, 207). The casting jet, originating from the Havelte hoard, is a more important clue according to Butler. It is a waste product of the production process, retained only to be re-melted again. According to Butler (1961, 210), the only person in whose presence one could expect such a casting jet would be a bronze smith. Consequently, this hoard must have been a collection of old items, ready to be re-melted (*ibid.*). In 1984 another hoard is discovered at Drouwenerveld (fig. 4.5) containing around 70 pieces of bronze, mostly scrap, including some casting jets (Butler 1987b). Although aware of the discussion whether such deposition are functional or ritual (Levy 1982) he describes the find as

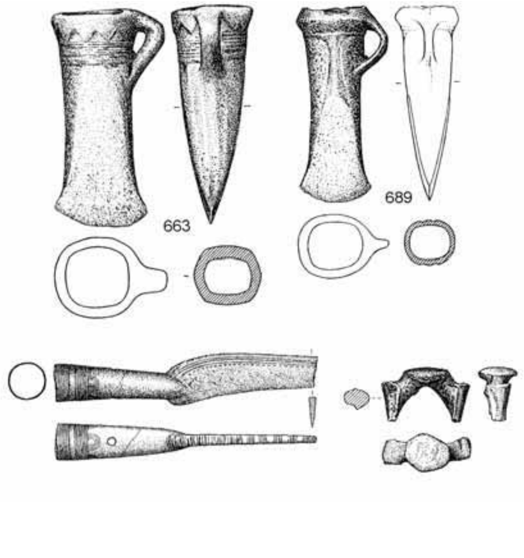


Figure 4.4 The Havelte hoard. Scale 1:4 (after Butler & Steegstra 2003/2004).

52 The hoard from Berg-en-Terblijt, for which Butler also claims that it belonged to a bronze-worker (1961, 202) is not discussed in his 1961 article as it had not been studied properly yet. In later publications, however, this hoard is not addressed as a bronze workers hoard anymore.

a clear example of accumulated bronzes ready to be re-melted and cast into new objects, and thus belonging to a metalworker (Butler 1987b, 105).

His second approach to advocate local production in the northern Netherlands (the 'Hunze-Eems Industry') is the identification of regional artefact types. In 1961 examples of such types are described as the "Lappenmunster type", or "socketed axes with highly decorated mouth". In the catalogue (Butler & Steegstra 2003/2004) Butler has grouped the socketed axes in four families of which three are made up of regional axes. Appendix 4 shows the diversity within these families. A group of several axes show the same so-called "VVV neck ornament" decoration around the collar (*Op. cit*, 271). According to Butler (1961, 218; Butler & Steegstra 2003/2004, 265), these resemblances suggest that they are made by the same group of metalworkers or even in the same workshop.

In 1973 Butler discusses the 'Niedermaas Industry', a southern local industry. Another bronze mould is mentioned, probably found in the Meuse nearby Maastricht (Butler 1973, 338, fig.15), but because of its unknown origins this mould is not discussed in detail. Later, this find is recognized as being a mould for a Helmeroth axe and the erroneous find spot is changed to Roermond (Butler & Steegstra 2001/2002, 303 Cat. No. 549; see appendix 2.1).

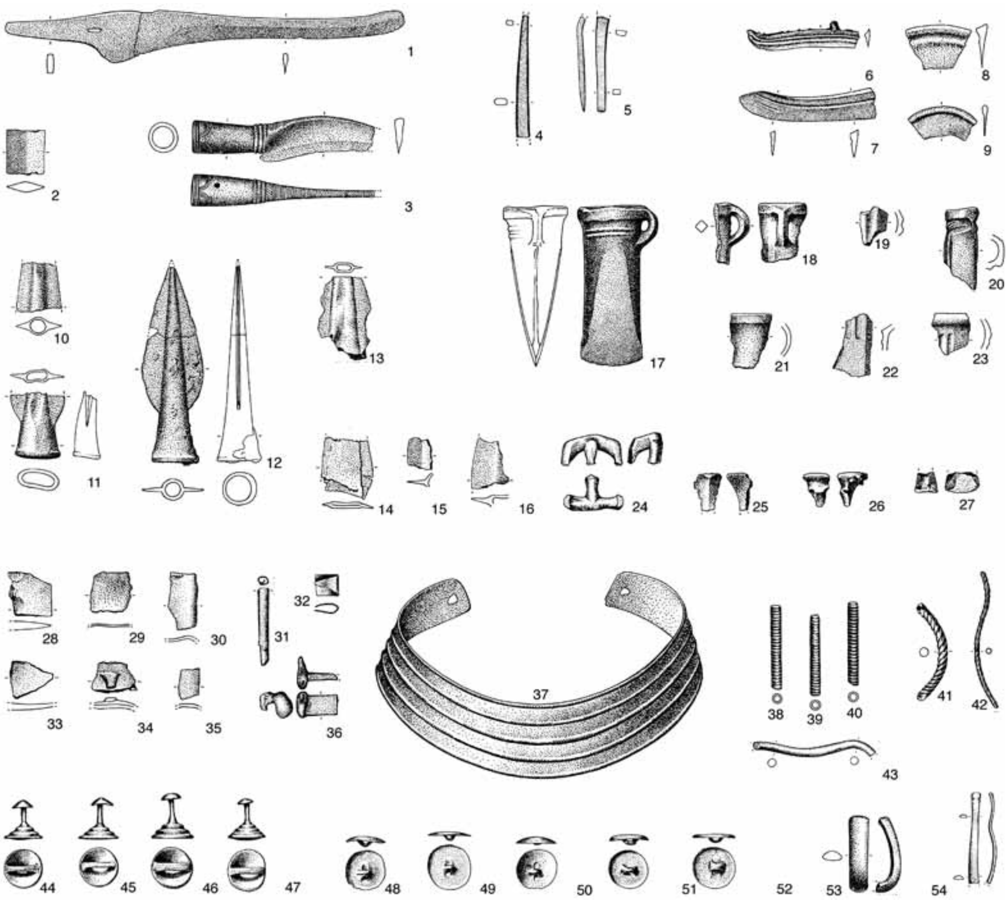


Figure 4.5 Part of the bronze hoard from Drouwenerveld. The finds were found togheter in a ceramic vessel. It most probably represent a stock of scrap metal as many of the items are broken. Scale 1:4 (taken from Van den Broeke 2005).

Again, the axe types are the most important indicators of this industry. In addition to the socketed axes of the Niedermaas and Helmeroth type, he distinguishes a very peculiar type of axe: the Geistingen axe. These axes have such specific characteristics that Butler argues that they must have come from one and the same workshop (Butler 1973, 341; Butler & Steegstra 2001/2002, 304).

### 4.4.5 Criticism on Butler's ideas

Butler's main argument, that he uses to postulate the existence of a local bronze production, is the existence of certain regional types of axes. However, as already mentioned, this is *indirect* typological evidence and therefore questionable. The style of execution or technological choices made may or may not be laden with social significance; they may reflect habit or they may consciously reinforce group identity (Costin 2001, 292). Fontijn (2002, 252) argues that the regional styles were open and inclusive, rather than closed and idiosyncratic because these axes functioned in supra-regional metalwork exchange network. Nonetheless they are idiosyncratic enough for Butler to recognize a certain 'local' style. Another possibility is that the decorations that define the 'regional' style is an isochrestic style: a style that results from enculturation in social groups as a result of growing up and learning (absorbing) traditions (Sackett 1986). This style is always used unconsciously, passively and has no meaning. These alternative interpretations show that style, as an analytical category is rather problematic.[53]

Another problem with Butler's theory on a northern and southern bronze industry is that he does not consider depositional processes. Several questions remain unanswered. How did the axes enter the ground and why (here)? How representative are the several hundreds of 'regional' axes? Butler sees a 1:1 relation between the region were the axes are found and the region where they were produced. Nonetheless Emmen axes (associated with the northern Hunze-Ems industry) have also been found in the southern part of the Netherlands (Fontijn 2002, 68-69). Can this be interpreted as trade between the northern and southern regions of the Netherlands? Or is the production region of Emmen axes not confined to the northern region as proposed by Butler?

A third problem with surmising a Dutch metalworking tradition based on 'regional' axes is that there is no reason to assume why a smith was not able to produce objects that look like imports. For instance, Butler does not discuss the mould from Havelte in line of Dutch metalworking because the axe that can be cast in it is not a regional type (Butler 1961, 207). Yet, this does not prove that it was not *used* by local metalworkers.

Finally, both Childe and Butler seem to assume a travelling smith, but it remains unclear where and how he organized his activities. Whether Butler also agrees with Childe's theories on the difficulties and abstruse nature of metalworking is unclear. Butler remains remarkably silent about *how* local production would have been organized and *who* the smiths were. This is probably due to the fact that there is almost no evidence on the 'workshops' from which he could draw these conclusions (Butler 1961, 199-200). This touches on another problem, which already has been discussed in section 3.3.2. The term 'workshop' immediately provides *a priori* definition on the organization (large-scale, supra-household) which seems unlikely for the Netherlands.

## 4.5 Conclusions

The possibility of bronze production in the Netherlands has so far only been researched thoroughly by Jay Butler. Before that, the ideas of Childe were followed and metal in the Netherlands was explained as either imported material or produced here by an itinerant smith/trader. At first sight it seems that Butler, by assuming a local tradition of bronze production instead of a travelling

53 See Costin 2001, 292 for several other arguments on the use of stylistic or technological variation as analytical category.

smith, contradicts Childes theories, yet this is not entirely true. Some of Childe's theories are clearly reflected in Butler's interpretations. Butler sees Childe's itinerant smiths as the tutors of the first indigenous metalworkers in the Netherlands. Furthermore, the hoard of Wageningen and Voorhout are both explained as belonging to an itinerant smith or trader. Even to today there is no other plausible explanation for the Wageningen hoard. The Voorhouten hoard has recently been explained as pars pro toto sacrifice of traders stock (Fontijn 2008). Who imported this stock remains elusive however.

### *Butler's arguments for indigenous metal production*

Metallurgy in the Bell Beaker Period is represented by two smith graves from Lunteren and Soesterberg. The cushion stones and other implements from these graves are interpreted as metalworking tools. Evidence for metalworking in the Early Bronze Age is given in the form of the Wageningen hoard and the appearance of a local variant of the Irish flat axe: the Emmen type.

A 'regional' type of axes is the most important argument on which Butler postulates an indigenous production. Flanged axes of the Middle Bronze Age have a regional variant in the Oldendorf-Ekehaar type. The Vlagtwedde type is a regional stopridge axe. Also from the Middle Bronze Age is a fragment of a bronze mould, dredged from the river Meuse near Buggenum. The Ommerschans hoard is explained by Butler as a 'founders' hoard. For the the Late Bronze Age Butler tries to demonstrate the existence of a 'Hunze-Eems' and 'Niedermaas' industry. Again, 'regional' products are the most important. The Geistingen type axes, socketed axes with VVV decoration and Omega bracelets are all products of an indigenous metalworking tradition. Half a mould from Havelte and a mould from Roermond are also discussed.

While the 'regional' axes recognized by Butler do seem to be a case in point for a thriving local bronze industry, there are some problems with this approach. Most importantly, it does not provide us with direct evidence of metalworking in the Netherlands. Furthermore, I have given several arguments why the recognition of a 'regional' product may be laden with problems. Style may consciously be used to reinforce group identity but may equally well be isochrestic behaviour. Production may also have involved the copying of imports as can tentatively be suggested from the find of the Oss mould (see appendix 2.1).

# PART II

# SOCIAL ORGANIZATION OF BRONZE AGE METALWORKING IN THE NETHERLANDS AND THE IDENTITY AND STATUS OF THE SMITH

# 5 A matter of elites, specialist and ritual?[54]

> *"Assumptions about how local production is organized (and how it will "look" like archaeologically) are based on the general types of objects under study (e.g. prestige goods as opposed to utilitarian tools) and whether there were many or few in use"* (Costin 2001, 303).

## 5.1 Introduction

For other aspects of material culture the distinction between 'everyday' (non-specialist) and 'special' (specialist) artefacts is easily made. There are the everyday flint tools which could have been made by anyone and flint daggers, made by a specialist. Everyday stone axes used for chopping down trees and the special non-utilitarian axe (*cf.* Wentink 2006); everyday pottery and special pottery. Still, the manufacturing of these objects is approached in the same manner and flint-, stone-, and woodworking, potting, or any other craft, is perceived *generally* as a normal, low-status, mundane activity for which the knowledge and skill was widely available. The production of beautifully crafted flint daggers, like the grand-pressigny daggers, is, although the manufacturers are seen as specialists, not connected with rituals and magic. With metallurgy these ideas seem not to be accepted and ritual, myth, magic, power and status is associated with it.[55]

The social position of the metallurgist in Bronze Age society has often been discussed since Childe, who regarded smiths as socially independent travelling tradesman (Childe 1963, 4; 1958a, 162ff; see section 4.3). Although Rowlands (1971) notes that there is great variety in smiths, especially the *specialist* nature of the smith is addressed by archaeologist. This probably originates from the idea that bronze was rare and therefore prestigious (*e.g.* Sherratt 1976, 557; Randsborg 1974). Interpretations were made with regards to the socio-economic significance of metallurgy and of metals in general, hence its producers must be specialists. Ideas of a close relationship between skilled craftsmen and the ruling class are also very popular among archaeologist (*e.g.* Rowlands 1976; Kristiansen 1987; Budd & Taylor 1995; Winghart 1998; Earle 2004, 161; Bradley 2007, 232; Vandkilde in press). Later, besides (or because of) the supposed complex and abstruse nature, a ritual dimension was also associated to metalworking (Budd & Taylor 1995; Meurkens 2004, Bradley 2005, 163-164). Although very persistent in studies on the Bronze Age, the theories on the ritual and specialist nature of the smith seem unfounded by archaeological data. Nonetheless, they are regularly used to enhance or explain each other. *Because* specialist craftsmen are seen as important persons with considerable status, the Bronze Age smith is also accredited this position. Following, the smith is interpreted as a high-status, special person, which is seen as an argument to associate it with a possible ritual dimension, and together this would be the basis of power and control. Neither of these associations, however, is thoroughly supported within the archaeological data as will be shown in the following sections.

In this chapter I will opt for a less one-sided approach in which a more mundane and 'normal' social status of the smith is postulated. I do not want to discredit the theories on the specialist and ritual nature of the smith completely. Surely, the objects that were meant to serve non-utilitarian purposes may have been produced by a special class of craftsman and attendant rituals (*cf.* Helms 1993). Rather, focussing on local small-scale production of simple objects, I will provide an alternative to this specialist smith; the farmer with some basic metalworking skills, who haphazardly produced some axes for his local community.

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54 Taken from Meurkens (2004).

55 *Cf.* Hawkes 1940; Childe 1963; Rowlands 1976; Chernykh 1985; Clark *et al.* 1985; Budd & Taylor 1995; Bridgefort 2002; Bradley 2003; 2005; 2007; Bertemes 2004; Meurkens 2004; Vandkilde in press.

## 5.2 The 'shine' of metal; the presumed predominance of metal over other materials

Since the Three-Age classification by Thomsen, bronze has been set apart from stone and regarded as one step higher in an evolutionistic process (*cf.* Childe 1951; 1963; Champion *et al.* 1984, 197). Metal has been seen as inherently desirable due to a self evidently more advanced and superior technology (Roberts in press). This predominance of metal appears to stem from the classification based on the material, which is made before any other classification on other aspects such as form or function. Hence, one could argue that classification on material is more important than form, function or any other property. However, this classification is made *a priori* by archaeologists and may not reflect the classifications made by prehistoric people.

The fact that there are some examples of swords and daggers made from flint, copying metal ones, the most famous example being the sword from Atte in Denmark (Zich 2004, 133), is often interpreted as evidence that metal was highly valued and a desirable scarce good (*e.g.* Van de Broeke 1996, 242).

> *"When (copper) supplies dwindled craftsmen made daggers and tools of silex and stone to the design of the actual metal versions"* (Shepherd 1980, 157, bracketed insertion by author).

In my opinion, such an explanation is an oversimplification and an *a priori* assumption that metal is dominant over stone. For instance, it is also possible that it was the *form* or *function* of the object (the sword or dagger), which was most important to Bronze Age people. Luster, shine, sound and form are all strong aesthetic factors of metal, besides the material 'superiority' and its technological advantages. What was most important to Bronze Age people, however, or whether any of these was important at all is difficult to assess from the objects alone.

In a recent research on Bell Beaker wrist-guards (Fokkens *et. al.* in press) it was noticed that the silver adornment on the wrist-guard (ketoh) of the Navajo is conceived as less important than the leather band on which it is attached (Laubing 1980, 108). In ancient West Mexico, metal was valued for its luster and sound. The way in which metallurgy was practiced (as well as the objects made) depended on these factors rather than metal replacing stone tools because of a technological superiority (Hosler 1995). Symbols of power had been around for several millennia (Clarke *et al.* 1985) and while metalwork may have been an excellent material for prestige good, they cannot be regarded as prestige goods solely on the grounds that they are made from metal. The cultural biography (Kopytoff 1986) and meaning of an object, its origins and possibly several other factors may have been far more important aspects which made an object into a symbol (of power or wealth) rather than the material from which it was made. Both examples given above show that archaeologist cannot presuppose the importance or dominance of bronze over other materials as a *condicio sine qua non*.

### 5.2.1 The metal as a more demanding technology myth

The idea that metal represented a superior product and was intrinsically more difficult to create is very persistent. However, the earliest copper objects were not necessarily superior to wood, bone or flint and there is no inherent functional reason why metal objects or metal production should be adopted by local communities (Roberts in press). Furthermore, while it might hold true for the mining and smelting of copper, I do not believe that basic metalworking skills (*i.e.* melting and casting a simple object) were more demanding than other crafts, as supposed by many:

> *"Compared to flint, bronze technology was both more demanding and exclusive"* (Kristiansen 1987, 33).

> *"The technology for producing the swords was highly esoteric, requiring special knowledge and skill in pyrotechnics, casting, and metalworking* (Earle 2004, 161).

Many more scholars argue that the effort for producing metal and the technical expertise needed are much higher then for working bone, wood, stone or flint (*e.g.* Childe 1963; Budd & Taylor 1995; Bridgefort 2002). Some go as far as to infer that that while flint, stone, wood and bone are gradually changed from the unworked shape to that of the final object, bronze has to be cast in a mould and the completed object must already have been fully conceptualised by its maker at this stage (Bridgefort 2002, 124). Such an argument implies that the craftsmen working with any other material then bronze, would *not* have been working from a conceptualized idea. Conversely, the argument would, when reversed, make even more sense. The possibility of re-melting can be explained as being an advantage in the training of apprentices. Whereas a flint-knapper has to work with flint from a given nodule, which to some degree determines what he can make from it, the metalworker can melt his raw material and is not restricted to base-material form. Beside this, if the flint-knapper makes a mistake there is the possibility that his original idea becomes impossible to produce and he has to change either his idea or get a new flint-nodule, whereas the metalworker, in case of failure has the possibility of making a new mould, re-melt the bronze and try again until he does succeed.

Even if bronze was indeed an exclusive product, there is no causal relation between exclusiveness and a more demanding technology. There are no reasons to assume why basic metalworking *an sich* would be more demanding in terms of skill or technology in comparison to other crafts.

### 5.2.2 Scarce material, scarce knowledge?

Scarcity of raw material is also used as an argument to surmise the importance of metalworking and its exclusiveness.

> *"In order to develop and maintain professional skills, it would actually be necessary to put the work in the hands of few people as possible as long as supplies were scarce. And after all bronze never really became abundant"* (Kristiansen 1987, 33).

In contrast to Kristiansen, I would argue that bronze supplies may well have been abundant but that its abundance is masked by the simple fact that the cultural biography most common for metal objects was to be re-melted eventually.[56] While metalworking may have been a more exclusive knowledge in the earliest stages, this probably changed during the later Bronze Age in which it became more widely available. Considering the amount of metal that must have been in circulation and the fact that – in the Late Bronze Age – metallurgy had been around for more than a thousands years, it seems highly unlikely that metalworking would still have been specialist job, available to a limited amount of people. More likely, metal was a commodity and the basics of metalworking mundane and widespread.[57] Skills to produce highly elaborate objects on the other hand may still have been confined to very few. Even for the Early and Middle Bronze age, the idea that metalworking would be confined to a small specialist group is debatable, as will be shown in section 5.4.1. I think it is valid to propose a less one-sided approach in which it is questioned whether we should consider metalworking as a more everyday and widespread craft; skilful, but not to a higher extent then other crafts; *i.e.* not o*nly* specialist are involved.

56 See section 2.4 and 2.4.1. See also Fontijn 2003, 33.

57 An argument brought forward by Peter Northover (personal communication, January 2008).

### 5.2.3 Metal, wealth, power

It seems that the durability of metal resulted in an overestimated importance of their role in European prehistory (Kienlin 2007, 2). A legitimate question to ask therefore is whether bronze really dominated the lives of prehistoric peoples, or whether this has more to do with the importance of metalwork to some Bronze Age scholars in their research of the Bronze Age (Bradley 2007, 179). The question is still far from answered. The archaeologists that believe that '*metal makes the world go round*' (Pare 2000) see bronze as fundamental both for economic and social reproduction (Pare 2000, 31). Bronze, at least must have played a considerable role in Bronze Age life, be it as tool, prestige good or trade good, but whether it was also the *basis* on which wealth and power was founded remains to be seen, as well as the role of metal in social change or the growth of social complexity in the Bronze Age. 'Power' may have come from either arable lands, the control over resources (bronze, amber, salt) or the manipulation of symbolic objects (prestige goods), or any combination of these. The debate on whether ore resources and production can be controlled is ongoing (Roberts in press). Recently Bartleheim (2002; in press) has argued that, for the Bayern region in Central Germany, it was not metal, but arable lands, from which the elites gained their wealth and founded their power. Bronze objects were used to *show* their status and power, but this status and power was not *based* on bronze or the bronze trade.[58] This is a small but very important distinction.

## 5.3 The preoccupancy with specialists

Whether discussing the economic or ritual dimension of production, full-time or part-time and itinerant or not, many scholars assume that metalworking was done solely by specialists[59]. Prestige goods are indeed often made by specialist, and rituals are often involved in their production (Helms 1993). The work of Helms – extensively cited by Bronze Age scholars when discussing bronze – is however only concerned with craftsmen that produce goods that serve *non-utilitarian* goals (Helms 1993, 13ff). My aim is to study the smith that produced simple 'everyday' utilitarian tools such as an axe. This research seems to have been denied until recently (Kienlin 2007).

Levy (1991, 68ff) has discerned three models on the organization of the bronze smith than can be found, implicit or explicit, in the archaeological literature:

1. *Childe*: this model implies an independent, specialist smith. Full-time because they are itinerant and thus have no land. The location of their activities would vary and not be specialised since they move around.
2. *Kristiansen*: attached, full-time specialist smiths, with highly developed skills. Elites were their patrons and controllers.
3. *Rowlands*: variability; smiths only rarely work full-time. Some are attached other independent. It implies at least a two-tiered organization for metalworking, with production of the most elaborate items separate from production of more everyday objects.

One of the main problems with these models is that it is not transparent at all what *specialist* means (Costin 2001, 279ff; see section 3.3.1). Childe sees *all* metalworkers as specialists. Rowlands distinguishes between smiths that produce everyday and elaborate objects. This can be interpreted as a distinction in specialism, although he himself does not mention this explicitly. What I consider to be

58 Bartleheim argues that it cannot be proven that metal was the primary mover. Instead of ore resources, the agriculture potential constituted the primary location factor which implies that agriculture was the economic base of that time. The mining areas were dependent on the settlements on the Bavarian plain rather than the other way around (Bartleheim in press).

59 *E.g.* Bertemes 2004, 144ff; Bridgefort 2002, 124; Childe 1963, 4-5; Earle 2004; Hawkes 1940, 285; Kristiansen 1987, 33ff; Torbrugge and Uenze 1968, 26.

the central problem in the archaeological study of metalworking is the tendency to favour explanations that see the smith and metalworking as a specialist, high-status, ritual person and activity. This seems to disregard the archaeological data, which does not support such an unambiguous view at all.[60] Theories on the specialist nature of the smith are biased in several ways:

- By a form of scholarism; in the wake of Childe, metalworking is seen as a difficult practice for which knowledge was only available to a small group of people. The supposed importance and value ascribed to metal is widely acknowledged and hardly questioned.
- By the archaeological record; the metalworking mostly found represents deposited objects. They were treated in special way and are thus better interpreted as the exception rather then the rule (of normally used tools and objects, see section 2.4.1).
- The preoccupation of archaeologists with (the production of) a special class of artefacts (*e.g.* Clarke *et al.* 1985; Fontijn 2001; Kaul 2004; Meller 2004; 2002).
- In many studies there seems to be circular reasoning. Metalworking is seen as a high-status, specialist job and consequently rituals and magic must be attached to it. Or, ritual metalworking is surmised, as found in ethnographic examples, and consequently Bronze Age metalworking must be the work of specialist, chiefs, shamans or other high-status, powerful persons (*cf.* Budd & Taylor 1995).

Although Budd and Taylor (1995) avert against the 'industrial model' of metalworking and the fact that metal technology is often seen as being qualitatively different from, and fundamentally more difficult than, preceding technologies (or crafts) such as basketry, flint-knapping or potting, which might all be done "unscientifically" (Budd & Taylor 1995, 134), they also fail to give an alternative on the specialist nature of the smith. They actually seem to agree with this and the alternative they opt for is as much 'specialist' as the specialist in the 'industrial model', which they try to discredit; only now it is a *ritual* specialist.

## 5.4 Specialisation and specialists in the archaeological record

The problems of recognizing both specialisation and specialists from the archaeological record (*i.e.* sites, debris and objects) have already been discussed in more general terms in section 3.3.1. In the following section I will look at the archaeological record and see what we can discern from it.

### 5.4.1 Specialism

Metallurgy is a craft that certainly *can* show a high degree of specialism. One of the reasons may be found in the fact that the organisation of metalworking differs from organisation of other crafts like pottery. Metalworking has (spatially) segregated stages, which allows for or encourages specialisation of craftspeople in particular stages (Miller 2007, 242). Nonetheless, as advocated in section 5.2.3, it is unlikely that we are *only* dealing with specialists. Looking at both the debris from the production as well as the finished objects, Meurkens (2004)[61] sees no indications of specialists during the Bell Beaker period and Early Bronze Age. The sites yielding metalworking debris were home to self-supporting communities in which metalworking was a relatively small-scale, unskilled affair, embedded in the domestic economy alongside other crafts such as pottery production and flint working (Meurkens 2004, 30). For the Middle and Late Bronze Age, he reconstructs a trend in

60 Since metal was accredited a high status and perceived as difficult to make, interpretations, almost without discussion, have remained the same.

61 Meurkens tried to access the organization of Bronze Age metalworking by using the model proposed by Costin (1991). He distinguishes between large-scale, full-time smiths (= specialisation) and small-scale, part-time 'everyday' metalworking.

increasing metalworking skills and thus the presence of specialist becomes more likely. The distinction between objects that require limited skill and objects that need highly specialized craftsmanship becomes more pronounced implying that a smith had the time and the means to train apprentices.

Even within the same object type, distinctions must have existed. The swords that are produced, used and end up in a scrap hoard may have had a different use-life and meaning than swords of the Plougrescant-Ommerschans type[62] that are deposited (*cf.* Kopytoff 1986; Fontijn 2002, 108; fig. 5.1). Consequently, the persons involved in producing these items may have also had different statuses according to the objects they produce. Costin (1998, 8) argues that there appears to be a general association between the relative status of artisans, the value of the goods they produced and the status of the consumers they served. Swords like the Plougrescant-Ommerschans, for which it seem plausible that they were made by the same smith (Butler & Sarfatij 1970-71; Butler 1990, 87; Fontijn 2001, 268), are objects of excellent workmanship and do strongly suggest the presence of specialists. However, these specialist objects only represent a very small part of the data. They do not represent 'everyday' tools for which production must have been vast and widespread.

Axes, for instance, show that many small production centres were present. According to Roe (1995, 54), material style is personal or assertive in societies where high status craftsmen are present. In such societies, the artefacts produced are of central cultural importance and a continuity of style across generations can be observed. However, when crafting is of low status, the production of goods may be a group endeavour, which results in low standards of workmanship and knowledge, and hence, low artefact complexity. In such cases isochrestic stylistic variation dominates. The stylistic variation is meaningless and traditional (an unconscious repetition) (Sackett 1982; 1986). The Dutch axe typology shows the adoption of decorative elements from west and central European axes (Fontijn 2002, 251). Decoration on socketed axes found in the Netherlands show diversity in which none is really alike and no style evidently pronounced.[63] Furthermore, many axes are crudely made. The axes of the Niedermaas type for example, exhibit "*somewhat crude and clumsy workmanship and some display rather ragged or eccentric casting seams*" (Butler & Steegstra 2001/2002, 268). Therefore, these axes seem indicative of low-status crafting and maybe even a group endeavour. They do not support theories that metalworking was practiced by trained specialists.

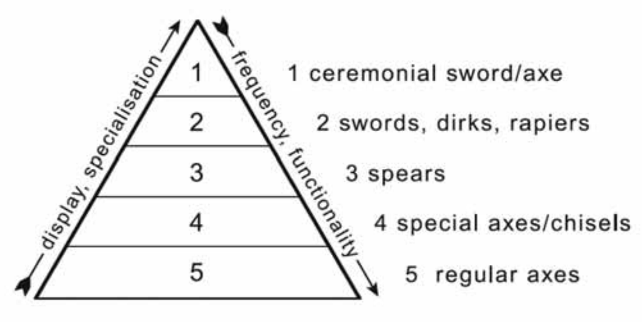


Figure 5.1 Structure of metalwork reportoire. Specialist metalworking (and possibly the accompanying rituals when producing prestige goods) only form the top of the pyramid. The current theories on the smith do not seem to incorparate the people who produced the objects that make up group 4 and 5, the bulk of the metalwork reportoire (taken from Fontijn 2002).

62 These swords actually seem to be a magnified, non-utilitarian representation of a dirk (Fontijn 2001).

63 The VVV decoration on the rim of the socketed axes may be an exception.

### 5.4.2 Specialisation

Certain sites are interpreted as 'trading' or 'industrial' sites indicating that large-scale metalworking has taken place. Cannes-Écluse, Choisy-au-Bac "Le Confluent", Killymoon and Rathgall are some examples.[64] The sites that have yielded considerable amounts of metalworking have bold typefaces in the table in appendix 3. The main problem with these sites is that it is debatable whether the material is the result of large-scale metalworking or due to very good conditions of preservation. Yet, I do agree with Meurkens that they are indicative of some form of specialisation or at least large-scale metal production (Meurkens 2004, 50), although recently it has also been argued that there was no increasing specialisation during the Bronze Age (Kienlin 2007, 18).

*Attached specialist and specialisation*

Meurkens also examined the so often proclaimed connections between elites and metalworking (*i.e.* an attached specialist, working for a patron) such as in the model of Kristiansen (1987; Levy 1991, 68; see section 5.3). In this model, craft specialisation is seen as a strategy for creating and controlling wealth, either by authority over the knowledge of metalworking (by controlling the smith) or the trade in metals. This would provide the elites with access to prestige goods and symbols of power and legitimacy as described by Helms (1993; Costin 2001, 307). Comparison of the archaeological evidence showed that there was no correlation whatsoever between the production of a special class of objects such as ceremonial swords and defended settlement/hillforts that may be indicative of elites (Meurkens 2004, 34ff). Furthermore, what is a more important question as to the connection between elites and metalworking is whether metalworking (specialisation) led to the rise of elites, or elites to the rise of specialist and specialisation of metalworking. In any case, production sites offer little support for this assumed relationship and it hardly seems to be a reality (Meurkens 2004, 36; *cf.* Kienlin 2007). Must be said that this might also have to do with the definition of the terms 'independent' and 'attached'. According to Costin (1991, fig 1.4), attached or independent are not static unvarying categories, but idealized extremes of a continuum characterizing control. Recognizing either of them in the archaeological record may therefore be rather difficult.

## 5.5 On smith burials we do have and we do not have

Another discrepancy between the high-status specialist theory and the archaeological data can be outlined using the burials. The amount of burials yielding metalworking artefacts is very small. In the Bell Beaker period (and the first part of the Early Bronze Age) this could be due to the general idealized manner in which people were buried. Strangely enough though, the burials most indicative of a smith's interment belong to this period.

Recognizing a smith's burial as such is problematic. Archaeologists do not agree on which artefacts are typically linked to metalworking (see section 8.3). An anvil or mould seems obviously related to metalworking but these are deposited rather then buried with the death. Cushion stones, such as those found in the Bell Beaker graves of Lunteren and Soesterberg (Butler & Van der Waals 1966), probably have functioned as anvils, but are presumably related to working gold rather then bronze. These artefacts are discussed more thoroughly in section 8.4. Even if we do recognize metalworking tools, an interpretation as a 'smith burial' may be flawed. The "Amesbury Archer" (Fitzpatrick 2002) is associated with the earliest metalworking in the British Isles because of the cushion stone, the copper tanged knives and gold earrings found in his grave. These artefacts however, no more make him a metalworker than the beakers (five in total) make him a potter, the

64 Cannes-Écluse (Gaucher & Robert 1967), Choisy-au-Bac "Le Confluent" (Blanchet 1984), Killymoon (Hurl 1995) and Rathgall (Raftery 1976; Tylecote 1986).

flints (a cache and 16 barbed arrowheads) make him a flint knapper or the arrowheads and wrist-guards (two in total) make him an archer (Barber 2003, 125-26).

For the Middle and Late Bronze Age smith burials are extremely rare. Obvious examples are found in Russia were metal artefacts, clay moulds and crucibles are found alongside the deceased.[65]. In North-west Europe there are only a few examples of possible smith burials. Sperber (2000) identified a smith grave in the burial of Lachen-Speyerdorf (Germany). At Ewanrigg (Scotland) an Early Bronze Age cremation cemetery yielded a burial in which, next to a Collared Urn and 'accessory cup', a possible tuyere was found (Bewley *et al.* 1992, 345; Barber 2003, 114-5).

Explanations for this puzzling absence of smith burials are available, but mostly favour the 'ritual – specialist theory'. Budd & Taylor (1995) and Vandkilde (in press) opt that the chiefs themselves were the specialist smiths, their specialism being one of the reasons why they could accumulate power and wealth, which does show from the graves.[66]

Another plausible but unsatisfactory explanation is that metalworking tools were 'dangerous' objects and were deposited in a different manner than being buried alongside the smith. Yet, these 'dangerous' tools were not removed from the settlement as can be seen in appendix 3, which severly hampers this theory. However, if one regard basic metalworking as a mundane activity it becomes somewhat explicable why there is no distinct set of tools in burials identifying a smith. Smithing was a 'normal' craft and in most cases not valued to such an extent that the deceased was buried with the tools of their trade. Possibly only the (full-time), true specialist, who devoted his/her life to metalworking and produced products of excellent workmanship, was chosen to be buried with his or her tools.

## 5.6 Metalworking as a ritual practice

In 1995 the article "*The faerie smith meets the bronze industry: magic versus science in the interpretation of prehistoric metal-making",* by Budd and Taylor, provided an interesting change of perspective to the then prevailing economic, industrialized view of Bronze Age metalworking and alternatively suggested a broad social-developmental perspective in which ritual and magic was given a more central place in interpretation. Effectively, the tendency of the last decade has been to focus on the ritual aspects and specialist nature of metalworking. This predominance of ritual can be seen in a larger scheme, in which the interest in ritual has arisen as a part of the post-processual backlash against the more extreme forms of functionalism (Brück 1999, 324). Most of the ideas on ritual metalworking have come from ethnographic examples (*e.g.* Bekeart 1998; Helms 1993 *cf.* Fontijn 2002, 28). As mentioned earlier, they most often deal with a class of objects that serve as valuables or prestige goods. Furthermore, Roberts makes a strong argument is stating that:

> *"Whilst the perennial criticism of the relative or total absence of the social and symbolic in their research (e.g. Rowlands 1971; Budd and Taylor 1995) when compared to ethnographic and anthropological research (e.g. Herbert 1984; Bisson et al. 2000) is an important point, it should not lead to the uncritical application of analogies"* (Roberts in press).

In the last years some scholars came to doubt the all important position of metal in explaining the Bronze Age and argued that far too much emphasis has been laid on the non-economic, non-industrial dimension of metal and its value in society (Bartleheim 2002, in press; Kienlin 2007; Shennan 1993, 59; 1995, 305; 1999, 353). Roberts (in press) even comes to the conclusion that

65 Burial 10 in Kurgan (Chernykh 1992, 80) and burial 21 at Volosovo-Danilovo (*Op. cit*, 135)

66 Assuming that they were indeed chiefs or priest-smiths, they could never have been the *only* smiths, for their production must have been gigantic. To give an idea on the volume of metal production: the Armorican socketed axes alone (Late Bronze Age) are represented by around 38.000 examples in Europe (Cunliffe 2001, 288).

neither the production nor the consumption of metal possesses serious enough credentials to be considered a major, let alone revolutionary, influence in the broader worlds of the communities involved.

Whether the appearance of metal should be seen as the flux for a crucial social transformation taking place during the Bronze Age is still heavily discussed. Recently Devernski and Sørensen (2002, 121) argued that technology does not drive itself and thus social complexity was present before metal, instead of metal being the reason for social complexity to develop. This chicken-and-egg conundrum is essentially a discussion on whether material culture (metal) is active or passive.[67] As this lies beyond the scope of my research I will not discuss this in more detail here (but see Robb 2004 for an introduction). It may be an inadequate discussion beforehand as the causal connection made between the technological change (to bronze) and organizational change is by no means clear-cut (Costin 2001, 288-289).

The shift, described by Brück (1999, 324), from a rather extreme form of functionalism to an extreme form of 'ritualism', in which almost everything has to be explained in some form of gift exchange or ritual is particularly evident in studies on metal.[68] However, creating a distance between *us* and *them*, because of this supposed different worldview, and subsequently the ritualization of the Bronze Age seems to be an oversimplification.[69] Nowadays several authors see that such clear distinctions like 'gift – commodity' or 'ritual – profane' do not really exist (*e.g.* Bazelmans 1999; Brück 1999; Bloch & Parry 1989; Fontijn 2002; Bradley 2005).

## 5.7 "The faerie smith" and the ritualization of metalworking

Budd & Taylor were mainly concerned with devaluating the 'industrial model' which they believed was an anachronistic back-projection of the modern notion of technological change.

> *"We believe that the concepts of large-scale extraction and production and concomitant reconstruction of specialized activities and monoplex social roles that figure strongly in the prevailing, orthodox 'industrial model' are either underdetermined or unsupported by archaeological data"* (Budd & Taylor 1995, 133).

Therefore, they alternatively suggest:

> *"that ritual and magical dimensions need to be given a more central place in interpretation and hypothesis formulation"* (ibid.).

To some extent Budd and Taylor were right, as the social aspects of metalworking – although noted by Childe – were indeed largely being neglected and focus lie on the 'industrial view'. Calculations on how much material was mined and thus how much bronze circulated were highly speculative. For instance, the calculations made by Jackson (1979), on the amount of ore mined at Mount Gabriel, are greatly overestimated (personal communication O'Brien, September 2007). Budd & Taylor thus had a point when they argued that:

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67 An active material culture is, on its own, capable of re-forming society, while for a passive material culture it depends on society whether the material is accepted or not (Robb 2004).

68 Compare the interpretations of the Langdon bay shipwreck; Needham & Dean 1987 see this as a clear evidence of large scale (economic) trade, Samson (2006) on the other hand, interprets this hoard as a ritual deposition.

69 The overemphasizing of the ritual aspects and the importance of not imposing modern western ideas has changed Bronze Age communities in some form of *other* people. This comes to the fore vividly in Kristiansen & Larson (2005). Here Kristiansen stresses *the Otherness* of Bronze Age culture several times in trying to give meaning to something elusive as the cosmological structure of Bronze Age society. I think, instead of *not* imposing Western ideas, they achieve exactly the opposite by creating a distance between *us* and *them* and subsequently the ritualization of the Bronze Age. As discussed in section 3.1 'ritual' itself is on of the most prominent categories made by *us* and our modern Western ideas.

> *"The established picture of prehistoric metallurgy in Eurasia is painted in terms of compositional standardization and industrial-scale production with economies of scale, markets and customers"* (Budd & Taylor 1995, 137).

By discrediting this model and taking metalworking out of the economic realm, the path was opened to introduce theories on skilled crafting and ritual. Skilled crafting, by contrast, is political and ideological rather than economic in nature (Helms 1993, 16). They suggest that metalworking was associated with socio-political power; the smith being a political leader, magician and/or priest in one. Even when bronze artefacts are clearly used as utilitarian products and produced by the hundreds they suggest that:

> *"There is no reason to see why power and charisma, once channelled via the spectacular alchemy of metallurgy, should have moved away from it, or been able to"* (Budd & Taylor 1995, 140).

Even though Budd & Taylor argue that the 'industrial model' is not supported by archaeological data, they themselves also fail to support their idea with empirical data.

*Ethnography and analogy*

Based on ethnographic evidence and elaborating on Eurasian folklore, Budd & Taylor opt for a ritual, magic dimension in metallurgy. However, the fact that metalworking in small-scale societies is *accompanied* by rituals does make the practice of metalworking a ritual one. Rowlands (1971) already noted that the ways in which the smith are appreciated socially are very diverse, ranging from fear and contempt to awe and respect. Herbert (1984, 33) also mentioned that attempts to generalize the social position of the smith are doomed, because so much variability exists; smiths being feared, revered or despised. Furthermore, ethnographic examples can by no means simply be used to explain the Bronze Age. Technology in small-scale societies is often regulated with rituals, and ethnographic data indeed shows that metalworking is often accompanied by rituals, taboos and regulation (Herbert 1984; Bekeart 1998; Bisson 2000; Barndon 2004; Haaland 2004).[70] These rituals however, are an integral part of the process. Rituals help co-ordinate labour and impose a framework of organization (Gell 1988, 3-4). To the people involved they are thus as practical as the actual work itself. A ritual sphere is often conceptually linked to mundane activities. As such, they are not as polarized as we tend to believe (Brück 1999; Bradley 2005). So, although metalworking probably was 'ritualised' to some extent, this conversion between the two spheres of technology and ritual does not instantly make metallurgy a ritual practice (see also section 3.2).

## 5.8 The interpretive dilemmas concerning 'ritual'

While Budd and Taylor's article provided an interesting change of perspective to metalworking, they did not present a more balanced view. They tipped the scale completely from an 'industrial model' to a 'ritual model' in which metalworking is a powerful, arcane, practice. This was also noticed by Meurkens (2004, 11), who argues that the highly ritualised picture Budd and Taylor sketch of metalworking is as much biased as the 'industrial orthodoxy' started by Childe. Notably, this is not confined to metalworking;

70 Many of the examples of ritual metalworking actually deal with the production of iron rather then bronze.

> *"Post-processual archaeology's interest in the social and ideological aspects of human existence, although timely, has meant that the symbolic aspects of human action have all too often been stressed at the expense of the practical"* (Brück 1999, 325).

Hence, Meurkens – in an elaborate study on metalworking debris in North-West Europe – researches whether the archaeological data supports the assumptions made by Budd and Taylor looking for any correlations between elites and metalworking and/or ritual dimensions. Meurkens has inventoried some 80 sites in North-west Europe on which metalwork debris was discovered. A substantial part of the following chapter is a re-evaluation of the data taken from his work (see Meurkens 2004 appendix). The table in appendix 3 lists all the sites that are catalogued by Meurkens, with some small changes and additions.

Meurkens (2004, 12) sees the grand-narrative styles of interpretation, that do not seem to take into account the way technology and production is structured in small-scale societies, as unsatisfactory. They diminish the importance of the archaeological data. Consequently his approach is to collect the available data and take these as a starting point. Beside Levy (1991), Meurkens is the only one, presently known to the author, who tries to approach the problem based on a considerable dataset, instead of building theories on a single example of a metalworking site or no archaeological data at all.

Besides focussing on specialisation and the link between specialists and elite, Meurkens also dealt with the "symbolic and ritual dimensions of Bronze Age metalworking" (Meurkens 2004, 37). Although Meurkens acknowledges that most of the metalwork debris is found on settlements, he seems determined to show the 'ritual dimension'. In his conclusion he states that "evidence in favour of this assumption was remarkably strong" (*Op. cit,* 51). I think Meurkens interpretations are good examples of the interpretive problems archaeologist have with the imposition of the 'ritual – secular dichotomy' described by Bell (1992) and Brück (1999). Meurkens uses 'ritual' as an analytical tool to survey the data (see section 3.1). An explanation of what will be interpreted as ritual is indeed given beforehand (Meurkens 2004, 33ff). These definitions (interpretations) on ritual are then used to survey the date. Hence, they are used as an analytical tool. The association between metalworking and ritual is actually acknowledged before looking at the data. Our definition of ritual, however, only rarely fits the data and it is here were interpretative problems occur (see section 3.2 and 3.3). Looking at the data listed in appendix 3 in the alternative manner proposed in chapter 3, the evidence for a ritual dimension seems far less convincing, as will be advocated below.

## 5.9 The ambiguity of the 'ritual' data

The 'ritual dimension' of metalworking is mostly advocated on the grounds of archaeological finds that we do not understand. For instance, if metalworking debris is deposited in a ditch at the entrance of a settlement, it may be interpreted as *evidence* for the ritual dimension of metalworking (Meurkens 2005, 37). A discussion and re-evaluation of this kind of data, used to outline the 'ritual dimension' of metalworking, is presented below.

Arguments used to show the ritual dimension of metalworking can be generally placed in two groups: (1) Metalworking debris and/or equipment that is found in a non-domestic context; burials, caves, ponds, the deposition of tools in rivers (ritual or limenal places). (2) Metalworking debris and/or equipment in a domestic context, but treated in a 'ritual manner' (the carefully deposited debris in a certain part of the settlement). In the table in appendix 3 I have italicized the sites that, according to Meurkens' (2004) interpretation, have this 'ritual dimension'. First, for both groups I will show how ambiguous the interpretation as 'ritual' is. Second, as explained in section 3.3, singling out specific actions to show the 'ritual dimension' is concealing the larger framework in which they should be placed. If put into this perspective interpreting metalworking as a ritual practice does not hold, as I will show in the subsequent sections.

### 5.9.1 Metalworking in non-domestic context

*Isolated*

Claimed examples of isolated metalworking sites are Lough Gur, Knockadoon (Ireland; Waddel 1998) and Nursling, Hampshire (UK; Rees 1993). Beside the fact that it is difficult to prove that these sites indeed were isolated[71], this isolation is by no means clear-cut evidence for the ritual nature of metalworking. There is also evidence that certain workshop areas were present on the edge of or just outside the settlement (for instance Rathgall, Co. Wicklow; Raftery 1976; Coghlan 1986) indicating that a spatial division between living quarters and working area was made. This may have had many other reasons besides (ritual) beliefs. It is also interpreted as a form of specialisation. Without a clear pattern of isolated metalworking, which clearly shows that this activity was deliberately practiced outside the settlement area, isolation alone cannot be used as an argument in favour of ritual metalworking.[72]

*Ceremonial sites*

Examples of metalworking debris at burials or ceremonial sites are Ballyconneely and Richardstown (Ireland) for the Middle Bronze Age and Loanhead of Daviot (Scotland), Old Connaught (Ireland), Dainton (Devon, England) and the Kings Stables (Ireland) for the Late Bronze Age. Heathery Burn cave cannot be more positively dated than Bronze Age.[73] There are two problems with most of these sites. First, the interpretation as ceremonial site is often debatable. Examples of this are the cairns found at Dainton, whose exact function is unknown, or Old Connaught, which might be a probable barrow on a site that shows traces of habitation also. Secondly, is the metalwork debris found on the sites contemporary with the ceremonial site? At the site of Richardstown it is not clear whether the metalworking activity is contemporary with or post-dates the burials. A furnace and/or slag is difficult to date if there are no other, more datable, artefacts, such as moulds.[74] Whether contemporary or not, it might still mean that the smith deliberately went to this location because it was, or used to be, a ceremonial place. Intentions, however, do not fossilize and thus the 'ritual dimension' between ceremonial places and metalworking is not as evidently marked as assumed. Exceptions are Loanhead of Daviot, the Kings Stables and Heathery Burn Cave for which the 'ritual' interpretation and connection with metalworking is indeed more evident, respectively being a stone circle and burial, an artificial pond, and a cave with evidence of feasting, sacrifice and deposition.

Even *if* we assume that all the sites listed above were indeed burials and ceremonial places, and metalworking *deliberately* took place at this location, the interpretation of metalworking debris on these sites remains enigmatic, as shown by Brück (1999). Do the flints and shards of a pot found at ceremonial sites also mean that flint-knapping and potting was a specialist activity with a ritual dimension?  Or should we look in a different direction for explanations? The same problem is present in the interpretation of depositions in settlements (5.9.2).

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71 For instance, the isolated pits at Nursling, Hampshire yielding Late Bronze Age pottery, clay mould fragments and a socketed axe might be associated to the Early Iron Age settlement found some 300 meters further (Rees 1993).

72 If metalworking was truly practiced outside the settlement area in isolation it will be extremely difficult to find such places as metalworking leaves very few traces (see chapter 7 and 8).

73 Ballyconneely (Read 1999);  Richardstown (Byrnes 1999); Loanhead of Daviot (Kilbride-Jones 1936); Old Connaught (Coghlan & Raftery 1961), Dainton (Needham 1980); Kings Stables (Lynn 1977); Heathery Burn Cave (Britton & Longworth 1968).

74 At Ballyconneely a small bowl furnace was found with slag in it. This slag showed no evidence of iron oxide thus the initial *feeling* is that this is copper slag (www.excavations.ie). The furnace, however, is not dated.

### *Ritual deposits of moulds and metalworking related artefacts*

The deposition of metalworking tools is the strongest argument to assume a 'ritual dimension' of metalworking. A considerable number of stone and bronze moulds are stray finds and several of these have come from a wet context (*cf.* Coghlan & Raftery 1961; Collins 1970). From the Netherlands two of the six known moulds come from a wet context. Both the Buggenum mould (Fontijn 2002, 138) as the one from Roermond (Fontijn 2002, 159) have been found in the river Meuse. The Seine has yielded several anvils (Ehrenberg 1981). Another interesting phenomenon are mould hoards such as Omagh, Ireland (Coghlan & Raftery 1961) containing intact moulds. Furthermore, so-called 'toolkit-' ('craftsmen') and the 'scrap-', or, 'founders-' hoards are found all over Europe.[75] While, these depositions seem to undeniably indicate some form of *ritualised* practice in which the objects were deliberately treated in a very specific matter (*i.e.* deposited in selective places), the interpretation may be much more complicated. I have already touched upon the ideas of Fontijn (2002, 2008) that the traders and scrap hoards were *pars pro toto* sacrifices in a *sacrificial economy* where commodity and gift exchange are intertwined. Nonetheless I would also like to make a remark on the general explanation given for the toolkit depositions and present an alternative that puts the 'ritual dimension' of metalworking, derived from these depositions, in perspective.

The argument is that these metalworking tools were 'dangerous' objects that should be treated differently and with care; *i.e.* deposited in ritual places. This is also used to explain why we are not finding any burials that contain such artefacts (see section 5.5). The 'dangerous object theory' might explain the deposition of moulds and metalworking equipment, it is however not consistent with the presence of mould fragments and metalwork debris found in settlements and even within houses (see appendix 3), something which one would not expect if these objects were truly perceived as dangerous. Hence, a different approach, one that does not explain depositions as an individual event, is needed.

The deposition of a mould or anvil in a river is the *end* of the use-life of that object. As such, it reflects the meaning that this object had acquired during its life (Kopytoff 1986; Fontijn 2002, 23ff). Fontijn opted that sacrifice or transformation of some representative item(s) was a way to make a foreign, ambiguous item derived from beyond the morally acceptable at home (Fontijn 2002, 278). This interpretation deserves to be followed here as it may also explain the deposition of moulds and other metalworking related objects. If a bronze or stone mould had produced several tens of axes, it may have been appropriate to sacrifice the mould as a votive offer to make the products cast 'acceptable'. The same goes for an anvil. If it had seen a sufficient amount of work, the appropriate thing to do might have been to sacrifice it. In order to make all the objects it has produced morally acceptable. The products used in making them were given back to the earth, which provided the materials to make these objects in the first place. This could also explain why the majority of these hoards and depositions contain bronze and/or stone moulds. Both have the capability to produce several castings. These products were used normally in settlements but curated in a distinctive way that led to their deposition outside the settlements (Levy 1991, 66). They show a characteristic of metalworking which *we* would refer to as ritual (the depositional 'act' is singled out). If placed into context however, it does not make the production of axes from a mould a ritual practice. This theory needs more research, but may be more satisfying as it does not create clear-cut categories between the ritual and the mundane. A tool can be mundanely used during its active life time and ritually discarded (*cf.* the cultural biography of axes; Fontijn 2002, 247ff; section 2.4.1 this thesis).

75 Such as the hoard from Saone-et-Loire (Thevenot 1998).

### 5.9.2 Metalwork debris treated in a 'ritual' manner

*'Ritual' deposits at settlements*

At Springfield Lyons (Essex, UK; Buckley & Hedges 1987) and Norton Fitzwarren (Somerset, UK; Needham 1989; Ellis 1989) metalworking debris was deposited deliberately in a selective manner. Springfield Lyons yielded two large deposits of fragments of clay moulds for the production of Ewart Park type swords. These deposits were made in a ditch at the eastern and western entrance of the site (Buckley & Hedges 1987). On the site of Norton Fitzwarren two nearly complete jars with some 70 clay mould fragments of a sword were found deposited in a pit, which was related to the gateway of a Late Bronze Age hillfort. Both phenomena are, according to Meurkens (2004, 45), directly related to the way in which the craft of metalworking and their practitioners were incorporated in, and perceived by, Bronze Age society.

These depositions could also be the material representation of a completely different phenomenon, however. Ellis (1989) sees the deposition at Norton Fitzwarren as a foundation deposit. Brück (2001) explains them in terms of fertility rituals and Bradley (2005) argues that this kind of depositions refer to everyday society and economy ('ritualization' of the domestic sphere). Although Meurkens takes note of these interpretations he still uses these depositions as an argument to show the 'ritual dimension' of metalworking. Though the manner in which these objects are deposited indeed show that a certain meaning was attached to them, I am not convinced that this is meaning is clearly associated with the practice of metalworking. If metalworking debris in these ostensibly 'ritual' depositions would indeed indicate the 'ritual dimension' of metal production it would mean that we have to consider that other crafts also had a ritual dimension, beside the mundane production, for these deposition contain all kinds of objects. Of course, this is possible, but it shows that using these depositions to argue for metalworking as a ritual and arcane practice seems biased. It does not make metalworking anymore of a ritual or more specialised practice than producing pottery, flint-knapping or any other craft. Another, more likely, conclusion is that these depositional acts were a ritual on its own (be it foundation, fertility, community hoard) and thus *not* directly related with the production of metal. They may also have been part of the whole process of metalworking. That is, integrated in the process to organize the (technological) work. Either way, metalworking is (partly) a mundane activity.[76]

## 5.10 Arcane metallurgy and the masters of these mysteries

Childe stressed the abstruse nature of metalworking several times and describes smiths as "masters of mysteries" (Childe 1963, 4). He does so because:

> *"The change in properties of copper by heat is really startling; it is distinctively more dramatic than the effect of baking upon potter's clay"* (Childe 1963, 4)

This transformative aspect of metallurgy and hence, the ability to put on a "spectacular" show (Budd & Taylor 1995, 140) is used to support both the relation between ritual and metalworking as well as elites and metalworking.

> *"The fantastic transformation of raw copper into finished objects may further have invited both myths and secrecy, thus being another possible medium for gaining control"* (Vandkilde in press).

76 This argument generalizes metalworking for the entire Bronze Age; it is likely however that the social significance of this technology changed from its first acceptance in the Early Bronze Age towards a common knowledge in the Late Bronze Age where participation in metal circulation (and production?) was open to more people than before (*cf.* Fokkens 1997).

It seems that *all* metallurgy is lumped into one group and no distinction between smelting and melting is made. The argument is overestimated for the two reasons given below.

Firstly, the scholars arguing such a view seem not to take into account the totally different characters of the processes of smelting and melting (see section 2.2). The actual transformation of *rock* to raw metal is confined to the regions where ore extraction took place. Although this does not mean that people in other regions did not value this transformation, the fact that only a handful of people would actually see this process greatly diminishes the argument. The process of melting is a lot less 'spectacular'. No rocks are transformed and a simple small furnace is enough to melt a piece of bronze (most probably an old object or scrap) and cast a new object from it. While this still is a transformation in which a piece of metal is completely reformed and this transformation differs from the kind of 'transformation' that other materials undergo, far too much emphasis is laid on it being "mysterious" and "arcane", which brings us to my second argument.

If the transformation from rock to metal was indeed so "spectacular" and "ritual" to these people, that it commanded considerable respect and may have been a medium for gaining control; this is not reflected by the archaeological record. Metal producing areas such as the Mitterberg stand out for their *lack* of wealth. This wealth seems to be concentrated in the areas were distribution could be controlled, rather than the abstruse knowledge of smelting (such as the Bavarian plane, and the Saalach and Salzburg area). Here metal was traded in the form of casting cakes and/or Ösenringe and Ribbenbarren.[77] The most spectacular transformation from rock to metal had thus already taken place.

The ideas on confined and therefore valuable knowledge seem to deal with a certain aspect of metalworking: the creation of *special* artefacts and the sort of *skilled* crafting discussed in Helms (1993). Everyday metallurgy, the simple casting of an axe, may have entailed knowledge and skill that was far more widespread and less demanding. This is both supported by the archaeological record as well as experiments. According to Roe (1995) isochrestic styles are indicative of a low standard of knowledge and the crafting being a low-status activity (explained in section 5.4.1). This supports the idea that the basic knowledge of metallurgy was available to many different people. Furthermore, experimental archaeology illustrate that there are presumably fewer difficulties to metalworking than assumed (see chapter 7; and appendix 1).

## 5.11 Mundane metallurgy

One of the arguments by Budd & Taylor to argue against an industrial model is that the standardized production of Ösenringe should not be seen as 'industrial' in our modern sense but could also be the outcome of the use of the same mould.[78] Looking carefully at these rings, this argument does not hold however. The fact that pieces were cut-off or additionally cast on to several Ösenringe (Moosleitner 1988; Lenerz-deWilde 1995; 2002) clearly shows that the Bronze Age smiths were interested in getting approximately the same weight and were even prepared to put in extra work to achieve this. This striving for standardization both in form and weight reflects a deliberate choice made by the Bronze Age smith and is not the coincidental result of using the same mould. Therefore, I would opt for the interpretation of Ösenringe and Ribbenbare as some form of proto-currency and thus some form of ('industrial') economy (see section 6.2). Sickles and axes have also been interpreted as proto-currency (Shennan 1993; Briard 1995, 190-1; Lenerz-de Wilde 1995, 2002; Winghart 2000). The objections raised by Budd and Taylor to this 'economic vision' seem unfounded, because the archaeological data clearly point in this direction. Given the difference in how these rings appear and are used (various stages of finish, found in hoards as well as graves)

77 The casting cakes came from the mountains and were re-melted into rings and ribs for further distribution.

78 By using the same (stone) mould or by using an already cast item as imprint for the next mould.

Vandkilde (2005, 263) rightly questions whether either economy or sociality ruled in the societies of the Bronze Age. Some sort of economy, in which production was a mundane practice and bronzes were traded as commodities, was present, nonetheless, as shown by the interest in standardization, described above.

Appendix 3 clearly shows that metalworking was most commonly practised at normal settlement sites; most often dated to the Middle and Late Bronze Age. The data shows neither a distinct correlation between a specific (supposedly ritual) location and metalworking, nor any relation between a specific kind of object and a certain site to produce it. This seems to contradict the presence of a significant ritual component as advocated by Meurkens (2004, 51).

> *"The presence of metalworking debris in settlements does not mean that metalworking was regarded as a mundane activity" (Meurkens 2004, 45).*

This 'urge' to look for ritual and explain it likewise and the focus on the ritual aspect of metalworking is not supported by the archaeological data. Even if all the ostensible 'ritual' metalworking sites would indeed be so, by far the majority of metalworking debris is found on normal settlement sites, alongside debris of other crafts and activities. Hence, such a straightforward view of a considerable 'ritual dimension' to metalworking cannot be given.

## 5.12 Conclusions on the social organization and position of the smith

Much has been written on the organization and social aspects of the bronze smith, but this has mainly been an extension of the meaning of bronze in Bronze Age society and thus highly theoretical. Theories have all been founded on either ethnographic comparisons or folklore, or are a continuation of a grand-narrative style of explanation started by Childe in which metal and subsequently the bronze smith plays a central role.

In this chapter I have clarified that the current prevailing view of specialist and ritual metalworking is by no means an unambiguous interpretation supported by the archaeological record. Rather, it stems forward from classifications and presupposed dominance of bronze over other materials. Furthermore, interpretations seem biased by a form of scholarism, the archaeological record and mostly by the preoccupancy of archaeologist with a special class of objects. The relationship between the skilled craftsmen researched by Helms (1993) and the Bronze Age smith seems troublesome. Helms' (1993, 13ff) definition of skilled crafting is the production of 'special' artefacts, with certain aesthetic qualities, symbolism and political-ideological qualities connected to it and intended for use to votive ends. The objects mostly produced by the Bronze Age smith, however, were axes, spears and other tools meant for *everyday* use.

### *Concluding remarks on specialists and specialization*

Metalworking may have seen a form of specialization, although this is very difficult to surmise from the archaeological record and heavily dependent on the definition of 'specialization'. The presence of specialist metalworkers seems undeniable and they were probably the smiths that produced the valuable objects that may have functioned as prestige goods and/or symbol of power. It is these kind of objects on which the current image of the bronze smith appears to be postulated. They, however, only represent a small part of the bronze in circulation. Research into the production of normal objects such as axes appears to be subordinate although they were produced by the thousands.

I have opted for a less one-sided approach in which the metalworker who haphazardly produced some utilitarian tools is also incorporated. I have argued that basic metalworking skills were – at least in the Middle and Late Bronze Age – widely available and many people may have had the knowledge to produce some simple tools. The skill to produce fine products may still have been confined to a few. Given the different object types and the highly elaborate artefacts such as the ceremonial dirks, a strong case can be made for the presence of specialists or master smiths. Nevertheless, the majority of the bronze production would have entailed everyday products such as axes and other 'simple' tools.

*Concluding remarks on the 'ritual dimension'*

Meurkens (2004) is one of the few scholars that is looking for a ritual component within the archaeological data on metalwork debris, instead of just assuming it or copying from ethnographic examples. However, by using ritual as an analytical tool and 'sieving' the data with this tool, archaeologists run into interpretational problems. Here, I think, instead of re-contemplating, Meurkens is rather determined in showing the ritual dimension. The greater part of the data actually shows that metalworking was practiced 'normally' within settlements alongside other crafts. This does not mean that *no* ritual form of metalworking took place. The process itself could be ritualised to some degree (which does not make metalworking a ritual activity) and a small part of the production, that is *special* objects, could indeed have implied specific rituals (*cf.* Helms 1993). Nonetheless, no strong argument, based on archaeological data, can be made for the 'ritual dimension'. There seem to be several 'degrees' of metalworking in which the 'ritual dimension', in my opinion, is only partly representative and the exception rather then the rule.

### 5.12.1 A multi-tiered organization

Although Rowlands (1971) argued that at least a two-tiered organization of metalworking must have existed, interpretations have remained one-sided. His ideas do not appear to be widely acknowledged and are even dismissed by some (Kristiansen 1987, 34). The archaeological data however, is mostly in support of his model. A multi-tiered organization in which there are full-time and part-time smiths, either attached and independent, as a specialist or for everyday production, throughout which the scale of production could vary. Ethnographic data supports this view, without contradicting that metalworking may partly have been a ritual and specialist practice.

> *"The degree of specialisation obviously depended on the volume of metalworking and its complexity, which themselves were determined by the availability of the raw materials and the market for finished products. Smiths of certain ethnic groups became famous for their art, but few regions seem to have been entirely without craftsmen of some sort"* (Herbert 1984, 32).

*Variability* appears to be a good way to describe the organization of Bronze Age metalworking (following Levy 1991, 68). Nonetheless, I would argue that *generally* metalworking was a mundane activity; without denying that in some cases a strong ritual dimension could have been present, as well as specialists (with according (high) status). All the aspects (specialism, specialization, attached, independent and ritual) are impossible to 'measure' absolutly. They are heavily dependent upon the definition of the term. Furthermore, all the aspects should be seen as a continuum; there is no non-arbitrary line that can be drawn which would separate the specialist from the non-specialist, ritual from mundane metalworking or specialization from haphazard production. We can discern differences, however, and interpret different 'degrees'. Given that far more axes are around than, for instance, swords, basic metalworking is best interpreted as a mundane, non-specialist, low-status activity unless evidently proven otherwise.

# PART III

# TECHNOLOGICAL ORGANIZATION OF BRONZE AGE METAL-WORKING IN THE NETHERLANDS: SUPPLY, MELTING AND CASTING AND THE RECONSTRUCTION OF A METALWORKERS' TOOLKIT

# 6 The supply of metal

*"Geology had cheated the North European plain by depriving it of native metal resources; geography partially made amends by providing river routes – Vistula, Oder, Elbe, Weser, Rhine – down which by canoe or raft the fruits of the mountains could descend conveniently to the plain"* (Butler 1963a, 193).

## 6.1 Introduction

Without a supply of raw material, no local industry could have existed in the Netherlands since all the necessary ores to produce bronze are lacking. Therefore, it is necessary to look at how the bronze smith would have acquired his materials. How was metal traded and in what form? Both questions provide us with certain problems, which will be outlined in the discussion on Ösenringe and Ribbenbarren. Subsequently, both problems will be tackled. First, the form in which metal is traded. I will try to formulate a definition for 'ingot' that is useful in context of the European Bronze Age. Secondly, a brief discussion on trade-models is given. Cleary, trade cannot be addressed without the understanding of exchange systems. Therefore, without being exhaustive, I will touch upon the problem of gift versus commodity exchange. As the trade and circulation of bronze has been dealt with extensively in other studies (*e.g.* Northover 1982; Scarre & Healy 1993; Needham 1998; Pare 2000) the main focus of this chapter will be to determine whether the bronze smith in the Netherlands had a steady supply of bronze intended for re-melting and in what form this metal reached the Netherlands.

## 6.2 Rings and ribs revised

One of the most discussed items that are generally thought to be ingots are the Ösenringe and Ribbenbarren.[79] The archaeological record consists of several thousands of these rings and ribs (Lenerz-de-Wilde 1995). They only seem to appear in the Early Bronze Age and their distribution is mainly confined to Southern Germany and the Danube region (Lenerz-de-Wilde 1995; Vandkilde 2005). Only the Ösenringe (especially those found in hoards with other materials) have a wider distribution (Vandkilde 2005, fig. 4). They have been categorised in several groups; Ösenringe, C-looped Ribbenbarren, Ribbenbarren and miniature Ribbenbarren.[80] According to Butler (2002) there is a subcategory within the Ösenringe: true ingot rings, partially finished rings and fully finished rings.

Butler (1979, 2002) analysed the metal composition of Ösenringe and Ribbenbarren to investigate and comment on the function of these rings and ribs and to find a standard as to which kind of metal was used for ingot material. Ösenringe (fig. 6.1) could have served a range of purposes from medium of exchange, to votive, to a proto-currency, or any combinations of these (*Op. cit*, 355). None of them have been being mutually exclusive to each other, however. He argues that C-looped Ribbenbarren and roughly cast Ösenringe were rough-outs for neckrings (Butler 1979, 356). In 2002 he revises this idea due to the fact that the metal composition of the Ösenringe and C-looped Ribbenbarren do not satisfactorily match, hence they both must have had a distinct own

79 Von Brunn 1947; Childe 1963, 44; Butler 1979; 2002; Moosleitner 1988; Lenerz-de Wilde 1995; 2002; Krause & Pernicka 1998; Shennan 1999; Vandkilde 2005; Innerhofer 2004.

80 Several other names are used but refer to the same artefact: Osenhalsringe / C-looped Spangenbarren / Spangenbarren, {-shaped Ribbenbarren, Halskragen.

function. He envisages a process in which many small and large producers are actively involved and postulates that:

> *"Those responsible for the deposition of hoards such as as Munchen-Luitpoldpark and Havalda must have been able to distinguish between the ingots of the different metals in them, and distribute each type to its appropriate destination for further working"* (Butler 2002, 235).

A significant problem, I think, lies in the fact that scholars like Butler and Krause and Pernicka (1998) try to interpret Ösenringe and Ribbenbarren on the basis of the metal composition. Butler

Figure 6.1 Osenringe from the Munchen-Luitpold hoard. The rings are approximately 21 cm (photograph by the author).

clearly implies that the people who made these rings and ribs had intimate knowledge of the metal composition in question and were making choices on the basis of that knowledge. Yet, however interesting these metal analyses are to *us,* it is debatable whether *they* really knew, and cared, what exact kind of metal composition they were dealing with. [81] The metal composition of these rings shows impurities of such low levels that these would mostly have been imperceptible. [82] Furthermore, explaining a certain metal composition in terms of its possible function may be flawed for

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81 It is questionable to what extent the smith was interested in the metal types as recognized by Butler (*i.e.* As-Ni copper, Ösenringe copper etc.). The bronze smith may however been able to distinguish the quality (and purity) of the copper by its colour and/or malleability.

82 Experimental archaeology can help archaeologist to find out which changes would have been noticeable to the ancient metalworker. For instance; adding tin clearly increases the hardness of the bronze and lowers the melting temperature. Adding lead would make it distinctly easier to pour as it flows much better. These properties would have been noticeable by the ancient metalworker. They are deliberate alloys (Northover & Staniaszek 1982; Northover 1989). In the case of arsenic it is already more disputable, it also changes the properties but did the ancient metalworker had knowledge of this or is it due to the fact that a lot of arsenical copper was mined? (*cf.* Roberts in press) For most of the impurities however, even when they have a distinct effect on the bronze (such as bismuth, making it brittle at only 0,1 %) , I think it is highly unlikely that the bronze smith knew what was going on or what exact metal composition he was dealing with.

another reason: there may be other culture specific traditions or taboos that could have influenced the choice of a specific metal (Ottoway 2002, 7). What we see here is the construction of 'etic categories'. Instead, we should be looking for 'emic categories' which would tell us a lot more on how these Ösenringe and Ribbenbarren were used and what they meant to Bronze Age people (see the discussion in section 3.2). What we can say, is that the Bronze Age communities involved in the Munchen-Luitpoldpark hoard or any other hoard, were concerned with accumulating copper, be it of high As-Ni impurities, Ösenringe metal or any other.[83]

Lenerz-de Wilde (1995; 2002) groups all the Ösenringe and Ribbenbarren together. She is concerned with the weight of rings, ribs and several other artefacts rather then their metallographic composition. In her 1995 article she demonstrates that these rings and ribs have standardized weights. Moreover, she argues that this standardization was the result of an organised exchange system and that they represent a form of proto-currency (Lenerz-de Wilde 2002). Moosleitner (1988) showed earlier, in the case of the Obereichen hoard, that the smith was clearly interested in producing rings that share approximately the same weight. Several of the rings found in this hoard showed cut-offs or additional pieces of bronze deliberately cast on afterwards, in order to give them the right weight. From these observations can be surmised that the people involved directly were indeed concerned with, and acted upon, characteristics such as weight rather than metal composition. A more 'emic' approach I believe. Nonetheless, it does not fully explain the differences, from rough casts to fully finished, that may be discerned in the Ösenringe. Nor why some Ösenringe end up in hoards and graves instead of being re-melted. Furthermore, it is rather strange that this ingot or 'proto-currency' disappears after the Early Bronze Age, which means that a different exchange-form must have come into existence. More importantly, not a single example was found in the Netherlands, suggesting that metal for the melting-pot must have taken on a different form than Ösenringe and Ribbenbarren or that all the examples have been melted down.

The research of Ösenringe and Ribbenbarren provide us with two problems as to the supply of metal in the European Bronze Age. First, there seems to be no general agreement on what exactly, in context of the European Bronze Age, can be interpreted as an ingot. There appears to be no distinct development from the Early Bronze Age to the Late Bronze Age as to which metal was used for exchange. Secondly, the debate on whether bronze was traded in a gift or commodity exchange is ongoing. The rings and ribs (as well as other objects) appear to be standardized in weight, which is explained as being part of an organized exchange system of commodities (Lenerz-de-Wilde 2002; discussed above). However, since Renfrew (1973), circulation of metal is more often that not seen as a gift exchange (between elites) in a prestige good economy (*e.g.* Rowlands 1980; Kristiansen 1998). Both these problems will be discussed in the following sections.

## 6.3 The ambiguity of ingots

By modern definition found in encyclopaedias[84] an ingot is a piece of valuable metal cast into a simple, often standardized shape. It requires a second procedure of shaping, by means of cold/hot working to produce the final product. This definition immediately provides us with two difficulties. What is 'simple' and when can we call something a 'standardized' shape? While the ox-hide ingots (Jones 2007; fig. 6.2) of the Aegean area seem to be a clear example of an ingot (by the modern definition), recognition of a 'true' ingot form in Central and North-Western Europe is far more problematic. Shennan (1995, 204) for instance, distinguishes between casting cakes and ingots, although the former can also be classified as 'simple, standardized forms' of metal. Several scholars

83 Ösenringe copper: high-impurity copper considered to have been smelted from *fahlerz*. As-Ni copper (also known as Ribbenbarren copper: high impurity copper, with Arsenic and Nickel as main impurities. See Butler 1979; 2002 and Junghans/Schröder/Sangmeister 1966; 1968; 1974.

84 From definitions found in Wikipedia, Encyclopedia Britannica and Dictonary.com.

Figure 6.2 Ox-hide ingot from the Ulun Burun shipwreck (Jones 2007).

have classified axes and sickles as ingots (Briard 1965; Harbison 1969; Primas 1986 Eogan 1993; Fontijn 2002). Moreover, scrap was re-melted (Northover 1982), but scrap did not occur in simple, standardized shape. Here already the modern definition of ingot appears to fail.

Evidently 'ingot' is not a satisfactory term in the archaeological discourse as it does not entail a distinction between form and function. The form of an ingot may be defined by several socio-cultural factors which may or may not have a relation as to it function(s).[85] Furthermore, form can also differ per period as well as region. Recognizing an ingot by form is thus somewhat impracticable in archaeological discourse and this might be one of the reasons why there is no agreement within archaeological discourse on what exactly an ingot is. The functional definition of an ingot, on the other hand, is much more transparent. *Everything* that can be used as a supply of metal inherently has the function of an ingot. Whatever forms they are shaped, bronze objects inherently function as store of raw material because these objects can always be re-melted. The sword of Jutphaas (Butler & Sarfatij 1970/1971; Fontijn 2001; Fontijn 2002, 104), without attention to its form, function and meaning is essentially a store of useable bronze. This clearly is a too pragmatic approach to the problem of identifying an ingot. Hence, in the next sections, I will try to formulate a more elaborate definition, based on its essential function of an ingot (*i.e.* a supply of metal), but taken into account that bronze objects had a meaning in Bronze Age society. I will not adhere to the modern definition as this clearly is incompatible with the archaeological record.

### 6.3.1 The difference between ingots in function and ingots in form; intrinsic value and face value.

Based on ethnographic examples it appears that the ingot form is culturally dependent and ingots can appear in any form (Herbert 1984; Hosler *et al.* 1990; Bisson 2000). In all cases, the ingot is a store of raw material, a symbol of wealth and product for exchange and trade (proto-currency), these three functions supplementing each other. The form appears to depend somewhat on which of the three 'functions' is most important. In the case of a proto-currency a generally accepted and easily manageable form is preferred. If it is merely a store of raw material, which, of course, is also a form of wealth, the ingot can take any form. When ingots *represent* wealth however, there appears to be a difference. It seems that, if ingots act as an artefact to *show* wealth, form becomes more important. For this purpose, the ingot is often shaped such that it can be easily carried and showed. A nice example is the cruciform ingot (*croisettes*) in Sanga, Africa, of which a special smaller

85 Why are the flat axes, also interpreted as ingots (Eogan 1993), shaped they way they are? If they are ingots this does not seem necessary. Are they shaped as axes because this was the accepted form in which metal was exchanged or is their shape determined by the fact that *in essence* they are axes that may also be used as ingots whenever bronze was needed?

version was used to attach to the belt of the owner, to show his wealth (Bisson 2000, 120). Manillas (surprisingly like Ösenringe), a ingot type imported in Africa from Europe (Bisson 2000, 114), were mainly used for high-status purchases, but also served as means of conserving wealth, being a store of copper that could readily be converted into goods (*ibid.*; Herbert 1984). Because, in many cases, all three functions; symbol of wealth, proto-currency and supply of raw material, are operative at the same time, it is difficult to say which one is most important and decisive for the form of the ingot.

What determines which function is most important has to do with the intrinsic and face value of copper. This might also be true for Bronze Age ingots. I define face value here as the extra value of objects (complementary to the intrinsic value), based on how they looked and the cultural meaning attached to it. Ösenringe may have started out as ornaments and/or trade form for high-status exchange. The former is supported by the fact that they are found in graves, where they are worn as neckrings. I would argue that the fully finished neckrings were mainly used to display wealth, which does not mean that they did not have the function of proto-currency or store of raw material. In the cases where Ösenringe mainly acted as a symbol (of wealth) they are more likely traded then re-melted. Distribution patters indeed show that fully finished Ösenringe have a far wider distribution than the distribution of the partially finished or 'true' ingot form of Ösenringe (Lenerz de Wilde 1995; 2002). Even so, Ösenringe remain ingots because of their intrinsic value; being a store of raw copper.

During the Early and Middle Bronze Age, as more bronze became available and more elaborate bronze objects were made, the face value of the Ösenringe may have shifted to these objects. According to Gero (1985 cited in Levy 1999) value of object rises with increased input of human labour and skill. Conspicuous wealth was perhaps now shown through the ownership (and ritual deposition?) of, for instance, swords. or prestige axes 'Loosing' the function of display of wealth might have resulted in the form of the ingot metal becoming less important. This may explain the change from Ösenringe to C-ringen and finally to Ribbenbarren.[86] It could reflect a shift in function; the 'store of raw material' function (intrinsic value) becoming more important than the 'symbol of wealth' function (face value).

According to Needham's 'flow of metal' theory; it becomes more difficult to believe that rigid cast-once-only systems could have existed, away from the ore sources (Needham 1998, 289). The further away from the main source, the more likely it is that secondary (*i.e.* already once melted down) metal is used. This may explain why the rings and ribs are mainly found throughout the Bavarian plains. When trading something that has intrinsic value it has considerable advantages to have a standard form and weight, but this is not a necessity. In smaller quantities, the product can be traded in any form. If, however, the form was of no importance, metal intended for the melting-pot may have been traded in many forms.

## 6.3.2 Recognizing Bronze Age ingots

In the sections above I have advocated that the essential function of an ingot, to provide a supply of raw material in order to be recast, is not limited to any form. Scrap, therefore, seems a perfect candidate. However, more forms of bronze may have been ingots. It is argued that axes and sickles have *dual roles;* on the one hand they are multifunctional tools and on the other hand they are a widely excepted exchange item and store of bronze (Bradley 1990, 119; Fontijn 2002, 251). The suggestion that axes circulated unhafted (as ingot rather than functional axe) is strengthened by the fact that edge wear can be found along the whole length of the axe (Moyler 2008, 85). I am inclined

86 Whereas we perceive most artefacts to evolve during the Bronze Age (becoming more elaborate such as axes; *cf.* axe typology Butler & Fokkens 2005, fig 17.10), it seems that the ingot rings devolve; going from fully finished Ösenringe to simple C-rings to very crude Ribbenbarren.

to go even further and argue that this *dual role* is true for many, if not all, bronze objects. This functional definition however, entails that potentially *all* the metal present in the Netherlands could have been used. The problem, of course, is that archaeology is not about potential and deposition such as the ceremonial dirk of Ommerschans (Fontijn 2001) clearly show that certain objects were not re-melted but selected to be deposited.

Although many depositions have been interpreted as trader's hoard, which implies that the objects involved were ingots, this interpretation is widely dismissed nowadays (*e.g.* Bradley 1990; Levy 1982; Fontijn 2002) Depositions (including scrap hoards) which are deposited in wet places, such as rivers or swamps, are unlikely to have been ingots for they could not have been retrieved in order to be re-melted. They may, however, be part of the stock operating in a *sacrificial economy* as explained in section 2.4. Hoards on dry land, for which it was possible to retrieve them, are equally difficult to interpret as a supply of bronze smith. There can be a range of other reasons that may have led to their deposition, besides the (temporary) storage of bronze. In essence, bronzes from deliberate depositions *de facto* are not ingots because they were selected to be deposited and thus were given another function and meaning; even if the hoard is part of a larger bulk of metal that actually was re-melted (*cf.* Fontijn 2008). Recognizing an ingot appears to be a catch 22 situation. Essentially the only way to be one hundred percent sure that an object was an ingot is when it was used as such (*i.e.* re-melted), which inherently means that it cannot be found by archaeologist.

## 6.4 Ingots as store of raw material, a definition on archaeological terms

Bronze must either have been brought to the Netherlands in the form of copper ore or as objects (of any form). The former, although movement of ore is not infeasible (Jovanovic 1988), does seem highly unlikely for the Netherlands.[87] Consequently, bronze supplied to the Netherlands already had been (s)melted once and may appear as objects ranging from scrap to highly elaborate artefacts. As discussed above, what can be interpreted as an ingot depends on the meaning a certain bronze object has acquired, and how Bronze Age society reacted to that.

> *"Objects which have played a restricted role in one region might have lost their original significance when they were accumulated in another area. Here they could be treated as a source of raw material"* (Bradley 1998a: 144-50).[88]

Bronzes that are found in deposition have been selected (for whatever reason) to *not* be re-melted. This problem involves dealing with the cultural biographies of objects, which is outside the scope of my thesis (but see Kopyoff 1986). Given that we have information on items that were not re-melted and the fact that it is known that re-melting did take place in the Bronze Age (Northover 1982; Needham 1998; Liversage & Northover 1998) I would define the term ingot on the basis of these premises: *Every bronze object, unless it is distinctly clear from the archaeological record that it was treated in a separate field of discourse (i.e. deliberately deposited), may be interpreted as a possible ingot.* This has implications for the way we should look at the supply of raw material. The question now, in particularly for the Netherlands, is not whether there was a supply of raw material and how much. Rather, the question is which types of artefacts were used for re-melting and which artefacts had a meaning that *prevented* them from disappearing in the melting-pot. It also provides a new problem. Bronze objects

87 Enormous amounts of ore would have had to be transported in order to extract a small amount of raw copper. Transportation of these massive amounts of ore would have left traces. Furthermore, an additional supply of tin would have been needed to make bronze.

88 Sundstrom (1965, 258) for instance, gives an example in new Guinea where the further objects travelled outside their culture area the more they lost their value and became ingots / raw material. The argument however is equally strong when reversed; objects from far away are more valued (Helms 1998). Besides, the meaning of objects can also change over time and space.

most visible archaeologically, the depositions only represent a part of the spectrum. The objects that have been used as raw material, the ingots, leave few to no traces visible archaeologically. The amount of bronze available for the Dutch metalworker may therefore have been much larger than generally assumed. The same conclusion can be drawn if one regards hoards such the one from Voorhouten represent as the part of the traded 'alien' stock that was sacrificed (*pars pro toto;* Fontijn 2002, 247ff; Fontijn 2008; see section 2.4). The majority of metal must have been recycled instead of deposited (Fontijn 2002, 33). In conclusion, I think it is safe to assume that the supply of bronze for the Netherlands was sufficient to support local metalworking.

## 6.5 Bronze circulation; commodities or gifts?

> *"Despite a central belief in archaeological circles that metalwork and its distribution are fundamental to the understanding of trade and other social interactions, as well as to the spread of metalworking skills, associated technologies and ideas, the literature seems neglectful of the value of modelling the passage, or flow of metal."* (Needham 1998 285-6).

The trade and circulation of metal is unlikely to have been a static practice throughout the whole Bronze Age. For instance, the processing of sulphide ores in the Central European region must have led to a great expansion of metal production, which may have determined the availability and accessibility of copper for different cultural groups in different regions (Shennan 1993). This may also have had an effect on the way it was handled, traded and valued.

As Needham points out, it is necessary to understand the exchange and circulation of metal in order to fully understand the process of metalworking. Since the disposal of 'economic western views' on the Bronze Age, that explained the circulation of bronze as some form of (economic) trade (*e.g.* Hawkes 1940; Childe 1963; Butler 1963a; O'Conner 1980), scholars have turned to the ritual and/or social aspects of object exchange (*i.e.* gift exchange). Metal was moving around in vast quantities over great distances (Northover 1982) and often this is seen in line with the power of elites (*e.g.* Kristiansen 1987; 1990). The trade has also invariably been treated as 'specialist orientated' with specific connections assumed between miners, smelters and smiths who operated a well defined network (Hawkes 1940, 379-80; Childe 1950, 166) or controlled by 'middlemen' trading in a number of different materials (Clark 1952, 257). However, as Shennan points out, too much an emphasis has been put on social ranking and stratification and the elites of the Bronze Age. This 'myth of control' as Shennan (1993, 59) calls it, is the ideology that everything happens in society as a result of the efforts of early elites (*cf.* Earle 2004 ; Kristiansen & Larsson 2005). Accordingly, Shennan argues that there is a general denial of the self-interested aspect as a drive for trade and that:

> *"In our determination not to impose 'western' values on prehistoric societies we have tended to follow the view that exchange was almost entirely to do with the maintenance of social relations between groups, and with evening out inequalities of resources"* (Shennan 1995, 305).

The archaeological record nonetheless clearly shows an interest in weight and standardization which be interpreted as characteristics for trade (see section 6.2). Winghart (2000, 152) argues that copper casting cakes were divided into identifiable fractions of a whole piece, down to a quarter. Lenerz-de-Wilde (1995; 2002) argues for an organised exchange system based on weight and for sickles it even seems that a system of counting has been worked out (Sommerfeld 1994; 2004), which is also advocated for the rib and pelleted axes by Huth (2000).

As with the ritual – profane dichotomy, the clear-cut contrast between commodity and gift, and hence the problems we have interpreting 'trade' hoards such as the Voorhouten hoard is a problem of our own making (Fontijn 2008). More likely, gift and commodity exchange are intertwined

(Bazelmans 1999, 15) and operative at the same time. Bronzes in the Bronze Age are liable to have functioned both in gift as well as in commodity exchange (Bradley 1990, 144-8; Fontijn 2002, 31).

Considering long-term (gift) and short-term (commodity) exchange[89] I would argue that the supply of raw material for metalworking belongs to the latter and was traded as commodity (*cf.* Liversage & Northover 1989, 141). Metals, intended for the melting-pot, were traded as a commodity and their circulation must have been considerable. Next to the sizable hoards found on land, finds like Langdon Bay (Muckelroy 1981; Needham and Dean 1987), Huelva and Ulu Burun (Cline 1994) support the idea that vast quantities of material were traded overseas. Although for both the 'sea hoards' as well as those find on land, ritual explanations have been given (Samsom 2006; Bradley 1990) they do show the enormous amount in which metal circulated. Furthermore, for many hoards the problem of a ritual (gift) or profane (commodity) interpretation may not necessarily be contradictive (*cf.* Fontijn 2008).

## 6.6 Discussion

As described in section 6.3.1, the meaning of bronze mattered. If the face value of an object is high, it is more likely to be traded as a symbol (of wealth) and hence be operative in gift exchange. Trade in Ösenringe and Ribbenbarren may have changed from gift exchange to commodity exchange due to the fact that Ösenringe, as symbols of wealth, were replaced by other objects. If we use the propositions described above on the trade of Ösenringe and Ribbenbarren, the fully finished neckrings should be plotted on the left side of the Ribbenbarren in figure 6.3.

As shown by Fontijn (2002, 247ff), objects could undergo transformation. The axes in circulation during the Bronze Age were most probably commodities. Yet, the axes found by archaeologist, mainly from depositions, are probably gifts (*ibid.*). Swords also show that a distinction between gift and commodity, on the basis of the object, is by no means clear-cut. Swords have been found as depositions in wet places (mostly rivers) (Fontijn 2002) but pieces of swords also appear in scrap hoards (Bradley 1990; Bradley 2005, 145ff). Clearly there is no strict rule as to how a certain object should been treated. Rather this seems to be dependent on the meaning and transformation an object would undergo. Placing an object on the line in figure 6.3, is therefore difficult. The line should be seen as a continuum in which true gift and true commodity are the extremes and

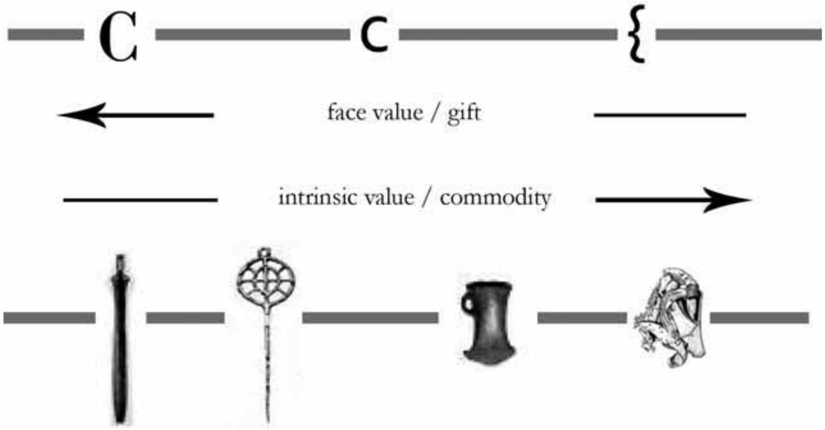



Figure 6.3 Simplified impression on the value of objects relative from each-other. C = fully finished Ösenring (neckring), c = Ösenring, { = ribbenbar. Objects may change position on this line depending on their cultural biography.

89 See Kopytoff 1986, 71-2; Bloch & Parry 1989, 15; Fontijn 2002, 31 for a more thourough discussion on this topic.

on which an object may move according to its meaning. The same object may have a completely different meaning in another region for instance.

The image given must be seen as a general and oversimplified. It explains that, while everything in essence is still an ingot, it is more likely that the objects on the right side of this line end up in the melting-pot. Most of the objects that came down to us via deposition probably represent the long-term, gift exchange (*i.e.* the left side of the line). They, by no means, reflect the actual bronze in circulation (Fontijn 2002, 33).

## 6.7 Concluding remarks on the supply of metal

Dealing with the question whether and where bronze production took place in the Netherlands, I have argued that we should not confine ourselves to the modern definition of an ingot as the only evidence for the supply of metal. With the newly formulated definition, which I believe to be more useful in the context of the European Bronze Age, many more pieces of metal could have been gathered by the smith to melt down. Hence, the amount of bronze available for the Bronze Age smith is far larger than originally thought. Assumptions made on this topic, however, will remain difficult to proof, because the evidence was destroyed by the ancient metalworker himself. The function of an ingot inherently prevents archaeologists to exactly determine what they were. The majority of bronzes that we see and are studying mostly represent a group that was deliberately *not* chosen to be re-melted.

Examples like the giant Ösenringe and Ribbenbarren hoards of the south Bavarian plain, which are all approximately the same weight (Moosleitner 1988), indicate a clear interest in weight systems, which are difficult to explain other than being useful in some sort of trade (*cf.* Lenerz-de-Wilde 1995; 2002). The same goes for sickles (Primas 1986; Sommerveld 2004). It shows that metal circulation was at least partly standardized and probably traded as a commodity. However, the greater part of the artefacts found and given special attention to by archaeologists, represent the special, ritual treatment of bronzes, thus attached to the sphere of gift exchange. This dichotomy is not going to change, for we can imagine that the bronzes that were not deposited remained in use except when lost. The problem of the melting-pot is especially evident in recognizing ingot forms. Fontijn (2002, 33) also argued that is is unlikely that a regional bronze industry could have existed and depositions could have been made if there was not a surplus of bronze. As advocated in this chapter, we can convincingly surmise that a steady supply and thus surplus of bronze was indeed present during the Bronze Age in the Netherlands.

# 7 Melting and casting bronze

## 7.1 Introduction

Having dealt with the supply of bronze, we can now look at the following step in the process: melting and casting. As my research question revolves on the recognition of the production locus of a smith, it is essential to know how such a locus would present itself in the archaeological record. The subsequent chapters will be a research on the objects needed for the melting and casting of an everyday object such as an axe. It is not an in depth research on the *use* of these objects. Thorough use-related descriptions can be found in the references given in the footnotes. I am primarily concerned with the preservation of these artefacts. What observable traces does the melting and casting of a few axes leave in the ground and how can it be recognized as such? To answer this question I combined information gathered from excavations with information gained from experiments as to see whether the archaeological record is representative. Furthermore, the experimental data is used to provide ideas on what to expect archaeologically. Subsequently, the Dutch archaeological record has been studied to find any examples of objects related to metalworking.

## 7.2 Furnaces[90]

> *"This chapter is mainly addressed to the archaeologist who is seeking an explanation for a hole in the ground containing ash and perhaps burnt clay lining or merely highly vitrified pieces of clay. In these remains, together with slag and other debris, lie all that may be left of a metal production site"* (Tylecote 1987, 106).

As mentioned in section 2.2 the distinction between smelting and melting is not commonly made. Little is known about the furnaces and the process used to *melt* a small amount of bronze. Most technological literature deals with furnaces used to produce metal from ore (*e.g.* Craddock 1995; Craddock & Hughes 1985; O'Brien 2004; Herdits 2003). These furnaces leave more definite traces in the ground (although still difficult to recognize). Archaeologist dealing with the technology of Bronze Age metallurgy do not frequently enough ask themselves where, or more importantly, how ingots were re-melted to produce the artefacts we are finding all over Europe. Exceptions are both Tylecote (1987) and Coghlan (1975), who do go into detail about melting and casting.

Different types of furnaces may have been used for melting, but usually it is not much more then a hole in the ground, sometimes lined with clay or stone. Simple, unlined types of furnaces will leave very little traces and appear much like ordinary pits in the archaeological record (Tylecote 1987, 181). As long as there is a fire and sufficient airflow to get the temperature up, melting some copper or bronze in a crucible is possible.[91] Experimental archaeology has shown that a small and controlled fire, like the one at the experiment I witnessed, can easily be fired up onto a temperature of 1200 ˚C (personal communication J. Zuiderwijk, 2006), with the help of bellows. Some hundred grams of bronze can be made liquid in 15 to 20 minutes, ready to be cast. Rehder's (2000, 89) exceedingly technical study of furnaces confirmed that it is indeed possible to melt pieces of copper and bronze contained in a shallow bowl by covering them with a layer of charcoal and supplying

90 A.o. Hodges 1989; Craddock 1995; Craddock & Hughes 1985; Tylecote 1987, 106-115; Coghlan 1975, 27-37; Herdits 2003; O'Brien 2004.

91 Copper melts at a temperature of 1084 ˚C. The melting temperature of bronze can, according to its alloy, go down to around 800 ˚C.

combustion air from the top. Invaluable in this process is the constant flow of air. During excavations, recognizing a furnace like the one used in experiment 1 (see appendix 1) may be extremely difficult. The clay lining crumbles entirely because of the enormous changes in heat and thus it will be nothing more than a small discoloration in the ground; a shallow, easily misinterpreted, trace with some remains of charcoal. Even if the furnace is visible archaeologically, which is unlikely because it is such a shallow feature, it will be problematic to associate it with metalworking activities. Charcoal alone is not enough and can only lead to an interpretation as "hearth". Copper droplets are unlikely as all the material will be (re)used (see section 7.6.2).

## 7.3 Bellows[92]

As mentioned above, a fire can only reach the right temperature for melting bronze if there is a constant and sufficient flow of air. The air should be applied with force, and as directly at the crucible as possible in order to rapidly increase temperature. This can be accomplished in three different ways: (1) use of blowpipes (labour-intensive but possible), (2) with the use of bellows and (3) by exploiting natural airflow. Fasnacht (1999) tried to melt bronze with the use of blowpipes as air-supply. Although highly labour-intensive, not without danger[93] and for a small amount of bronze (some hundred grams) at least six blowers are needed, he did succeed. Evidence for exploiting natural air flow is supposedly found at Heidenschaschanze, Dresden-Coschütz (Goldmann 1985). This sophisticated method allows a continuous airflow without any human help. This is a method that is particularly profitable for larger furnaces. Even with calm winds, the slightly sloping angle at which the furnace is build (Goldmann 1985, 54, fig. 1) will provide airflow because of suction. Goldmann sees this kind of furnace as evidence for mass production and a 'real' metal industry (*ibid.*)

Let us now turn to the second option, the use of bellows. Even though no direct evidence from the bellows itself has been found in Europe, the so-called tuyeres, made from refractory materials (see section 7.4) show us that there must have been several. It is assumed that the development from blowpipe to bellow went rather quickly. Some illustrations of bellows are known from later periods. In the Near East, pots have been found that were used as bellow (Davey 1979; Craddock 1995, 180). These so-called bellow-pots are covered with a piece of leather with a stick in it, thus operating as bellows. For Europe, however, it is assumed that bellows were made completely out of organic materials (except the tuyere). The bellows from our experiment are based on an illustration as seen on a Greek vase (personal communication J. Zuiderwijk, 2006) and are made from a couple of pieces of leather sawn together (fig. 7.1). Other possibilities for bellows are shown in figure 7.2. As the tuyere is the only part that survived not much can be said on the bellows that were used during the Bronze Age.

Figure 7.1 Model of the bellow used in the experiment (www.1501bc.com, J. Zuiderwijk).

When using bellows for the air supply two problems arise; (1) how to keep a *continuous* air flow going (necessary to get the right temperature) and (2) how to prevent hot air and burning particles from the furnace to enter the bellow. The first problem can simply be overcome by using two bellows, either with two tuyeres separately or, as in the experiment, by using a Y-shaped wooden air pipe connecting the two bellows together. This is based on an actual find of one of these wooden air pipes in Hjortspring, Denmark (fig. 7.3), dated

92 Tylecote 1987:115; Coghlan 1975, 67-70; Rehder 1994; Craddock 1995, 174-185.

93 Medical examination afterward showed that oxygen deficiency could set in (Fasnacht 1995, 245 cited in Fasnacht 1999).

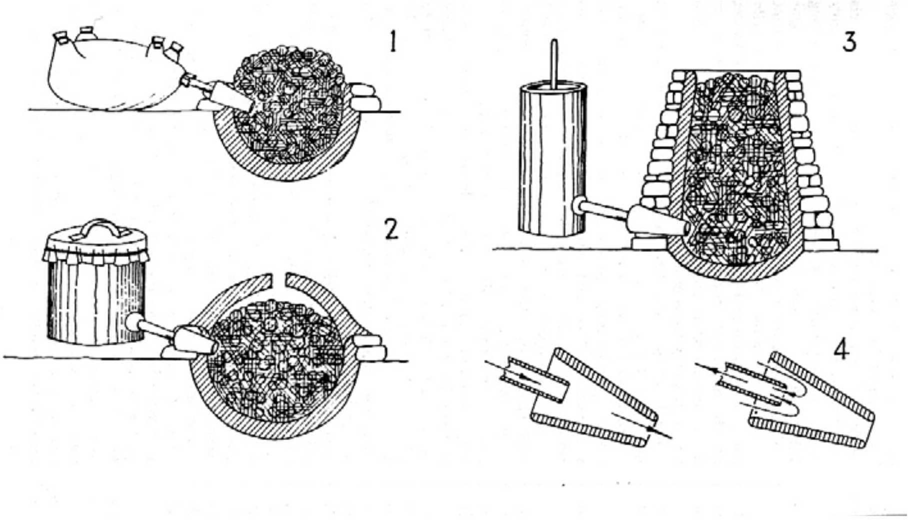



Figure 7.2 Different bellow techniques.1: Bowl furnace with skin bellows, 2: domed furnace with drum bellows, 3: shaft furnace with cylinder bellow. The tuyere acts as a simple air valve (4).

to the Iron Age (350 B.C.; Crumlin-Pedersen & Trakadas 2003). No examples from the Bronze Age are known to the author. Adjusting the form of the tuyere (fig. 7.2 (4)) can solve the second problem. This tuyere is bigger and acts like a sort of air valve through which hot air can escape and cool air is sucked in. In the experiment, a completely different way is used to solve the problem. The leather sacks of the bellows are not sewed together, but are kept tight by slats, making it possible to open and close the bellows. New air is not sucked in through the tuyere but literally 'grasped' by opening up the bellow. In this manner it not only solves the problem of hot air entering the bellow, operating the bellows is also made considerably easier. If we look at the closed tuyeres found in

Figure 7.3 On the left the wooden hollowed out Y-shaped air pipe from Hjortspring, Denmark. On the right the wooden airpipe from the experiment. Instead of hollowing it out it was carved and covered with leather ((photographs by the author).

Belgium (fig. 7.4) such a bellow technology is most likely. Once a certain pace is picked up, keeping a constant airflow going is quite simple. One bellow is closed and pushed downward, forcing the air out through the pipe and tuyere into the fire, while the other bellow is opened and moved upwards in order to get new air in. Some practice is needed to get the pace going, but then, operating the bellows is a very simple task. Maybe therefore, it was done by the apprentice (experiment 1, see

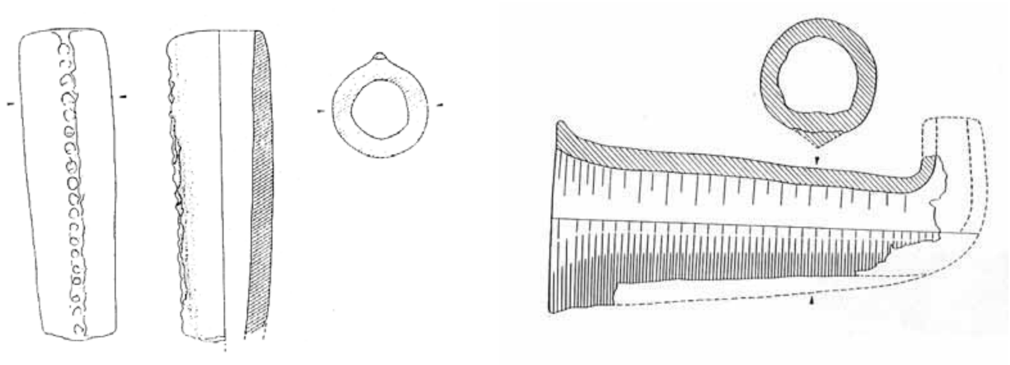


Figure 7.4 On the left the tuyere from Loenshout (Belgium), on the right an elbow tuyere from Marche-les-Dames. Not to scale (after Meurkens 2004).

appendix 1). I was surprised how much this young apprentice already knew about casting bronze (like estimating the temperature of the fire by looking at its colour), just by operating the bellows, looking and learning from the bronze smith.

## 7.4 Refractory materials

> *"Refractory is a term commonly used in archaeometallurgy to embrace the range of crucibles, tuyeres, furnace linings and moulds associated with early metallurgical activity"* (Freestone 1989, 155).

The term refractory is used for the material built with the intention to be resistant to very high temperatures. Not every kind of clay is suitable to produce, for example, a crucible. Special clay and tempering are needed to give it the right properties. These specialised pastes, prepared for metallurgical ceramics, differ from those used for domestic wares (Freestone 1989, 159). This fired clay is the kind of material we would expect to survive in the ground. The clay is baked in the fire of the furnace and, like pottery, should therefore be present in the archaeological record. Refractory artefacts are important clues to archaeologists; they can tell a lot about the metallurgical operation performed at the site, even when the actual metals are missing. Unfortunately, research into refractory materials is scarce and very little is known on this topic.[94] In the following section tuyeres and crucibles will be discussed. The moulds are dealt with in section 7.5.

### *7.4.1 Tuyeres[95]*

A tuyere is the end of an air pipe that is attached to a bellow. While the pipe itself is probably made out of wood, and possibly covered with leather, the end should be made from inflammable material, for it is positioned in or just above the fire. Several types of tuyeres are known. Horizontal tuyeres, which were meant to go into the fire almost entirely. Block tuyeres, which are part of the furnace (usually in smelting furnaces), and elbow tuyeres, which were probably used most often by the bronze smith. A crucible containing bronze is best heated from the top, for which the elbow tuyere is most suitable. From the metal producing areas many tuyeres or pieces of them are known, often

94 Apart from some exceptions like Bayley (1986; but for Roman examples), or Howard (1983): unfortunately an unpublished PhD thesis which I was not able to get hold of.

95 Tylecote 1987, 115 – 125; Craddock 1995, 185-189; Rehder 2000

clogged with slag material and therefore discarded (Tylecote 1987, 117).[96] However, from sites were smelting, most likely, did not take place, tuyeres are rare. Only five sites have yielded tuyeres as is shown in the table in appendix 3.

The tuyere used in experiment 1 is an elbow tuyere (fig. 7.5), made from the same material as the crucible (see appendix 1). It can be placed right above the fire and crucible, which will provide a direct airflow that has been accelerated. It can penetrate the fire deep and fuel the furnace fast because the draught is forced trough a small opening. A wide opening causes the air to spread across the surface and will only heat the top (personal communication J. Zuiderwijk, 2006). The wooden air pipe is inserted in the tuyere and attached with leather. The tuyere must be baked well before use, or it may literally explode because of the heath and thermal stress. Thermal stress is enormous, since the top of the tuyere will get red hot while the rest remains cold, because of the cold air flowing trough it. If baked well and if no cracks appear, these tuyeres have a long lifetime. This is also due to the fact that, in contrast to smelting, no rest material from the melting procedure can clog the tuyere. This could explain why tuyeres are sometimes decorated. It is a specific tool, made to last, and not disposable such as the clay moulds or crucible, hence worth the time and effort to decorate it (Tylecote 1987, 123). Their long lifetime might also explain why so few are found. It was a rare object already in the Bronze Age.

Figure 7.5 The elbow tuyere from experiment 1 (photograph by author).

96 This might also explain why the only tuyere found in the Netherlands dates to the Iron Age, when smelting of ore did take place (van de Broeke 2005, 607).

### 7.4.2 Crucibles[97]

The crucible is in direct contact with an unevenly divided fire and is therefore subject to large thermal and physical forces. The clay, from which the crucible is made, must withstand temperatures of up to 1300 °C, but must also be resistant to rapid cooling. To reduce the forces imposed on a crucible as much as possible, it is heated from above. Clay conducts heat rather poorly and while the outside can be only a couple of hundred degrees, inside the crucible there can be molten metal (Freestone 1989, 157). Crucible fragments are more regularly found (appendix 3) although in the Netherlands no examples have been found that can be dated to the Bronze Age.[98] Research has shown that in England a special clay was used to produce refractory pottery used in metallurgy. This clay differs remarkably from normal pottery clay used to make household pottery and contains very high levels of silica (Howard 1983, cited in Freestone 1989).

Lifting the hot crucible may be done with the use of so-called whitties. The crucible is clasped between two sticks and lifted. Another method for lifting the crucible is by adding a handle to the crucible, containing a hole. A stick can be inserted to lift the crucible. Spoon-like crucibles made completely from clay are also possible but are more likely to break. The enormous temperature differences cause the clay to crack. To prevent this from happening, sand is mixed through the clay. The cracks occurring in the crucible will be held together by vitrification of the sand (fig. 7.6). On average a crucible will last approximately five castings; depending on where the cracks occur (personal communication J. Zuiderwijk, 2006). If the possibility exists that the crucible will break, the smith will discard it. The crucible used during the experiment is lifted by the use of a stick that can be inserted into it. Getting the crucible out of the fire and pouring the bronze should happen

Figure 7.6 Vitrification of the crucible in detail (photograph by author).

97 Coghlan 1975, 71-74; Tylecote 1987, 183-192; Freestone 1989; Hodges 1989:205.
98 Examples dated to the Iron Age are known (van de Broeke 2005, 605, fig. 27.3).

rapidly, for the bronze will generally start coagulating within less than twenty seconds after removal from the fire.

Because crucibles will often be baked to the temperature where vitrification takes place, it is may be assumed that these artefacts are preserved in the archaeological record. Vitrified pottery would definitely be noticed by archaeologists. Absence of crucibles in the Netherlands can be used as a argument against the presence of local bronze smiths. Nonetheless, what actually would survive in the Dutch soils is difficult to say. Weathering (especially water) seems to have a strong effect on the crucibles because of the cracked structure, besides the risk of trampling of course. If not buried rather quick after it was discarded, it is not likely that crucibles will survive in the archaeological record. At the experiment, I noticed that the heap of waste material next to the smith's hut consisted mainly of grit. The parts that were still recognizable as crucibles or moulds were quite small and very brittle. Given the amount of crucibles found on settlements in other countries (*cf*. appendix 3) I do think that – next to the moulds – crucibles should be one of the most common artefacts that can help identify metalworking and the production locus of the smith. A more elaborated research in the characteristics of crucibles and refractory materials should prove helpful.

## 7.5 Moulds[99]

### 7.5.1 Introduction

Different materials were used to produce moulds and the choice of mould material probably depended on the desired object and the quantity of replicas required. Clay was probably used most often, but complete clay moulds are rarely found. Due to their durability, (complete) stone and bronze moulds are more commonly found. Casting in (form) sand is also a possibility (discussed below). Because I am specifically interested in the archaeological remains that bronze casting produces I will not delve into the use of the moulds, which differs per material.

Table 7.1 shows the different casting techniques and the materials used for the moulds involved. Several experiments have been undertaken to find out if it is possible to determine the mould material from the surface structure of the cast objects. The structure indeed seems to differ per mould material (Wang & Ottoway 2004; Northover & Staniasczek 1982; Experiment A[100]). It remains to be seen if this technique also works on archaeological bronzes from the Netherlands, which have been affected by oxidation, patina, bronze rot etc. If so, valuable information could be gained; for example, to see in which kind of mould the axes were cast that are labelled regional by Butler.

| Casting technique | Materials |
|---|---|
| open mould casting | stone, clay, loam, possibly in sand |
| bi-valve moulds | clay, stone, loam, bronze |
| multiple moulds | clay, loam, stone |
| cire perdue | clay, loam |
| lost-sand (form sand) | sand |

Table 7.1 Casting techniques and the materials that can be used for it.

99 Tylecote 1987, 209-226; Coghlan 1975, 50-67; Goldmann 1985; Miller 2007, 159.
100 Experiment A is the name of a group involved in metallurgical experiments (http://www.experimentarch.ch).

### 7.5.2 Stone[101]

Especially in the Early Bronze Age stone moulds may have been commonly used. Ireland, for example, yielded several simple, open stone moulds used for casting flat-axes (Eogan 1993). They were probably covered with a capstone to ensure a good casting, so the term 'open' is debatable. The axes cast in this kind of mould would have needed a lot of finishing. The top layer of the cast object, if not covered (completely) by a capstone, will contain a lot of air. This form of axe is often seen as an ingot instead of a finished artefact (*ibid.*). The stone used to make the mould should have two essential properties: (1) easy to work (in order to carve the desired form into it) and (2) resistant to very high temperatures (refractory). Sandstone was commonly used, but also moulds made from limestone, biotite and steatite (soapstone) are known (Coghlan & Raftery 1961; Tylecote 1987). The latter is extremely useful for making moulds but hard to come by. Limestone is easy to work on but when heated to temperatures above 800 °C, it slowly decomposes. Stone also should be pre-heated before use, to prevent cracking, or even bursting (!), because of the sudden thermal shock. From the Middle and Late Bronze Age stone moulds are known in which multiple objects can be cast (Tylecote 1987, 213, fig. 6.22). These moulds must have been rather precious objects. Multiple and bi-valve moulds from stone are much more difficult to produce than clay moulds. It is also argued that multiple moulds were made because of their portability; this in line with the believed itinerancy of the smith (Tylecote 1962, 116). These moulds could be used over and over again. Coghlan (1975, 56) sees this more permanent nature of stone as the reason why stone moulds were more widely used than other materials:

> *"It is not until we come to the late Bronze Age that two-piece moulds of baked clay appear, and then in nothing like the numbers of stone moulds ascribed to the earlier periods."* (Coghlan 1975, 55).

However, as mentioned earlier, I think this has more to do with the preservation of both materials. Whereas stone will be preserved, the clay moulds are often destroyed either already in the casting process or later, due to its poorer durability.

No stone moulds have been found in the Netherlands, although the mould from Oss could possibly be mentioned here. The material from which this mould is made looks like stone, but this has not been tested yet (see appendix 2.1 for a more thorough description on the Oss mould).

### 7.5.3 Clay and loam

Clay moulds were probably made by pressing a model into the clay, although a form can also be cut. These moulds can be repeatedly made from the same model and thus produce approximately similar casts. Evidence for the use of a wooden model has been found at Jarlshof, Shetland (Hamilton 1956). Three fragments of an unused mould for casting a sword clearly show that a wooden pattern was used for the production of this mould. Clay for a mould is prepared from a specific refractory mixture (Freestone 1989). When casting a socketed axe in a bi-valve mould a core and pouring cup are also needed to ensure a good casting. Coghlan (1975, 56) argues that stone moulds had an advantage over clay ones because casting in a clay mould required a new one for each casting. However, in the case of simple moulds without a core – such as the one used in experiment 1 (appendix 1), in which a stopridge axe could be cast – it is sometimes possible to get two or three casting from the same clay mould (personal communication J. Zuiderwijk, 2006). More complex moulds, such as those for socketed axes, are destroyed when removing the cast. Clay moulds were

101 Tylecote 1987, 211-221; Coghlan 1975.

probably the best option to cast objects like spears and swords because the elaborate long form can easily be made into clay.

The *cire perdue* or lost-wax method of casting is also done with clay or loam. The model made in wax is surrounded by clay or loam. The wax is melted out and the form hardens. The artefact is cast by pouring the bronze in the mould. In order to get the artefact out of its form, the mould has to be destroyed. The few recognizable parts of the mould that would survive the casting process are likely to easily disintegrate. Furthermore, when finely fragmented, it becomes hard to indentify the fragments as pieces of a mould.

A fragmented clay mould was found in Cuijk (Fontijn 2002, 138-9; see appendix 2.1). Recently, a second example, made from loam, has been found in Someren (personal communication H. Hiddink, March 2008; see appendix 2.1). I believe this to be a very good example of what one can expect to find. Although the mould is most often destroyed, which could make the pieces more exposed to weathering and more difficult to recognize, surely some pieces would have been preserved if metalworking took place. They were probably abundantly used. This can alsop be deduced from the data in appendix 3. From the sites that may be associated with metalworking, most of them have yielded clay mould fragments.

### 7.5.4 Bronze

Bronze moulds seem rather costly, looking at the amount of metal used for it. It is therefore argued that these moulds are an instrument for mass production (Drescher 1957; Coghlan 1975, 59). Bronze moulds can indeed be used over and over again. If the mass of the mould is great enough as compared with the casting, there is no danger of melting the mould (Tylecote 1987, 210). Bronze moulds too should be pre-heated to a temperature of around 50 to 100 °C in order to ensure a good casting. Both Drescher (1957) and Coghlan (1975) experimented with casting in bronze. In one mould fifteen socketed axes were cast without any apparent damage to the mould itself (Drescher 1957, 74-75). Bronze is very well preserved in all types of soil and thus these moulds are likely to be represented in the archaeological record.

Indeed, in the Netherlands, three bronze moulds have been found (Buggenum, Havelte, Roermond). Two of them come from a wet context. They appear to be deposited. Bronze (and stone) moulds are regularly found in hoards or as stray finds (which also often relates to a 'special' context). As discussed in section 5.9.1 from this it might me surmised that a special meaning was attached to these objects. All three bronze moulds from the Netherlands produce axes. None of them is complete. A thorough description of these moulds is given in appendix 2.1.

### 7.5.5 Sand

Casting bronze in a sand mould is a technique still used today. Even though the 'invention' is ascribed to a much younger period, somewhere at the start of the 18th century (Goldman 1985, 57), I would like to discuss this casting method as well.

> *"Wie leicht aber waren dann entsprechende Befunde bei einer Ausgrabung oder Bergung zu ubersehen, wenn der rest einer Form nichts als ein Haufléin sand is?"* (Goldmann 1981, 110).

As soon as the object is cast and pulled from the mould, the mould will become nothing more than sand again. Absence of evidence however is no evidence of absence and the possibility of casting in sand in the Bronze Age must not be ruled out. Childe already (1963, 31) pointed at the possibility of casting simple artefacts in sand. Recently, Ottaway has delved into the research of casting in sand (Ottaway & Seibel 1997, Wang & Ottaway 2004).

*An enigmatic Bronze container*

In the early summer of 1960 a Bronze Age hoard was found during peat extraction in Holmer Moor near Seth (Germany). The hoard is published in *Germania* (Kersten 1964, 289-90); so only a very brief description of the artefacts is given here. It contained seven stopridge axes, two girdle plates and a bronze container. The bronze container was originally found with a lid, though unfortunately, this has been lost (fig. 7.7). After six years the bronze container, a unique find, was studied again, and the description now included the contents of the bronze container:

> *"Im Innern des Gefässes befand sich eine rotbraune, ziemlich lockere Masse, die den Topf noch etwa zu zwei Drittel füllte"* (Kersten & Drescher 1970, 26).

The assumption was made that the contents might have been a kind of core used in the production of the container itself (Kersten 1964). Kersten and Drescher (1970) however, think that this interpretation is improbable because the barrel shaped container shows almost no production traces and looks fully finished. They argue that it is not a semi-finished product and therefore the content is not likely to be a casting core (*Op. cit* 1970, 27). Goldmann, after studying the contents

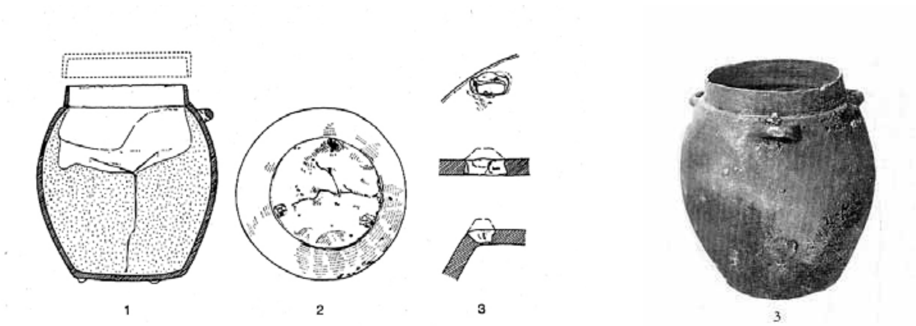



Figure 7.7 The bronze container from Seth, with contents. The container measures 9,3 cm in height. Width varies from 5,1 at the bottom to 8,7 in the middle (taken from Kersten 1964; Kersten & Drescher 1970).

concludes that the sand was heated up to 800 ˚C (Goldman 1981, 109). Accordingly, he advocates that this might be proof of casting in sand and argues that sand casting might even have been the main casting method of the bronze smith. It would, according to Goldmann, also partly explain why there are several tens of thousands bronze artefacts against several hundred moulds. Another argument he put forward is Von Brunn's (1958) research on 237 sickles from the Frankleben hoard. For the sickles at least 182 different moulds were used.

> *"Die Anzahl von mindesten 182 Gussformen spricht ebenso gegen Stein- oder Bronzeformen, so dass von Brunn eben den Guss in Formsand für die einzige warscheinliche Technik für die Fertigung der Sicheln vermutet"* (Goldmann 1981, 115).

Sand casting will leave no traces, but may be the easiest way to cast an artefact fast and in multiple numbers. It especially works well for production of flat objects (Miller 2007, 161). Figure 7.8 shows the practice of sand casting of an elaborate object. Sand is resistant to heat and has excellent casting abilities. Moulds can be rapidly made in sand and easily recycled, which can be seen as a great advantage over stone moulds (*ibid.*). Sand casting, which seems very likely to be practiced in the Bronze Age, remains difficult to prove.

Hopefully, explorations in archaeometallurgy and experimental archaeology (like in Experiment A) will provide ways that make it possible to identify casting methods used. Until there is a sound way to do so, casting sand remains nothing more then a plausible hypothesis.

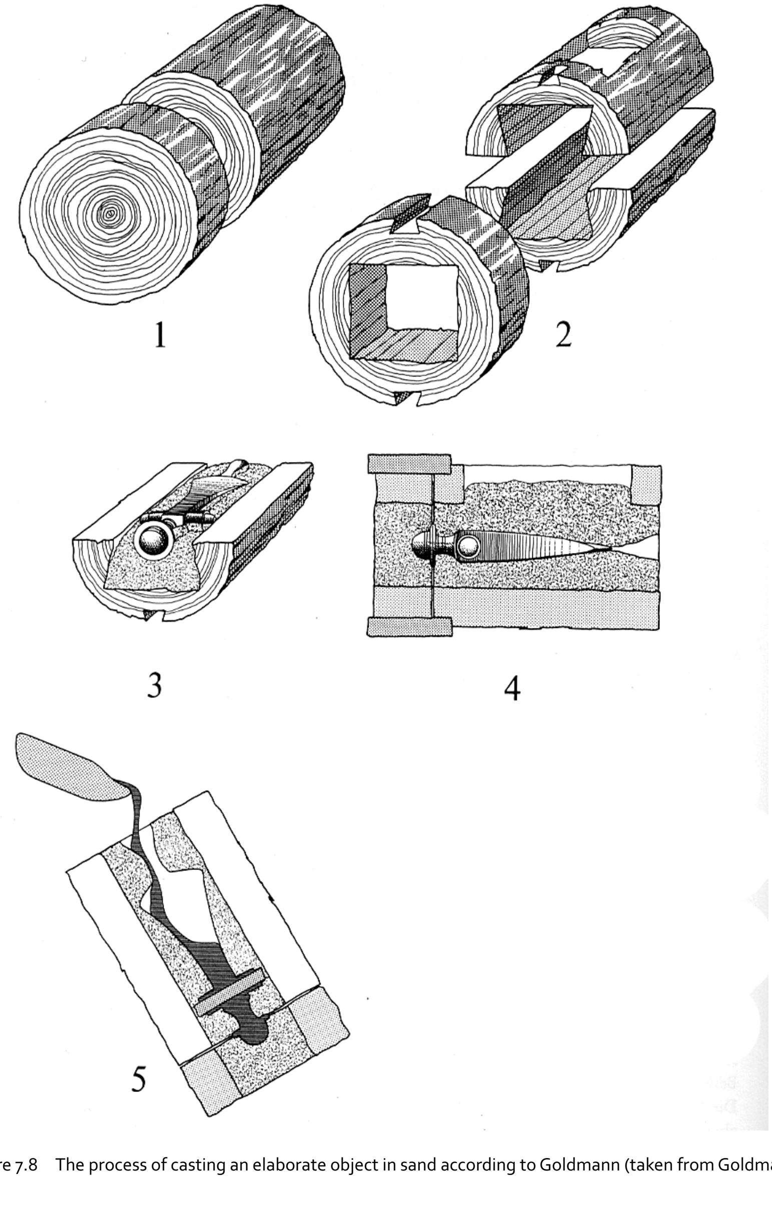



Figure 7.8 The process of casting an elaborate object in sand according to Goldmann (taken from Goldmann 1981).

## 7.6 Droplets of evidence

Besides the artefacts used in the melting and casting, there are of course also waste and by-products related to these processes. The most evident piece of evidence that bronze was melted would of course be the molten metal itself. Not in its finished form, but in a stage which clearly shows that metalworking took place. Casting jets and droplets of bronze may provide us with such evidence. These will be dealt with in the following sections.

### 7.6.1 Casting jets

Casting jets or runners are the by-products of the production of socketed axes, knives or spears in a bi-valve mould and therefore indicative of Middle and Late Bronze Age metalworking practices (see fig 7.9). These 'waste' products however – rather large pieces of bronze – most probably were re-melted instead of discarded (see section 2.4.1; *cf.* Costin 2001, 294). Even so, because they consist of bronze I would regard them as one of the objects that archaeologists are most likely to find, for they preserve rather well. In a secure context they may represent strong evidence for metalworking. Problems do occur, however.

Firstly, most of the bronze objects recovered are not found by archaeologist. Looking at the primary find provenance of the bronzes from the Southern Netherlands (Fontijn 2002, 39, fig. 4.1), only around 5 % is found during excavations. More than 70 % is found by amateur archaeologist, metaldetectorists and laymen. Whilst these persons would recognize the importance of an axe,

Figure 7.9 A casting jet; still attached to the mouth of an experimentally cast socketed axe (photograph by J. Zuiderwijk) .

spear or sword and report it accordingly, one may doubt whether they would also see the value of reporting such a meaningless looking object as a casting jet. I have tried to tackle this problem by publishing an article in *The Detector Magazine* (Kuijpers 2007) in the hope that metaldetectorist would recognize casting jets in their finds. Several casting jets were reported but none could be recognized as a Bronze Age casting jet.[102] The second problem concerning casting jets is that *if* they are found, without a clear context it is almost impossible to date them properly. Thirdly, casting jets cannot be associated to actual metalworking in the same area *sine qua non*. This causal relation is likely but casting jets may of course also have been traded as scrap (such as in the hoard from Drouwenerveld; van den Broeke 2005, 604) which may mean nothing more than that there was a supply of bronze. Eight casting jets are known from the Netherlands, these are discussed in detail in appendix 2.2.

### 7.6.2 Bronze droplets

During the experiments that I have attended, the pouring of the molten metal into the mould was not perfect. Drops of molten bronze fell on and next to the mould, coagulating into small bronze droplets. Obviously, this happened in the Bronze Age too. Although most bronze droplets were probably picked up and re-melted again, bronze smiths surely must have missed some. The presence of small bronze droplets would therefore represent the most solid evidence for metal production at a site. This does not mean, however, that they are easily found in the archaeological record. Because of their size, these bronze droplets are very easily missed. Moreover, such small objects can only withstand minor oxidation and bronze rot before disintegrating completely. Although metaldetectors have become very sensitive and widely used on excavations nowadays, these have only been developments of the last decade. Many droplets may already have been missed and even now, metaldetecting does not offer assurance that bronze droplets are found and recognized. Furthermore, they, of course, are also only meaningful if found in a securely dated context. A couple of sites have yielded bronze droplets: Nijmegen-Hunerberg, Meteren-De Bogen site 29 and possibly Maastrich-groeve Klinkers (Fontijn 2002, appendix 8). They are discussed in the appendices (2.4).

## 7.7 Concluding remarks: the ephemeral nature of metalworking evidence

It this chapter I have looked at the process of melting and casting bronze and the traces it leaves behind for archaeologist to find. In table 8.1 the observations are summarized. It is clear that the preservation of artefacts related to metalworking processes is rather poor. Archaeologists should not expect too much evidence from melting and casting bronze, but scarce clues might give an indication that these processes have taken place. Fragments of clay moulds are most likely to turn up, considering all the factors influencing the recovery change. This is supported by actual metalworking evidence found at other sites in North-West Europe (see appendix 3). Casting jets, due to their durability, are also very likely to turn up. If not brought to the attention of an archaeologist however, they most likely will go unnoticed. Bronze droplets on newly excavated settlement sites, although there preservation is poor, I regard as one of the most promising finds. Use of experienced metaldetectorists is a must; otherwise these tiny clues are likely to be missed.

102 I based the possibility that the casting jet dated to the Bronze Age foremost on other finds from the same site. Form, similarity to other known Bronze Age casting jets and patina played a lesser role but was also looked upon. Because casting jets found by detector amateurs would always be out of context and thus extremely difficult to date, this article was meant to assess how much possible Bronze Age casting jets may have been found already in contrast to the very few found by archaeologists. I expected several but this turned out not to be the case.

# 8 Fabrication and treatment of non-molten metal; hot and cold working. The tools of the bronze smith

*"Einem Fingerabdruck gleich hinterläßt jedes Werkzeug unverwechselbare Spuren, aus denen auf den Herstellungsprozeß geschlossen werden kan"* (Armbruster 2001, 7).

## 8.1 Introduction

Beside moulds and crucibles, the tools used for metalworking must have comprised out of many, more permanent, implements. Although important for fine-working and finishing of newly cast bronze objects, the tools used for this production stage are rarely studied in a similar degree as other aspects of metallurgy. This could be a result of the problems interpreting definite metalworking tools and the marginal amount of tools founds. One of the reasons may be found in the possibility that tools were re-melted. An anvil is a store of quite an amount of metal (Ehrenberg 1981, 14; see section 2.3). Not all the tools were made out of metal, however. Recognition of metalworking tools may also play a substantial role (Kienlin 2007, 5). A good example is the small anvil found in a cremation grave in Lachen-Speyerdorf (Sprater 1929). This anvil was mistakenly seen as a lead ingot in 1929 and therefore went unnoticed until Sperber (2000) recognized it as an anvil. Although we know how metal was worked and which technologies were employed[103] we still do not know a great deal about the tools used in these technologies. Only a few scholars studied the tools themselves, such as Ehrenberg's (1981) and Needham's (1993) work on anvils, Hundt's (1975, 1976), Jockenhövel's (1982) and Doumas' (1998) studies on (socketed) hammers and Thevenot's (1998) and Pernot's (1998) study of the organization of a smiths workshop. A nice overview is given by Coghlan (1975, 90ff) and, more recently, Armbruster (2001). In the following paragraphs I will try to construct a distinct metalworker's *toolkit.* Given that we only expect a small-scale production with simple objects for the Netherlands, I will not elaborate too much on the highly specialized metalworker tools and focus mostly on the most common tools, with the anvil and hammers being the most important tools (see below). I make no claim to completeness: the same ends could probably be reached by several means and therefore many features of metalworking technology remain uncertain. First, some problems considering this approach are discussed.

## 8.2 Specialist tools and all-purpose tools

Most of the known smith tools have been found in hoards, such as the one from Bishopsland (Eogan 1964), which included an anvil and flat chisel next to seventeen other bronze objects. Several hoards have been found in France, including the sizable depot of Saône-et-Loire (Thévenot 1998). This hoard seems to represent a whole workshop, comprising tools such as punches, socketed hammers, several different anvils as well as moulds, unfinished artefacts and scrap bronze. It has greatly improved our knowledge of how a workshop may have been organized and which activities were undertaken (Pernot 1998). Although much information can be gained from such hoards, it is questionable how useful that information is when focusing on the Netherlands. Almost all studies deal with tools that are used in gold-working, sheet bronze working or decoration. None of these are necessary in the production of simple tools such as axes. They are meant for highly

103 Thanks to detailed researches on how artefacts were produced (*e.g.* Drescher 1962; Holmes 1978; Armbruster 1998; Wunderlich 2004).

specialized (fine) working of metal. Tools like punches, gravers, and tracers, are decorative tools and thus, unless the Dutch metalworking tradition is far richer then expected, not very probable in the Netherlands.[104] These tools may not be representative for a 'normal' smith, whom is involved in the haphazard production of some simple objects. Given the range of objects found in the Netherlands and the local production that, according to the regional types recognized by Butler, does not comprise more elaborate objects than sparingly decorated axes, knives and omega-bracelets, it is highly unlikely that these special kind of tools will turn up here. To find out which techniques and tools were actually used, the best approach would be by metallurgical research both on the macro and micro level because:

> *"Werkzeuge zur plastischen Metallbearbeitung sind im algemeinen kaum im archäologische Fundstoff vertreten. Dagegen sind die von ihnen hinterlassenen Spuren stets an den Metallartefakten zu beobachten"* (Armbruster 2001, 7).

If the object is not too badly damaged or corroded, obvious traces of hammering and/or decorating can easily be distinguished. It is also possible to determine manufacturing techniques by using metallography. With this technique a piece of bronze object is ground flat and polished. The sample can then be etched to reveal the micro-structure of the metal, which is examined with the use of an optical or electron microscope. This reveals the microstructure or 'flow' of the metal. Hot or cold forging can be recognized in the lines of flow within the metal (Coghlan 1975, 90). It is also possible to determine if the object was cold-worked (hammered) and subsequently annealed. Unfortunately, for the Netherlands, such analyses have only been done for metalwork belonging to the Bell Beaker and Early Bronze Age (Butler & Van der Waals 1966).[105]

Coghlan (1975, 91) doubts whether much heavy forging of bronze took place because (except in the case of flat axes) most of the objects would be cast in nearly perfectly desired shape. Nonetheless, for the mould of Oss (appendix 2.1) it is likely that the pin of the wheel-headed pin was hammered out. The mould of an urnfield knife from Someren (appendix 2.1) although it is not complete, must have been hammered, either to extent the blade to its right shape or at least to improve its hardness. Moreover, re-sharpening of axes would also have involved hammering and many of the Dutch axes show such traces (Butler & Steegstra 1997/1998, 165). Hammering of axes in order to re-sharpen them however, is no evidence for production. Still, if any post-casting activities took place, cold-working (hammering / forging) would be among them, for it increases the hardness and sharpens the cutting edge.

## 8.3 Interpretative problems

A more complicated problem lies in the fact that many of the tools that could be related to metalworking, such as awls, chisels, anvil stones and hammers, also function in a whole array of other crafts. As such, relating them to anything more specific than 'crafting' is difficult. Many hammer and anvil stones have been found in the Netherlands, but, apart from the Bell Beaker cushion stones, they have never been associated to metalworking (Butler & Van der Waals 1966). However, some of the sites that yielded these artefacts, such as Meteren-De-Bogen may have seen metal production. Use-wear analysis of hammer-, whet-, polishing- and anvil- stones might reveal

104 Besides decoration on Omega bracelets and the VVV-axes no regional objects have been decorated. The decoration of the VVV-axes, however, were probably made in the mould and thus formed during casting.

105 Research in this area could be extremely useful and with facilities such as the technical university in Delft, more can and should be done on this kind of research.

that they were indeed used on metal. Unfortunately, use-wear analysis, so far, has mainly focused on the production and use of flint.

Another problem, already partly mentioned in the previous section, is the fact that an anvil and hammer are not necessarily associated with production. Although they are plausible indicators they cannot be seen as guide-artefacts for metalwork production. Re-sharpening of tools and weapons would also have been done with the same tools. This may even be a very common practice as it prolongs the use-life of these artefacts. For both reasons described above, these metalworker tools alone are not indicative of metalworking in the strict sense of production.

## 8.4 Anvils[106]

### *Bronze anvils*

Presently 65 bronze anvils are known in Europe (Jantzen 1994 cited in Armbruster 2001, 14).[107] No clear typology or chronology is available although they are grouped into 'simple', 'beaked' and 'complex' types by Ehrenberg (1981, 14) or into anvil families by Armbruster (2001, 15 ff),who identifies *'Brettambosse'* (simple, flat anvils), *'Riefen- und Kugelanken'* (anvils with negativs in them), *'Steckambosse'* (with a hinge to secure it to a wooden block), *'hornambosse'* (anvils with a horn) and *'Treibfäuste'* (fist-like anvils used in the production of cauldrons and bronze pots). They first appear in the later Middle Bronze Age, but most of them are dated to the Late Bronze Age. Given the size of most of these anvils (rarely exceeding 10 x 7 x 4 cm, *cf.* Ehrenberg 1981, 26-7) it is unlikely that they were used for heavy duty work. Indeed, analyses on some of them revealed tiny gold particles still embedded in the anvil (Needham 1993; Sperber 2000, 391), indicating the working of gold rather then bronze. The majority, if not all, of these bronze anvils are meant for delicate decorative work and therefore they may not have been abundant during the Bronze Age. In addition to possible re-melting, this may explain why so few are found (Ehrenberg 1981, 14).

A possible bronze anvil in the Netherlands may be the fragment of a Grigny-Swalmen axe found in Baarlo (Butler & Steegstra 1999/2000, 134-135, cat. No. 451). This axe may have been secondariliy used as an anvil (fig. 8.1).

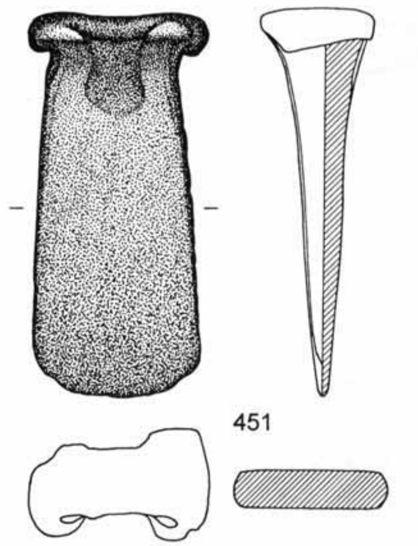



Figure 8.1 Half of the blade of a Grigny-Swalmen axe; it seems that this axe was (re-)used as a wedge, hammer or anvil. Scale 1:2 (taken from Butler & Steegstra 1999/2000).

106 Ehrenberg 1981; Needham 1995; Armbruster 2001, 14ff; Coghlan 1975, 94ff.

107 Also to appear as *Praehistorische Bronzefunde XIX, 2*

### *Stone anvils: cushion stones and other anvil-like objects*

Since these bronze anvils were possibly not used by regular smiths, something else must have functioned as blow-receptor. The cushion stones found in the Bell Beaker graves of Lunteren and Soesterberg (and as stray finds), are interpreted as metalworker tools (Butler & Van der Waals 1966; Butler & Fokkens 2005, 384). There are aspects that raise some doubts, however. First of all, the cushion stones are rather small, which does not make it easier to use them as an anvil. They date to the Bell Beaker period and Early Bronze Age in which flat axes are common. These flat axes needed the most cold-working (Coghlan 1975, 91). Yet, the cushion stones found in the Netherlands show only minimal traces of pecking and hammering. Even more so, they are polished and the edges are nicely rounded, something which would seem unnecessary if the purpose was to mainly use them as blow-receptors. They may have only functioned in the working of gold and possibly pure copper.[108] From the Early Bronze Age onward these cushion stone disappear and other, more irregular stones might have been used as anvil. Though, it seems that for these kinds of anvils (fig. 8.2 & 8.3), archaeologists are very reserved in appointing them to metalworking.

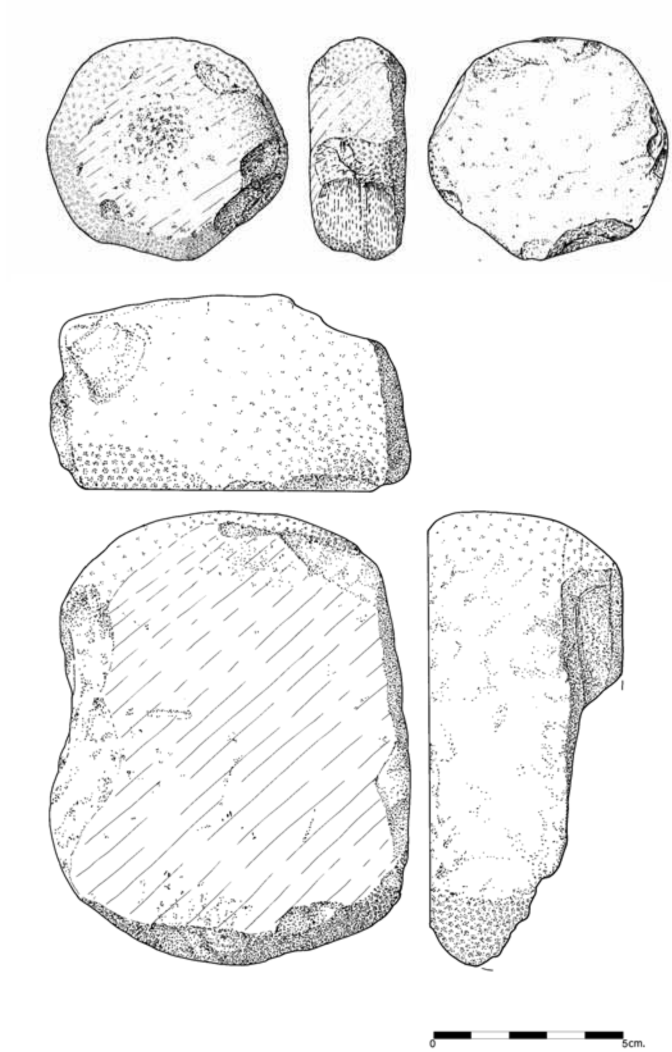



Figure 8.2 & 8.3
Anvil stones found at Meteren-de-Bogen. The stone above has use-wear traces that indicate it was used primaly as grinding stone. After it broke it was secondarily used as anvil and a hollow was formed in the middle. Stones like these were probably used in a whole array of crafts (taken from Van Gijn *et al.* 2002).

108 If these stones truly are the tools of the first metalworkers, it might be that these pioneers indeed did have a certain status because of their capability to work metal. Their tools, subsequently, being an important trademark, which they also took to their graves.

It does however make sense that, at a point where metalworking became a widespread phenomenon and was more and more a normal activity, as advocated in chapter 5, tool use may have become more opportunistic and special, nicely crafted anvils, such as the cushion stones, were not made anymore.

According to Ehrenberg (1981, 14) stone anvils were almost certainly used by tool and weapon smiths for finishing larger implements, such as axes.[109] I agree because the function of an anvil, being a blow-receptor, is not bound to a certain form. The hardness is important, making stone a very likely option. It would also make them very hard to recognize as anvil stone because they may appear in any form. O'Kelly and Shell (1979) discovered two big boulders during their excavations at Newgrange, which they have interpreted as a seat and anvil.

> *"Nearby were two boulders firmly set close together and well bedded into the subsoil surface. The upper surface of the larger of these was almost polished as if from having been used as a seat, while the surface of the smaller one was deeply picked and abraded from having been used as an anvil. There is no evidence to show that the anvil was used by a metal worker, but it could have been so used"* (O'Kelly & Shell 1979, 127).

Although no evidence of metalworking was found in this case, these may very well be the kind of anvils to expect. Why would one want to create (labour intensive) anvil stones (such as the cushion stones) if perfectly usable stones were already available? A good anvil for heavy duty work only needs one property, which is being strong enough to withstand the blows. Anvil stones could, however, have functioned in any other activity which would require a solid surface (*e.g.* polishing, crushing or grinding of stone or food), making them hard to recognize as metalworking tools (*cf.* Kienlin 2007, 5).

## 8.5 Stop! Hammertime![110]

Hammering most certainly would have been part of the metalworking process. The arrowheads and wheel-headed pin that could be cast in the Oss mould all need additional hammering to finish the product.[111] The same goes for the Urnfield knife from the Someren mould. Many Bronze Age axes in the Netherlands show traces of re-sharpening by hammering. For instance, almost all the flanged axes and palstaves from the Netherlands show extensive traces of re-sharpening trough hammering, but also many socketed axes have so-called 'pouches' and a J-formed blade, indicating heavy hammering (Butler & Steegstra 1997/1998, 165). These axes were very likely hammered and subsequently annealed in order to harden the hammered blade.[112] Kienlin and Ottoway (1998) convincingly demonstrated that even limited cold working of an axe significantly increases the lifespan of the blade.

Many of the axes labelled regional by Butler also show other traces, such as hammering and grinding to remove the casting seams. Surely, hammers would have been used by the smith who produced these axes. These hammers are most certainly made out of a hard, durable material and therefore archaeologist should be able to find them. Several possible tools that could have functioned as hammers will now be presented.

109 Ehrenberg (1981, 14) even opts that wood may also have been used as anvil.

110 Coghlan 1975, 94ff; Jockenhovel 1982; Hundt 1975; 1976; Armbruster 2001, 11ff; title from Mc. Hammer 1990.

111 Only a small part of the pin was cast, the rest had to be hammered out. The blade of the arrowheads is very small and would probably need hammering after the cast.

112 Hammering copper makes it brittle. This can be solved by annealing, by which the crystalline structure is restored.

### 8.5.1 Metal hammers

272 socketed hammers are listed by Jantzen (1994 cited in Armbruster 2001, 13). These socketed hammers are tools that appear to have been especially designed for the job. Jockenhövel (1982, 459-461) lists six different types, all with different characteristics when used. Two of them (type 5 and 6) may have had the additional function of an anvil. They were probably used in sheet bronze working, for most of them are rather light and thus not very well suited for heavy duty work (Jockenhövel 1982, 461). These socketed hammers are dated to the Late Bronze Age. According to Hundt (1975, 116) the hammer of the Early and Middle Bronze Age must be found in either unknown bronze examples or was made of stone. Because bronze or copper hammers could be re-melted, he believes that particularly the stone hammers must be present in the archaeological record (Hundt 1975, 117). Hundt also tried other materials, such as bone and antler as hammers in experiments, but these do not have enough mass to effectively hammer-out the blade of an axe (*ibid.*). He states that bronze axes showing a (deliberate) flattened edge should be (re-)interpreted as hammers. A year later Hundt (1976, 117) argues that the flat axe from the Meckenheim hoard is a hammer instead of an axe. This hammer, however, which is of a heavier type, is also not heavy enough to have produced the traces found on many of the larger objects (*Op. cit*, 121). Therefore, he advocates that the heavier hammers must have been made from stone, but also tentatively suggests lead as an option. Lead has an ideal mass to function as a heavy hammer. They would completely lose their form when used due to the soft nature of lead, but can easily be re-shaped or even completely re-melted and formed again (*Ibid.*).

Two possible hammers are found in the Netherlands. The copper axe (fig. 8.4) with blunted cutting edge (Butler & Steegstra 1995/1996, cat. No. 1) could have secondarily been used as a hammer following Hundt's (1975; 1976) arguments. Furthermore, Butler & Steegstra (2003/2004, 242) themselves opt for the possibility of a hammer for cat. No. 669: "*the lower part of the blade have been sawn off and the object has apparently been secondarily employed as hammer.*" Unfortunately, this object has been lost during house removal (fig. 8.5 ).

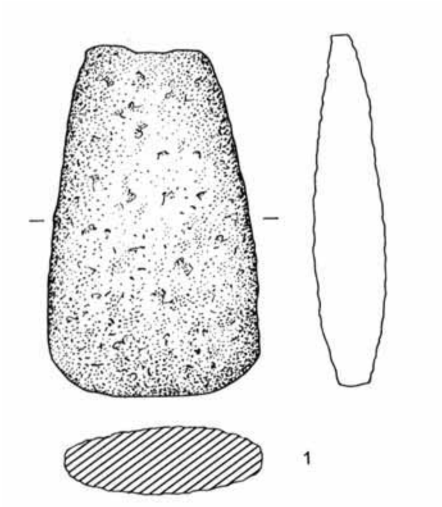



Figure 8.4 As the cutting edge of this flat axe is battered it may have seen action as some sort of hammer. Scale 1:2 (taken from Butler & Steegstra 1995/1996).

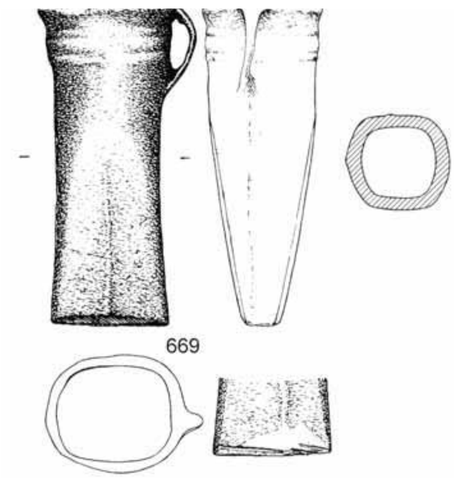



Figure 8.5 The lower part of the axe has been sawn of and the object has been secondarily employed as a hammer. Scale 1:2 (taken from Butler & Steegstra 2003/2004).

### 8.5.2 Stone hammers, hammer-axes and the battle axe

Stone hammers seem to be the most likely candidate for the heavy duty hammering of bronze and copper. The aforementioned Late Bronze Age hoard of "La petit Laugère" Saône-et-Loire indeed contains a simple stone hammer alongside all kinds of specialist smith's tools (Thevenot, 127-8, fig. 3 no. 4). The hammer looks like a Neolithic axe cut in half. Butler & Van der Waals (1966, 63-75), through comparison with known metalworker's implements from Peru, also recognized this form of hammer as a metalworker's tool. Hundt (1975, 115), inspired by Butler's article, gives several other examples, of which the functionality was tested by experiments. As with the bronze axes, he is convinced that many of the stone axes are actually hammers.

> *"Die oft großen Museumbestände an Einzelfunden von Felssteingeräten enthalten nicht selten kleine trianguläre "beile", die nicht für ein Biel zu fordernde scharfe Schneide besitzen, sondern deren Schneide im rechten Winkel zur Gerätachse abgeschliffen ist, so daß die Stelle der Schneide eine etwa ovale, völlig ebene Fläche einnimmt"* (Hundt 1975, 116).

Hundt, however, assumes that there must have been even heavier examples.

> *"Die Schlagspuren, die sich an den Kupfer- und Bronzebeilen finden, setzen Hammer eines gewichtes voraus, wie es die hier nachgewiesenen kleinen, mehr oder weniger trapezoiden Steinhammer nich bieten konnen"* (Hundt 1975, 117).

Possibly, also the pierced hammer-axes like were used for metalworking. The typology and dating of such axes can be seen in figure 8.6. During the Neolithic (as well as the beginning of the Bronze Age) they are mainly found in graves, but in later periods they appear in settlements and, because of their assumed utilitarian function, they were labelled *arbeitsaxe* (see below; fig 8.6 type 14).

The axes of the Single Grave Culture are seen as battle-axes instead of a utilitarian tool (Butler & Fokkens 2005, 395). Doumas, however, doubts this interpretation:

> *"Among the objects that I believe are victims of misnomer, is the stone artefact established in the archaeological literature as the "battle axe". This name is so closely identified with its interpretative content that is precludes any thought on a different use [ …]Here we must face a depressing possibility that has been lurking in the background, namely that our splendid battle-axes with which our Indo-Europeans are supposed to have fought their way through Europe were nothing more than tools of miners, masons and carpenters"* (Doumas 1998, 157-159).

Doumas has examined the relationship between these hammers and early metallurgy in Greece, and has forwarded a reasonable argument. First, these axes are cleverly designed tools. Early metalworkers had achieved the ideal form for controlling the accuracy and the impact of the blow (Doumas 1998, 160). Second, he also notes that several half-fabricates were found in the supposed smith's workshop at Pliochni, Lemnos (Greece). Lastly, they are very alike the later Roman smith's sledgehammers. Doumas also argues that this "magical" tool had such a considerable importance that it was decorated and buried with the dead (*Op. cit*, 161).

> *"Consequently its spread in Europe – and indeed as a grave good – could easily be interpreted as an indicator of the spread of metallurgy, particularly the technique of hammering"* (Doumas 1998, 161).

A difficult problem with this theory, is that the battle-axes belongs to the Late Neolithic and that either the dating of these axes or the appearance of metalworking need to be adjusted in order to fit his theory.

Doumas tried to solve this problem by arguing that the axe was given a "different" treatment in northern Europe, which it reached before the advent of metallurgy (*Op. cit*, 161). Use wear analyses of these axes might give an answer. If the Greek examples indeed show traces of metalworking his theory would gain credibility and it may be worthwhile then to also examine the examples from northern Europe. Until, his theory of the battle-axe as metalworker's tool seems too far fetched.

The successors of the 'battle-axe' are less problematic as they occur in a period in which metal was widely used. They appear in settlements and are ascribed as work-axes (*arbeitsaxe*) rather than battle-axes. They are given this function because bronze weapons would have taken over the function of the battle-axe (Butler & Fokkens 2005, 396). They are thought to have mainly been used in woodworking, but, since bronze axes would also have been available for this work I think other functions must be considered too. They may also have been used in metalwork-related activities. For instance, the blunt side of the *arbeitsaxt* or Baexem type (fig. 8,6 type 14 and 15) could have easily functioned as a hammer. Again, use wear analysis in combination with experimental archaeology may in the future confirm or refute this assumption.

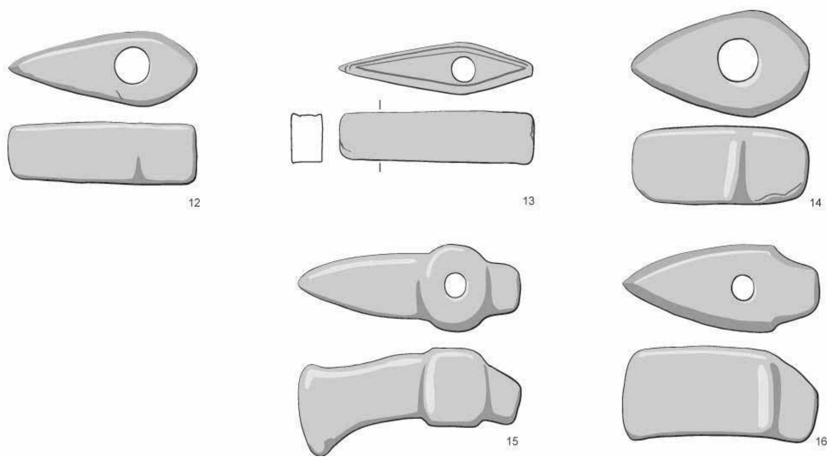



Figure 8.6 Axes from the Bronze Age and Early Iron Age. 12: type Emmen, 13: type Zuidvelde (2000-1800 BC), 14: Arbeitsaxt (1800-1500 BC), 15: type Baexem, 16: type Muntendam (1000-400 BC). Scale 1:6 (after Butler & Fokkens 2005).

### 8.5.3 Hammer-stones

Although form, weight, and material thickness, all have their implications on the effect a hammer has (Armbruster 2001, 11) this seems primarily important for precision working. When cold-hammering the blade of an axe, the main factor is to have a sturdy hard material that can deliver hard blows and has enough mass. Hence, in essence, every piece of hard rock would do. The main difference between the hammer-stones and the stone hammer(-axe) dealt with above, lies in the fact that these are hafted, while the hammer-stone is a very rudimentary tool worked from the hand.[113]

113 Butler seems not to distinguish between stone-hammer and hammer-stone. The conical hammer (Butler & Van der Waals 1966, 68-9, fig. 14 No. 7506) is described as both a stone hammer as well as hammerstone (*Op. cit,* 133). I would say it belongs to the stone-hammers; it was probably 'hafted' by fastening handles of wood in the groove (*cf.* O'Brien 1994, 130 fig. 60).

Many of the hammer-stones found are simple, round, water-rolled stones.[114] These stones might also have been used in metalworking, next to other functions. Though, this assumption can also only be confirmed by use-wear analysis.

## 8.6 Grinding-, whet- and polishing stones

Grinding-, whet-, and polishing stones constitute a group of tools that are related to each other and thus intermediate forms may occur. In Dutch literature both the term "*wetstones*" as well as "*slijpstenen*" (sharpening-stones) is used (*cf.* van Gijn *et al.* 2002). They can both be described as whetstones but the first group, "*wetstones*" in Dutch, are small enough to be handheld (and carried along) as where the latter (sharpening-stone) is a stationary stone. Grinding stones could also have functioned as a coarse whetstone and even as an anvil (O'Kelly & Shell 1979, 127). All these stones are used to shape, crush, retouch and (re-)sharpen materials like bone, stone, flint, pottery, foods and possibly metal. It is, unfortunately, difficult to empirically proof the latter usage. Until today, function-analyses and use-wear analyses on these kinds of stone tools has been limited to the their use in stone axe production (Van Gijn *et al.* 2002, 511). It is likely however, that metal will leave a different polish then other materials. The metalworking locus found in Feudvar (Kienlin 2007) shows grinding stones with metal particles embedded in it. Unmistakeably, these stones have been used in the metalworking process (Kienlin 2007, 5).Yet, the problem remains that sharpening and polishing of metal does not have to be considered as clear evidence for production (see section 8.3).

## 8.7 Decorative tools and other small implements[115]

### *Punches*

Punches were used to decorate sheet bronze (Armbruster 2001, 19). They acted as a stamp. Some examples are found, mainly in France (Briard 1984). Punches are clearly tools belonging to a more specialist form of metalworking, which I have argued was not common during the Bronze Age in the Netherlands. These tools are one of the few finds however, that can more reliably be associated with metalworking, as this kind of decoration is seen very often on bronzes.

### *Chisels*

Chisels may have functioned as a tool to cut the runners and/or casting jet from the cast. They can also have had a decorative function (Armbruster 2001, 19) although this is doubted by others (Coghlan 1975, 99; Drescher 1957) because working bronze with bronze is considered as problematic by them. Plain chisels make up the majority of the archaeological record on bronze tools, yet some bear marks. Chisels would have had several different functions of which woodworking was probably the most important. Chisels also may have had a function in leatherworking (Roth 1974, Burgess & Cowen 192, 217-128).

### *Awls and tracers*

An awl is used to pierce holes through leather, wood or cloth. In metalworking they may have been used for decoration, although it is questionable whether such a thin bronze tool could have been used on other bronzes (*cf.* chisels). It may have sufficed for decorating very thin pieces of sheet bronze, but it seems rather unlikely that awls were crucial to the production or decoration of sturdy objects like axes.

114 So-called pecking stones ("*klopstenen*") can also be accounted to the group of hammer-stones.

115 Armbruster 2001, 19ff; Coghlan 1975, 97ff; Braird 1984.

Tracers are awl-like objects used to incise pieces of sheet bronze. They 'cut' the bronze rather then indent it. The tip has to be very hard in order to perform this task without damaging itself. These tools were therefore probably only used in decorating thin sheet bronze work or a softer material like gold.[116]

*Tongs*

If a bronze object is heated in order to re-work it, it must be held or picked up with some implement. Most probably this would have been wooden sticks or alternatively withies, but tongs made of bronze could also have functioned as such. The tongs could also have functioned to pick up the crucible containing molten bronze. Only a couple of bronze tongs are known thus it is unlikely that examples will turn up in the Netherlands.

## 8.8 Constructing a metalworker's toolkit

Although there are some tools, such as the bronze anvils and punches that can relatively sure be associated to metalworking, they were most likely part of a specialist's toolkit and may not be representative for the everyday smith. The anvils and hammers most common in the Bronze Age would have been stone specimens, such as the cushion stones. The problem is that they could have been all-purpose tools and function in a whole array of 'crafts' ranging from food-processing to the grinding of stone axes. Recognizing *the* anvil or hammer of a metalworker in the archaeological record is therefore problematic. Furthermore, many of the tools described above, even if they can be associated with related activities (grinding, polishing, hammering of metal) they do not necessarily also point at metalworking production (*i.e.* melting and casting).

Given these difficulties it seems that these tools are not going to be very helpful in locating the bronze smithy. Yet, while these objects on their own do not provide much information, together they could be indicative of metalworking. Archaeologists may assume, or at least be watchful of, the presence of a metalworking locus on the basis of a distinct *toolkit*. This toolkit could consist of all the abovementioned equipment but most likely would comprise an anvil, stone hammers, some whet- and polishing stones and maybe some implements for decoration. If several of these implements from a metalworker's toolkit are found on the same site, possibly together with other clues such as bronze(s) (scrap), hearths and burned clay, it would most definitely be worthwhile to study the tools more thoroughly on use-wear to see if any metalworking traces remain.

## 8.9 Concluding remarks on the tools of the smith

Table 8.1 shows, besides the evidence that would remain from melting and casting, all the artefacts that may be related to metalworking. In this table a distinction has been made between the preservation and expectation. The former is the probability that these objects are preserved in the ground, which can be deduced to a certain degree. The latter, expectation, also tries to account for a 'human factor'. That is, the possibility that they are found, recognized, and interpreted as metalworking tools by archaeologists. As we have seen in both chapters 7 and 8, part of the problem may lay here.

As mentioned above, only a few of the implements listed are typical for metalworking. A hoard like the one from Deurne (Butler 1963a, 126 ), containing two chisels and a gouge, is therefore nothing more then a hoard containing craftsman tools with a tentative indication that they may have also had something to do with metalworking. The scholar studying woodworking, however, would suggest that they are woodworking tools.

116 The enigmatic iron awl/tracer found in Emmen may have functioned as a decorative tool (Van der Waals 2001).

| Process and related artefacts | | Preservation | Expectation | Remarks |
|---|---|---|---|---|
| Supply | | | | |
| Ingot bronze | | high | high | |
| Melting and casting | | | | |
| Furnave | smelting | moderate | low | only in metalproducing areas |
| | Melting | low | nil | Too small and shallow to manifest itself. Highly ephemeral. |
| Bellows | bellows | very low | nil | most likely made from organic materials |
| | air-pipe | very low | nil | most likely made from organic materials |
| | tuyeres | moderate | low | Baked, but may be difficult to recognize when broken |
| Crucibles | | moderate | moderate | Baked to the point of vitrivication |
| Moulds | stone | high | high | deposited; often stray finds |
| | clay | moderate | low | destroyed in the process. Pieces difficult to recognize. |
| | (form)sand | nil | nil | |
| By products / waste | casting jets | high | moderate | recognition and dating is a problem |
| | bronze droplets | moderate | moderate | easily missed |
| Metalworkers' toolkit | | | | |
| Anvils | "cushion stones" | high | high | |
| | bronze | high | moderate | |
| | stone | high | high | Multi-purpose tool |
| | wood | low | nil | Multi-purpose tool |
| Hammers | metal | high | moderate | Multi-purpose tool |
| | stone (hammer-axe) | high | high | Multi-purpose tool |
| | hammer-stones | high | moderate | Multi-purpose tool |
| grinding-, whet-, and polishing stones | | high | moderate | Multi-purpose tool |
| (Decorative) implements | punches | high | moderate | |
| | chisels | high | moderate | |
| | awls | high | moderate | |
| | tongs | high | low | |
| | tracers | high | moderate | |

Table 8.1 Metallurgy related artefacts and debris. Preservation is a guesstimate on the likelihood that the artefact is preserved in the ground. Expectation takes into account that an artefact also has to be discovered, recognized and associated with metalworking by an archaeologist.

The conclusion from this chapter seem to reconcile with an observation made by Costin that the tools used in non-industrialized craft production were

> *"tools either made of perishable materials or were nearly identical in form to tools (such as cutting implements, perforators, polishers, scrapers, grinding stones, and hammerstones) used in other activities"* (Costin 2001, 294)

In constructing a *toolkit* I have tried to tackle this problem. I think this toolkit, in contrast to single objects, is a much stronger indication and argument for the presence of metalworking.

Use-wear analyses and experimental archaeology could proof extremely useful here. Although the tools may have served several functions at the same time, metalworking may leave distinct traces on the hammers, anvils, whet- or polishing stones and this could help archaeologist to recognize them as metalworking tools. Alas, as long as we cannot recognize traces of metalworking, these finds remain an *indication* and not *evidence* for metal production.

# 9 Conclusions: Bronze Age metalworking in the Netherlands

## 9.1 Introduction

I this thesis I have tried to look at both the social as well as the technological organization of metalworking in the Bronze Age, with particular reference to the Netherlands. My approach entailed a re-evaluation of the current theories on metalworking, which I believe to be unfounded and one-sided: they tend to disregard production of everyday objects of which the most prominent example is the axe.

With the use of data from metalworking debris found at other sites in North-West Europe, experimental archaeology and a literature study, a less one-sided approach is postulated. Furthermore, I have looked upon the processes and tools that comprise metalworking and if, and how, these can be traced by archaeologist. I have tried to found all these aspects on archaeological data as much as possible. Experimental archaeology was also of importance, especially in chapter 7. The last two chapters (7 & 8) examined the legacy that the bronze smith would have left during the practising of his craft. For the tools I have constructed a metalworking toolkit. These findings are summarized in table 8.1 and may help archaeologist to recognize the production locus of the smith.

## 9.2 Who crafts? How is metalworking organized socially and what can we say about the social position of the smith?

*Current theories / former research*

Theories on the organization and social position of the Bronze Age smith appear mainly to be founded on ethnographic examples or are a continuation of the grand-narrative styles, started by Childe, in which bronze and hence the bronze smith play a central role. While the detribalized and itinerant smith presented in the works of Childe has been dismissed, the social position of the smith still seems to be painted in terms of specialization, specialism, skill, knowledge and rituals. In order to study whether this image on the Bronze Age smith holds true in the archaeological record, I have first defined what these terms mean and how they can be used.

*Theoretical approach*

Ritual and the recognition of ritual in the archaeological record appear to be the most problematic. Defining ritual beforehand means that etic categorizes are constructed and one can doubt whether these tell anything about how prehistoric people perceived their world. In this manner, ritual becomes an analytical tool to survey the archaeological data and patterns are 'constructed' rather than actually apparent from the data. The archaeological record should be engaged in an emic way as much as possible for the categories that were made and meant something to prehistoric people are the most informative to archaeologist. Interpreting patterns will remain an etic practice, however, because it is done by us.

The ritual and domestic are by no means clear-cut categories. Rather they tend to be interwoven. Technology in small-scale societies is often regulated and organized by what we would call rituals. Nonetheless, to the people involved both the ritual as well as the functional acts are all part of one and the same process. This does not mean that archaeologist cannot use the term ritual. If a specific act is singled out we may well describe it as a ritual. However, this 'act' should also be placed in its context, which often is a mundane practice. Depending on the level (context) on which the interpretation takes place, it will always be partly concealing and partly revealing.

The core idea of specialization is that fewer people make a class of objects than use it. To be able to make a distinction between household production and workshop production I have added to this definition that specialization is also about the separation of tasks within a social system. No absolute measurement on the level of specialization can be made, but we may discern degrees which range from full-time (workshop) to part-time (household) smith. Specialization is not to be confused with specialism. Being a specialist or master smith is about skill and does not inherently mean specialisation. Although it is likely that the full-time smith is more skilled, production might limit itself to simple everyday tools. To determine the skill or quality of an object is a highly subjective assessment. Hence, no methodological practice can be established to make absolute measurements on specialism. Nonetheless, it is possible to distinguish objects relatively from each other. Producing a functional axe requires less skill than the production of a ceremonial sword. For the latter it is also more conceivable that rituals were involved, as production of prestige goods often encompass certain rituals. Lastly, skill is not to be confused with knowledge. While the latter may be 'available', the first can only be learned.

### *The archaeological record*

I have argued that the highly specialised image of the bronze smith appears to be unfounded and stems from our view on metal and its value. This view is biased by scholarism, the archaeological record and the pre-occupation with a special class of objects. The ritual aspect of metalworking is often stressed, but when scrutinized, there is very limited archaeological evidence that metalworking indeed was a ritual practice. No distinct pattern of 'ritual' metalworking can be discerned from the available archaeological data. From ethnographic and anthropological examples it has become clear that metalworking may have been ritualized to some extent, but I doubt whether this differs from any other technology that was practised in the Bronze Age. It is not metalworking *an sich* for which rituals were needed, but the production of a special class of objects (prestige goods), with political and powerful meaning (cf. Helms 1993). These objects can be made from any kind of material. Objects like the Trundholm Chariot or the sword from Jutphaas are objects that may have seen rituals during their production and these would probably have been made by a specialist. The bulk of bronze objects produced in the Bronze Age, however, are regular tools such as the axe, for which it is unlikely that specialist metalworkers and rituals were involved. A very large part of the production of metal tools may have been done by 'normal' farmers next to a range of other crafts.

As I have argued in chapter 2, it is very important to distinguish between smelting and melting. For the first it is much more conceivable that specialist knowledge is needed. Basic metalworking (melting) is possible without having intimate knowledge of smelting, flux or alloys. Melting a piece of bronze and pouring it in a form requires mostly pyrotechnical skills, which had been around for several thousands of years.

The data presented in appendix 3 does not show any evidence for the presumed relation between elites and metalworking as no correlation between elites and specialist metalworking can be discerned. Specialization may be tentatively surmised; there are some sites on which a workshop (area) has been discovered. Though, it remains debatable whether the considerable amount of metalworking debris found on some sites resulted from large-scale metalworking practices or is the outcome of either a hiatus or very good preservation.

### *What can we say?*

The negative evidence for the specialist, high status image of the smith does not mean that no specialist metalworkers were present in the Bronze Age. Even the theory of an itinerant smith may still hold some truth. Travelling long distances does not seem have presented a problem for Bronze Age people. Rituals may also have been involved, either in the production of a special class of objects or as a form of technological organization. There is also evidence for metalworking on specialized locations such as the Kings Stables in Ireland. These are the exceptions however, and no clear pattern can be discerned. Hence, I am inclined to interpret the negative evidence otherwise. Looking at the evidence of metalworking debris in context (appendix 3) and adhering to the discussion both from chapter 3 and 5, metalworking in general should be seen as a mundane and common practice. As argued in this thesis, knowledge of a basic metalworking technology; *i.e.* melting and casting an object like an axe from a piece of ingot bronze, was available to many from an early stage onwards. The lack of evident smith burials could also be explained as a case in point for how metalworking was perceived by Bronze Age people. If the smith truly was a special person, with according high status and power over the arcane practices of metalworking, why is this not transferred to the grave? The status of warrior or chief does seem to be stressed clearly by Bronze Age societies when burying their death. Tentatively this may be an indication that the 'warrior-status' was more important than a 'smith-status' or even that being a smith was not about status at all, but should rather be seen as a normal craft amongst others.

As to the question whether it likely that several Bronze Age communities in the Netherlands were practising metallurgy, I see no reason why this could not have been the case. Determining whether they were specialist or if any rituals were involved is more difficult however. Given that metalworking in the Netherlands has been surmised mostly on the ground of 'local axes' we are most likely dealing with 'everyday' smiths. Hence, Butler's observation that there were a goodly number of small producers working for local offset areas (Bulter & Steegstra 2001/2002, 265) appears valid. Production most likely was in the hands of several craftsmen who practiced the craft of metalworking next to other crafts and the ploughing of their fields. A workshop (*i.e.* large scale production) is unlikely to turn up in the Netherlands. The production locus of the metalworking is to be expected on the farmstead or even in the house itself as only house-hold production may have occurred in the Netherlands.

## 9.3 How does metalwork production work technically? And how does this process manifest itself in the archaeological record?

*Supply*

It seems very unlikely that a regional bronze industry could have existed without a surplus of bronze. Not confining ourselves to 'true' ingot forms we can consider the supplies as substantial. With the definition of ingot I have proposed in chapter 6, not only scrap, but every piece of bronze could have been re-melted if it was not given a special meaning that prevented the object from disappearing in the melting-pot. I have argued that the bronze depositions that came down to us represent only a fragment of the bronzes in circulation. They should be seen as the exceptions, which for some reason escaped the melting-pot. The most common biography of bronzes in the Bronze Age would have probably been to end up in the melting-pot. How many times this would have happened remains elusive. Most of the bronzes entering the Netherlands were probably commodities, operating in a short-term exchange. However, most of the objects known to us represent long-term, gift exchange: they have been deposited. The conclusions taken from chapter 6 are that bronze supply was abundant and although the Netherlands lack any copper resources, supply is therefore not seen as a counterargument for local production.

*Melting and casting and the tools of the smith*

Besides the social organization, the bronze smith and his practice is characterized by the tools of his trade. Chapters 7 and 8 dealt with the process of metalworking and the tools needed. Table 8.1 summarizes the findings from these chapters. Metalworking appears to be extremely difficult to indentify from the archaeological record. Evidence that may directly be linked to the melting and casting of metal, such as furnaces, moulds and crucibles, leave only ephemeral traces. More permanent artefacts are the tools that the smith may have used. Hammers and anvils made from stone or bronze are likely to survive in the ground. Wet- and sharpening stones would have been used and possibly small metal implements for decorating. The problem with these objects is that while awls, chisels, anvils and hammers are likely to have been in the possession of a bronze smith they could also have been used in several other crafts and the association with metalworking can therefore only tentatively be suggested but not confirmed. If several of these tools for metalworking are found on the same site they nonetheless may provide a good indication that metalworking took place. Only the objects involved in the melting and casting process can convincingly associate a site with metalworking however. Moulds, crucibles, casting jets or bronze droplets are clear-cut evidence if found in context. Unfortunately, as I have concluded in chapter 7, the process of melting leaves little traces in the ground and metalworking debris is only very scarcely found. Besides, recognition and dating these objects is also problematic.

Finding the production locus of the bronze smith by metalworking debris alone might prove difficult. Evidence for metalworking in the Netherlands is most likely to be found in the tools of the smith rather than the furnaces, moulds or crucibles. Use-wear and function analysis, supplemented by experimental archaeology, to associate these tools with metalworking, may prove very helpful. I think here most progress in archaeometallurgical research in the Netherlands, and North-West Europe, can be gained.

## 9.4 Discussion and further research

I have opted for a rather radical change of perspective for metalworking. The truth is far more complex, however. How metalworking was perceived and to whom the knowledge was available most probably changed during the course of the Bronze Age, becoming more widespread as more bronze became available. Several degrees of specialism must have existed, from the farmer who haphazardly produced a new axe to the smith involved in the production of the Plougrescant-Ommerschans sword. Whether these smiths worked independent or attached to a certain group or elite is difficult to say. Metalworking may also have been a group endeavour in some communities. All in all, variability seems to describe the organization at best (*cf.* Levy 1991; Rowlands 1971) and a single image of a bronze smith cannot be formed. Ethnographic records confirm these observations although also in this discourse, a bias towards the research of production of prestige objects can be found:

> *"In Borneo, whilst every village has a smith who makes and repairs tools, very few smiths are particularly good at making swords and spears and the products of those that are, are widely traded"* (Marschall 1968, 134).

This thesis has been a first attempt to look for the bronze smithy in the Netherlands on the basis of *direct* evidence. In some aspects it is therefore a general approach and many questions remain unanswered or unaccounted for. For instance, not much attention has been given to the aspect that the metalworking intensity, its meaning and the availability of knowledge may have changed during the course of the Bronze Age. Furthermore, I was only able to brush the topic of how technology works in non-industrial societies. Much more research can be done here.

A more systematic approach to metalworking is needed, from the selection of ore, ore extraction, the benefaction, processing and distribution of ore, smelting, distribution of raw material, melting, alloying, casting, the skill and techniques needed for different objects, the circulation and use of the objects and the extent of re-melting. A chain-operatoire may provide the basics for such a systematic approach.

A reappraisal of the local axes recognized by Butler might also be valuable. Can we really assume that they were made locally on the basis of style? If so, metallurgical examination is needed to determine their production techniques. Facilities like the Technical University in Delft have the knowledge and equipment to perform such research and together with archaeological research this might be an extremely useful research as we may then be able to determine whether clay, sand or stone moulds were used, and if the bronzes were hammered cold or hot and annealed or not.

A major drawback of this study is that it is destructive; a small example has to be cut out of the bronze object.

On the subject of the tools of the smith; I think it is here were the most progress can be gained in the search of a production locus of metalworking in the Netherlands. With help from experimental archaeology, function and use-wear analysis we might be able to proof that certain tools were used in metalworking activities. A site like Meteren-de-Bogen has yielded far more evidence that may be associated with metalworking than only the small droplets of bronze. The anvil stones, whetstones and polishing stones may bear traces of metalworking, but as no thorough research has been undertaken so far in use-wear analysis of metalworking traces, they remain undetected. The fact that many artefacts may have served as multi-purpose tools may provide difficulties and a pilot study is necessary to see whether metalworking traces are evident enough to be discerned. I would most gladly like to undertake such a study.

# References

Armbruster, B., 1998, Zu den technologischen Aspekten bronzener Fleischaken und Bratspieße der Atlantische Bronzezeit. In: C. Mordant & M. Pernot & V. Rychner *(eds.)*, *L'Atelier du bronzier en Europe du XXe au VIIIe siècle avant notre ère. Actes du colloque international "Bronze '96" Neuchâtel et Dijon, 1996. Tome II. Du mineral au métal,du métal à l'objet,* Paris, 183-191.

Armbruster, B., 2001, Zu Bronzezeitlichen Werkzeugen der plastischen verformung im Nördlichen und Westlichen Europa. In: W.H. Metz & B.L.v. Beek & H. Steegstra *(eds.)*, *Patina. Essays presented to Jay Jordan Butler on the occasion of his 80th birthday,* Groningen / Amsterdam, 7-26.

Arnoldussen, S., 2008, *A Living Landscape. Bronze Age settlement sites in the Dutch river area (c. 2000-800 BC)*, Leiden (PhD Thesis).

Bachmann, H.G., 1982, *The identification of slags from archaeological sites,* London (Occasional Publication No. 6).

Barber, M., 2003, *Bronze and the Bronze Age. Metalwork and society in Britain c. 2500 - 800 BC,* Gloucestershire.

Barndon, R., 2004, A Discussion of Magic and Medicines in East African Iron Working: Actors and Artefacts in Technology, *Norwegian Archaeological Review* 37, (1), 21-39.

Bartelheim, M., in press, *Elites and metals in the Central European Early Bronze Age*

Bartelheim, M. & E. Niederschlag & T. Rehren, 1998, Research into prehistoric metallurgy in the Bohemian-Saxon Erzgebirge. In: B. Hänsel *(ed.)*, *Mensch und Umwelt in der Bronzezeit Europas. Man and Environment in Bronze Age Europe,* Kiel, 225 - 230.

Bass, G., 1987, Oldest known shipwreck reveals splendors of the Bronze Age, *National Geographic* 172, 693-733.

Bayley, J., 1986, Non-metallic evidence for metalworking. In: Y. Maniatis *(ed.)*, *Archaeometry: Proceedings of the 25th Archaeometry Symposium*, 291-303.

Bazelmans, J., 1999, *By weapons made worthy. Lords, retainers and their relationship in Beowulf,* Amsterdam (Amsterdam Archaeological Studies 5).

Bekeart, S., 1998, Multiple levels of meaning and the tension of consciousness. How to interpret iron technology in Bantu Africa, *Archaeological Dialogues* 5, 6-29.

Bell, C., 1992, *Ritual theory, Ritual practice,* New York.

Bergstøl, J., 2002, Iron technology and Magic in Iron Age Norway. In: B.S. Ottaway & E.C. Wager *(eds.)*, *Metals and Society: Papers from a Session Held at the European Association of Archaeologists Sixth Annual Meeting in Lisbon 2000,* Oxford (BAR International Series 1061), 77-82.

Bertemes, F., 2004, Frühe Metallurgen in der Spätkupfer- und Frühbronzezeit. In: H. Meller *(ed.)*, *Der geschmiedete Himmel. Die weite Welt im herzen Europas vor 3600 Jahren,* Stuttgart, 144-149.

Bewley, R.H. & I.H. Longworth & S. Browne & J.P. Huntley & G. Varndell, 1992, Excavation of a Bronze Age Cemetery at Ewanrigg, Maryport, Cumbria, *Proceedings of the Prehistoric Society* 58, 325-354.

Bisson, M.S., 2000, Precolonial Copper Metallurgy: Sociopolitical Context. In: J.O. Vogel *(ed.)*, *Ancient African Metallurgy. The Sociocultural Context,* New York, 83-147.

Blanchet, J.-C., 1984, *Les Premiers Métallurgists en Picardie et dans le Nord de la France,* Paris.

Bloemers, J.H.F., & L.P. Louwe Kooijmans & H. Sarfatij, 1981, *Verleden land: archeologische opgravingen in Nederland*, Amsterdam.

Bradley, R., 1990, *The passage of arms. An archaeological analysis of prehistoric hoards and votive deposits,* Cambridge.

Bradley, R., 2005, *Ritual and Domestic Life in Prehistoric Europe,* Londen.

Bradley, R., 2007, *The prehistory of Britain and Ireland,* Cambridge (Cambridge World Archaeology ).

Briard, J., 1984, L'Outillage des fondeurs de l'Age du Bronze en Armorique. In: J. Briard *(ed.)*, *Paléométallurgie de la France: Age du Bronze (1),* Rennes, 139-166.

Bridgford, S.D., 2002, Bronze and the First Arms Race - Cause, Effect or Coincidence? In: B.S. Ottaway & E.C. Wager *(eds.)*, *Metals and Society. Papers from a session held at the European Association of Archaeologists Sixth Annual Meeting in Lisbon 2000,* Oxford (BAR International Series 1061), 123-133.

Britton, D. & I.H. Lomgworth, 1968: Late Bronze Age finds in the Heathery Burn Cave, Co. Durham. *Inventaria Archaeologica.*

Broeke, v.d.P.W., 2005, Blacksmiths and potters, material culture and technology. In: L.P. Louwe Kooijmans & P.W.v.d. Broeke & H. Fokkens & A.L.v. Gijn *(eds.)*, *The prehistory of the Netherlands,* Amsterdam, 603-626.

Brongers, J.A. & P.J. Woltering, 1978, *De prehistorie van Nederland. Economisch-technologisch,* Bussem.

Brück, J., 1999, Ritual and Rationality: some problems of interpretation in European Archaeology, *European Journal of Archaeology* 2, (3), 313 - 344.

Brück, J., 2001, Body metaphors and technologies of transformation in the English Middle and Late Bronze Age. In: J. Brück *(ed.)*, *Bronze Age landscapes, tradition and transformation,* Oxford, 149-160.

Brumfield, E.M. & T.K. Earle *(eds.)*, 1987, *Specialization, exchange, and complex societies*, Cambridge (New Directions in Archaeology).

Brunn, v.W.A., 1958, Der Schatz von Frankleben und die mitteldeutschen Sichelfunde, *Praehistorische Zeitschrift* 36, 1-70.

Buckley, D.G. & J.D. Hedges, 1987, *The Bronze Age and Saxon settlements at Springfield Lyons, Essex: an interim report,* (Essex County Council Occasional Paper ).

Budd, P. & T. Taylor, 1995, The faerie smith meets the bronze industry: magic versus science in the interpretation of prehistoric metal-making, *World Archaeology* 27, (1), 133-143.

Bulten, E.E.B. & E. Smits, 1998, *Aanvullend Archeologisch Onderzoek in het tracé van de Betuweroute, vindplaats 28, Geldermalsen / Knooppunt B-voetakker,* Amersfoort (Rapportage Archeologische Monumentenzorg 29).

Burgess, C., 1980, *The Age of Stonehenge,* London.

Butler, J.J., 1959a, A Note on the Maas-Rhine group of Irish Early Bronze Age Exports, *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 9, 291-292.

Butler, J.J., 1959b, Vergeten schatvondsten uit de bronstijd. In: J.E. Bogaers & W. Glasbergen & P. Glazema & H.T. Waterbolk *(eds.)*, *Honderd eeuwen Nederland,* 's-Gravenhage (Antiquity and Survival II), 125-142.

Butler, J.J., 1961, De Noordnederlandse fabrikanten van bijlen in de late bronstijd en hun produkten, *Nieuwe Drentse Volksalmanak* 79, 199-233.

Butler, J.J., 1963a, *Bronze Age connections across the North Sea: A study in prehistoric trade and industrial relations between the British Isles, The Netherlands, North Germany and Scandinavia, c. 1700-700 BC,* Groningen (Palaeohistoria IX).

Butler, J.J., 1963b, Ook in de oudere bronstijd bronsbewerking in Noord-Nederland?, *Nieuwe Drentse Volksalmanak* 81, 181-212.

Butler, J.J., 1969, *Nederland in de Bronstijd,* Bussum.

Butler, J.J., 1973, Einheimische Bronzebeilproduktion im Niederrhein-Maasgebiet, *Palaeohistoria* 15, 319-343.

Butler, J.J., 1979, Rings and ribs: the copper types of the "ingot hoards" of the Central European Early Bronze Age. In: M. Ryan *(ed.)*, *The Origins of Metallurgy in Atlantic Europe. Proceedings of the fifth atlantic colloquium,* Dublin, 345-362.

Butler, J.J., 1980, Metaalbewerking in de prehistorie. In: M. Chamalaun & H.T. Waterbolk *(eds.)*, *Voltooid verleden tijd? Een hedendaagse kijk op de prehistorie,* Amsterdam, 113-130.

Butler, J.J., 1986, Drouwen: end of a 'Nordic' rainbow?, *Palaeohistoria* 28, 133-168.

Butler, J.J., 1987a, Bronze Age connections: France and the Netherlands, *Palaeohistoria* 29, 9-34.

Butler, J.J., 1987b, Drouwen: Het einde van de Noordse regenboog?, *Nieuwe Drentse Volksalmanak* 104, 103-150.

Butler, J.J., 1990, Bronze Age metal and amber in the Netherlands (I), *Palaeohistoria* 32, 47-110.

Butler, J.J., 1995/1996, Bronze Age metal and amber in the Netherlands (II:1) Catalogue of flat axes, flanged axes and stopridge axes, *Palaeohistoria* 37/38, 159-243.

Butler, J.J., 2002, Ingots and insights: reflections on rings and ribs. In: M. Bartelheim & E. Pernicka & R. Krause *(eds.)*, *Die Änfange der metallurgie in der alten Welt. The beginnings of metallurgy in the old world,* Rahden, 229-244.

Butler, J.J. & H. Fokkens, 2005, From stone to brons. Technology and material culture. In: L.P. Louwe Kooijmans & P.W.v.d. Broeke & H. Fokkens & A.L.v. Gijn *(eds.)*, *The prehistory of the Netherlands,* Amsterdam, 371-405.

Butler, J.J. & J.B. Hielkema, 2002, Metaal. In: B.H.F.M. Meijlink & P. Kranendonk *(eds.)*, *Archeologie in de Betuweroute: Boeren, erven, graven. De Boerengemeenschap van De Bogen bij Meteren (2450-1250 v. Chr.),* Amersfoort (Rapportage Archeologische Monumentenzorg 87), 539-546.

Butler, J.J. & H. Sarfatij, 1970 - 71, Another bronze ceremonial sword by the Plougrescant-Ommerschans smith, *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 20-21, 301-309.

Butler, J.J. & H. Steegstra, 1997/1998, Bronze Age metal and amber in the Netherlands (II:2) Catalogue of the Palstaves, *Palaeohistoria* 39/40, 163-275.

Butler, J.J. & H. Steegstra, 1999/2000, Bronze Age metal and amber in the Netherlands (III:1) Catalogue of the winged axes, *Palaeohistoria* 41/42, 127 - 148.

Butler, J.J. & H. Steegstra, 2001/2002, Bronze Age metal and amber in the Netherlands (III:2) Catalogue of the socketed axes, part A, *Palaeohistoria* 43/44, 263-319.

Butler, J.J. & H. Steegstra, 2003/2004, Bronze Age metal and amber in the Netherlands (III:2) Catalogue of the socketed axes, part B, *Palaeohistoria* 45/46, 197-300.

Butler, J.J. & H. Steegstra, 2005/2006, Bronze Age metal and amber in the Netherlands (III:3) Catalogue of the socketed axes, part C, *Palaeohistoria* 47/48, 207-240.

Butler, J.J. & C. Tulp, 2001, Metaal. In: J. Schoneveld & E. Gehasse *(eds.)*, *Boog C-Noord, een vindplaats bij Meteren op de overgang van Neolithicum naar Bronstijd,* Amersfoort (Rapportage Archeologische Monumentenzorg 84), 135-139.

Butler, J.J. & J.D.v.d. Waals, 1964, Metal analysis, sam 1, and European prehistory. A review article, *Helinium* 4, 3-39.

Butler, J.J. & J.D.v.d. Waals, 1966, Bell Beakers and early metal-working in the Netherlands, *Palaeohistoria* 12, 44-139.

Byrnes, E., 1999, Richardstown, Louth. *Database of Irish Excavation Reports,* (www.excavations.ie).

Champion, T.C. & C. Gamble & S. Shennan & A. Whittle, 1984, *Prehistoric Europe,* London/San Diego.

Chernykh, E.N., 1985, La révolution métallurgie. In: V. Yanine & G. Federov & E.N. Chernykh *(eds.)*, *Fouilles et recherches archéologiques en URSS,* Paris,

Chernykh, E.N., 1992, *Ancient metallurgy in the USSR. The Early Metal Age,* Cambridge (New Studies in Archaeology ).

Childe, V.G., 1944a, *The story of tools,* London.

Childe, V.G., 1944b, Archaeological Ages as Technological Stages, *The Journal of the Royal Anthropological Institute of Great Britain and Ireland* 74, (1/2), 7-24.

Childe, V.G., 1951, *Social Evolution,* London.

Childe, V.G., 1958a, *The Prehistory of European society,* Hammondsworth.

Childe, V.G., 1958b, *The Dawn of European Civilazation,* London.

Childe, V.G., 1963 [1930], *The Bronze Age,* New York.

Childe, V.G., 1965 [1936], *Man Makes Himself,* Suffolk.

Clark, P., 2004, *The Dover Bronze Age Boat in Context. Society and water transport in Prehistoric Europe,* Oxford.

Clarke, D.V. & T.G. Cowie & A. Foxon, 1985, *Symbols of power at the time of Stonehenge,* Edinburgh.

Cline, E.H., 1994, *Sailing the wine dark sea: international trade and the Late Bronze Age Aegean,* Oxford (BAR International Series 591).

Coghlan, H.H., 1975 [1951], *Notes on the prehistoric metallurgy of copper and bronze in the Old World,* Oxford (Occasional papers on technology 4).

Coghlan, H.H. & J. Raftery, 1961, Irish prehistoric casting moulds, *Sibrium* 6, 223-244.

Coles, J.M., 1979, *Experimental Archaeology,* London.

Collins, A.E.P., 1970, Bronze Age moulds in Ulster, *Ulster Journal of Archaeology* 33, 23-36.

Costin, C.L., 1991, Craft specialization: issues in defining, documenting and explaining the organization of production. In: M.B. Schiffer *(ed.)*, *Archaeological method and theory,* Philadelphia, 111-140.

Costin, C.L., 2001, Craft Production Systems. In: G.M. Feinman & D. Price *(eds.)*, *Archaeology at the millenium. A sourcebook.,* New York, 273-329.

Craddock, P.T., 1995, *Early Metal Mining and Production,* Edinburgh.

Craddock, P.T. & M.J. Hughes, 1985, *Furnaces and smelting technology in antiquity,* London (British Museum occasional paper 48).

Crumlin-Pedersen, O. & A. Trakadas, 2003, *A pre-Roman Iron-Age warship in context,* Roskilde (Ships & boats of the North 5).

Cunliffe, B., 2001, *Facing the Ocean: the Atlantic and its peoples, 8000 BC-AD 1500,* Oxford.

Davey, C.J., 1979, Some ancient Near Eastern pot bellows, *Levant* XI, 101-111.

Dobres, M.-A. & C.R. Hoffman, 1994, Social agency and the dynamics of prehistoric technology, *Journal of Archaeological Method and Theory* 1, (3), 211-256.

Doumas, C.G., 1998, Metallurgy and the so-called battle axe: the tool of a trade? In: B. Hänsel *(ed.)*, *Mensch und Umwelt in der Bronzezeit Europas. Man and Environment in Bronze Age Europe,* Kiel, 157-162.

Drenth, E. & H. Heijmans & D. Keijers, 2007, Van Mesolithicum tot en met de IJzertijd. Sporen uit de prehistorie te Ittervoort - industrieterrein Santfort, fase 3, gem. Leudal (Li.). In: H. Heijmans & E. Drenth & D. Keijers & J. Schreurs *(eds.)*, *Archeologisch Onderzoek te Ittervoort. Oude bedrijvigheid op het industrieterrein Santfort ontsloten,* Ittervoort, 99-237.

Drescher, H., 1957, Der Bronzeguss in Formen aus Bronze. Versuche mit orginalgetreuen Nachbildungen bronzezeitlicher Gussformen aus Niedersachsen, *Die Kunde. Mitteilungen des Niedersächsischen landesvereins für Urgeschichte* 8, (1-2), 52-74.

Drescher, H., 1962, Neue Untersuchungen am Sonnenwagen von Trundholm und über die Gusstechnik bronzezeitlicher Tierfiguren, *Acta Archaeologica* 33, 39-62.

Ehrenberg, M.R., 1981, The anvils of Bronze Age Europe, *The Antiquaries Journal* LXI, (1), 14-29.

Ellis, P., 1989, Norton Fitzwarren hillfort: a report on the excavations by Nancy and Philip Longmaid between 1968 and 1971, *Somerset Archaeology and Natural History,* 133, 1-74.

Eogan, G., 1964, The later Bronze Age in Ireland in the light of recent research, *Proceedings of the Prehistoric Society* 30, 268-352.

Eogan, G., 1978, Irish Bronze Age manufacturing centers: Some evidence from moulds (summary only). In: M. Ryan *(ed.)*, *The Origins of Metallurgy in Atlantic Europe. Proceedings of the fifth Atlantic colloquium,* Dublin, 205.

Eogan, G., 1993, Aspects of metal production and manufactering systems during the Irish Bronze Age, *Acta Praehistorica et Archaeologica* 25, 87-110.

Fasnacht, W., 1999, Experimentelle Rekonstruktion des Gebrauchs von frühbronzezeitlichen Blasdüsen aus der Schweiz: Kupferverhüttung und Bronzeguß. In: A. Hauptman & E. Pernicka & T. Rehren & U. Yalcin *(eds.)*, *The beginnings of metallurgy: proceedings of the international Conference "The beginnings of Metallurgy", Bochum 1995,* Bochum (Der Anschnitt Beiheft 9), 291-294.

Fitzpatrick, A.P., 2002, The Amesbury archer' A well-furnished Early Bronze Age burial in southern England, *Antiquity* 76, 629-630.

Flanagan, L.N., 1979, Industrial resources, production and distribution in earlier Bronze Age Ireland. In: M. Ryan *(ed.)*, *The Origins of Metallurgy in Atlantic Europe. Proceedings of the fifth atlantic colloquium,* Dublin, 145-161.

Fokkens, H., 1997, The genesis of urnfields: economic crisis or ideological change?, *Antiquity* 71, 360-373.

Fokkens, H., 2001, The periodisation of the Dutch Bronze Age: a critical review. In: W.H. Metz & B.L.v. Beek & H. Steegstra *(eds.)*, *Patina. Essays presented to Jay Jordan Butler on the occasion of his 80th birthday,* Groningen / Amsterdam, 241-262.

Fokkens, H. & Y. Achterkamp & M.H.G. Kuijpers, in press, Bracers or bracelets? About the functionality and meaning of Bell Beaker wrist-guards, *Proceedings of the Prehistoric Society*,

Fokkens, H. & R. Jansen, 2004, *Het vorstengraf van Oss. Een archeologische speurtocht naar een prehistorisch grafveld,* Leiden.

Fokkens, H. & R. Jansen *(eds.)*, 2002, *2000 Jaar bewoningsdynamiek. Brons- en IJzertijd bewoning in het Maas-Demer-Scheldegebied*, Leiden.

Fontijn, D.R., 2001, Rethinking ceremonial dirks of the Ploughrescant-Ommerschans type. In: W.H. Metz & B.L.v. Beek & H. Steegstra *(eds.)*, *Patina. Essays presented to Jay Jordan Butler on the occasion of his 80th birthday,* Groningen / Amsterdam, 263-280.

Fontijn, D.R., 2002, *Sacrificial landscapes. Cultural biographies of persons, objects and 'natural' places in the Bronze Age of the Southern Netherlands, c. 2300- 600BC,* Leiden (Analecta Praehistorica Leidensia 33/34).

Fontijn, D.R., 2005, De speerpunt van Rhenen. In: L.G.L. Van Hoof & L. Meurkens *(eds.)*, *Vluchtige huisplattegronden. Erven uit de midden-bronstijd B en nederzettingssporen uit de vroege bronstijd en midden-bronstijd A (verslag van een tweede opgravingscampagne te Rhenen-Remmerden),* Leiden (Archol Rapport 51), 65-67.

Fontijn, D.R., 2008, 'Traders' hoards'. Reviewing the Relationship between Trade and permanent Deposition: the Cast of the Dutch Voorhout hoard. In: C. Hamon & B. Quilliec *(eds.)*, *Hoards from the Neolithic to the Metal Ages. Technical and codified practices. Session of the XIth Annual Meeting of the European Association of Archaeologist,* Oxford (BAR International Series 1758), 5-17.

Fontijn, D.R. & J.J. Butler & H. Steegstra, 2007, Een kokerbijl uit Tiel-Medel. In: L.G.L. Hoof, van & P.F.B. Jongste *(eds.)*, *Een nederzettingsterrein uit de midden- en late bronstijd te Tiel-Medel Bredesteeg* Leiden (Archol Rapport 64), 126-128.

Fontijn, D.R. & H. Fokkens & R. Jansen, 2002, De gietmal van Oss-Horzak en de inheemse bronsproductie in de Midden Bronstijd. In: H. Fokkens & R. Jansen *(eds.)*, *2000 Jaar bewonings-dynamiek. Brons- en IJzertijd bewoning in het Maas-Demer-Scheldegebied,* Leiden, 63-72.

Forbes, R.J., 1950, *Metallurgy in Antiquity: a notebook for archaeologists and technologists,* Leiden.

Freestone, I.A., 1989, Refractory materials and their procurement. In: A. Hauptman *(ed.)*, *Old World Archaeometallurgy: proceedings of the International Symposium "Old World Archaeometallurgy", Heidelberg 1987,* Bochum (Der Anschnitt Beiheft 7), 155-162.

Gaucher, G. & Y. Robert, 1967, Les dépots de bronze de Cannes-Écluse (Seine-et-Marne), *Gallia Préhistoire* 10, 169-223.

Gell, A., 1988, Technology and Magic, *Anthropology Today* 4, (2), 6-9.

Gelling, P.S. & H.R.E. Davidson, 1969, *The chariot of the sun and other rites and symbols of the northern Bronze Age,* London.

Gibson, D.B., 1996, Death of a Salesman: Childe's Itinerant Carftsman in the Light of Presence Knowledge of Late Prehistoric European Craft Production. In: B. Wailes *(ed.)*, *Craft Specialization and Social Evolution: In Memory of V. Gordon Childe,* Pennsylvania,

Gijn, v.A. & E.A.K. Kars & Y.M.J. Lammers-Keijsers, 2002, Natuursteen. In: B.H.F.M. Meijlink & P. Kranendonk *(eds.)*, *Archeologie in de Betuweroute: Boeren, erven, graven. De Boerengemeenschap van De Bogen bij Meteren (2450-1250 v. Chr.),* Amersfoort (Rapportage Archeologische Monumentenzorg 87), 501-535.

Goldmann, K., 1981, Guss in verlorener Sandform - das Hauptverfahren alteuropäischer Bronzegiesser?, *Archäologische Korrspondensblatt* 11, 109-111.

Goldmann, K., 1985, Bronzegusstechniken im prähistorische Mitteleuropa. In: H. Born *(ed.)*, *Archäologische Bronzen, Antike Kunst, Moderne Technik,* Berlin, 52-58.

Haaland, R., 2004, Technology, transformation and symbolism: ethnographic perspectives on European iron working, *Norwegian Archaeological Review* 37, (1), 1-19.

Hamilton, A.F., 1956, *Excavations at Jarlshof, Shetland,* Edinburgh.

Harbison, P., 1969, *The axes of the Early Bronze Age in Ireland,* München (Prähistorische Bronzefunde IX: 1).

Helms, M.W., 1993, *Craft and the Kingly Ideal. Art, trade, and power,* Austin.

Helms, M.W., 1998, *Access to Origins. Affines, ancestors and aristrocats,* Austin.

Henderson, J., 2000, *The science and archaeology of materials. An investigation of inorganic material,* London.

Herbert, E.G., 1984, *Red gold of Africa. Copper in Precolonial History and Culture,* Wisconsin.

Herdits, H., 2003, Bronze Age smelting site in the Mitterberg Mining Area in Austria. In: P.T. Craddock, J. Lang *(ed.)*, *Mining and Metal production through the ages*, 69-74.

Hiddink, H.A., 2008, *Archeologische opgravingen in Someren-Waterdael III,* Amsterdam/Amersfoort (ACVU-HBS brochure 13).

Hiddink, H.A. & E. de Boer, in prep, *Opgravingen in Someren-Waterdael III. Nederzettingen en grafvelden uit de prehistorie, Romeinse tijd en Middeleeuwen,* Amsterdam (Zuidnederlandse Archeologische Rapporten).

Hodder, I., 1982, *Symbols in action. Ethnoarchaeological Studies of Material Culture,* London.

Hodges, H., 1989 [1964], *Artifacts. An introduction to early materials and technology,* London.

Hoffman, C.R., 1999, Intentional Damage as Technological Agency: Breaking Metals in Late Prehistoric Mallorca, Spain. In: M.-A. Dobres & C.R. Hoffman *(eds.)*, *The Social Dynamics of Technology. Practice, Politics and World Views,* Washington, 103-123.

Holmes, P., 1978, The manufacturing technology of the Irish Bronze Age horns. In: M. Ryan *(ed.)*, *The Origins of Metallurgy in Atlantic Europe. Proceedings of the fifth atlantic colloquium,* Dublin, 165-188.

Holwerda, J.H., 1925, *Nederlands vroegste geschiedenis,* Amsterdam.

Hoof, L.G.L.v. & L. Meurkens, 2008, Rhenen-Remmerden revisited: some comments regarding site structure and the visibility of Bronze Age house plans. In: S. Arnoldussen & H. Fokkens *(eds.)*, *Bronze Age settlements sites in the Low Countries,* Oxford, 81-93.

Hosler, D., 1995, The Sounds and Colors of Power: The Sacred Metallurgical Technology of Ancient West Mexico., *World Archaeology* 27, 100-115.

Hosler, D. & H. Lechtmann & O. Holm, 1990, *Axe-monies and their relatives,* Washington D.C. (Studies in pre-Columbian art & archeology 30).

Howard, 1983, *The Bronze age casting industry in later prehistoric Southern Britain: a study based on refractory debris*, (Unpublished PhD Thesis).

Hundt, H.-J., 1975, Steinerne und kupferne Hämmer der frühen Bronzezeit *Archäologischen Korrespondenzblatt* 5, 115-122.

Hundt, H.-J., 1976, Ein frühbronzezeitlicher Kupferhammer aus Meckenheim, Kr. Neustadt / Weinstr., *Archäologischen Korrespondenzblatt* 6, 117-122.

Hurl, D., 1995, Killymoon - New light on the Late Bronze Age, *Archaeology Ireland*,

Huth, C., 2000, Metal circulation, communication and traditions of craftmanship in Late Bronze Age and Early Iron Age Europe. In: C.F.E. Pare *(ed.)*, *Metals make the wold go round. The supply and circulation of metals in the Bronze Age Europe. Proceedings of a conference held at the university of Birmingham in June 1997,* Oxford, 176-193.

Ingold, T., 1999, Foreword. In: M.-A. Dobres & C.R. Hoffman *(eds.)*, *The Social Dynamics of Technology. Practice, Politics and World Views,* Washington, I-X.

Innerhofer, F., 2004, Ring und Beil - Barrendepots der Frühbronzezeit. In: H. Meller *(ed.)*, *Der geschmiedete Himmel. Die weite Welt im herzen Europas vor 3600 Jahren,* Stuttgart, 98-99.

Jackson, J.S., 1979, Metallic ores in Irish prehistry: copper and tin. In: M. Ryan *(ed.)*, *The Origins of Metallurgy in Atlantic Europe. Proceedings of the fifth atlantic colloquium,* Dublin, 107-125.

Jansen, R. & H. Fokkens, 2002, Een korte biografie van Oss-Horzak, een lokale gemeenschap tussen Maaskant en Heikant. In: H. Fokkens & R. Jansen *(eds.)*, *2000 Jaar bewoningsdynamiek. Brons- en ijzertijdbewoning in het Maas-Demer-Scheldegebied,* Leiden, 315-340.

Jantzen , D., in press, *Quellen zur Metallverarbeitung im nordischen kreis der Bronzezeit*, (PhD Thesis) (To appear als Präehistorische Bronzefunde XIX, 2).

Jensen, J., 2002, *Danmarks Oldtid, Bronzealder 2000-500 f.Kr.,* Copenhagen.

Jockenhövel, A., 1982, Zu den ältensten Tüllenhämmern aus Bronze, *Germania* 60, (2), 459-467.

Jones, M.R., 2007, *Oxide ingots, copper production, and the Mediterranean trade in copper and other metals in the Bronze Age*, (Unpublished Master Thesis).

Jongste, P.F.B., 2002, De verlaten erven van Eigenblok. Deposities van metalen voorwerpen op twee erven uit de Midden-Bronstijd in de Betuweroute. In: H. Fokkens & R. Jansen *(eds.)*, *Brons- en ijzertijdbewoning in het Maas-Demer-Scheldegebied,* Leiden, 95-108.

Jovanovic, B., 1988, Early metallurgy in Yugoslavia. In: R. Maddin *(ed.)*, *The beginnings of the use of metals and alloys,* Cambridge, 69-79.

Junghans, S. & E. Sangmeister & M. Schröder, 1966-74, *Studien zu den Änfangen der Metallurgie I, II,* Stuttgart.

Kaul, F., 2004, Der Sonnewagen von Trundholm. In: H. Meller *(ed.)*, *Der geschmiedete Himmel. Die weite Welt im herzen Europas vor 3600 Jahren,* Stuttgart, 54-57.

Kersten, K., 1964, Bronzedepotfund von Seth, Kr. Segeberg, *Germania* 42, 289-290.

Kersten, K. & H. Drescher, 1970, Der Bronzedepotfund von Seth in Holstein, *Offa* 27, 20-30.

Kienlin, T.L., 2007, Von den Schmieden der Beile: Zu Verbreiotung und Angleichung metalllurgischen Wissens im Verlafu der Frühbronzezeit, *Praehistorische Zeitschrift* 82, (1), 1-22.

Kilbride- Jones, H.E., 1936, A Late Bronze Age cemetery: being an account of the excavations of 1935 at Loanhead of Daviot, Aberdeenshire, on behalf of HM office works, *Proceedings of the Society of Antiquaries of Schotland,* 70, 300.

Kopytoff, I., 1986, The cultural biography of things: commodisations as process. In: A. Appadurai *(ed.)*, *The social life of Things,* Cambridge, 46-69.

Krause, R., 1997, Vom Erz zur Bronze: Bergbau, Verhüttung und Bronzeguß. *Goldene Jahrhunderte. Die Bronzezeit in Südwestdeutschland* Stuttgart (ALManach 2), 26 - 41.

Krause, R. & E. Pernicka, 1998, The function of ingot torques and their relation with early bronze age copper trade. In: C. Mordant & M. Pernot & V. Rychner *(eds.)*, *L'Atelier du bronzier en Europe du XXe au VIIIe siècle avant notre ère. Actes du colloque international "Bronze '96" Neuchâtel et Dijon, 1996. Tome II. Du minerai au métal, du métal à l'objet,* Paris, 219-226.

Kristiansen, K., 1987, From stone to bronze - the evolution of social complexity in Northern Europe, 2300-1200 BC. In: E.M. Brumfiel & T. Earle *(eds.)*, *Specialization, exchange, and complex societies,* Cambridge, 30-51.

Kristiansen, K. 1998, *Europe before history,* Cambridge.

Kristiansen, K. & B. Larsson, 2005, *The rise of Bronze Age society. Travels, Transmissions and Transformations,* Cambridge.

Kuijpers, M.H.G., 2003, *De Bronstijdsmid in Nederland. Autochtoon of allochtoon?*, (Unpublished paper).

Kuijpers, M.H.G., 2006, *Looking for the bronze smithy. A research into the preservation of metallurgy-related artefacts in the Bronze Age; melting and casting*, Leiden (Unpublished Bachelor Thesis).

Kuijpers, M.H.G., 2007, Op zoek naar de Bronssmid, *Detector Magazine* 92, 33-36.

Laet, S.J.d. & W. Glasbergen, 1959, *De voorgeschiedenis der Lage Landen,* Groningen.

Laubing, G. & R. Laubing, 1980, *American Indian Archery,* Norman.

Lenerz-De Wilde, M., 1995, Prämonetäre Zahlungsmittel in der Kupfer- und Bronzezeit, *Fündberichten aus Baden-Württemberg* 20, 229-327.

Lenerz-De Wilde, M., 2002, Bronzezeitliche Zahlungsmittel, *Mitteilungen der Anthroplogischen Gesellschaft in Wien (MAGW)* 132, 1-23.

Letterlé, F., 1985 [1981], Traces d'occupation de la civilasation de Hilversum à Wijk bij Duurstede (province d'Utrecht, *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 31, 329-346.

Levy, J.E., 1982, *Social and Religious Organisation in Bronze Age Denmark: An Analysis of Ritual Hoard Finds,* Oxford (BAR International Series 124).

Levy, J.E., 1991, Metalworking Technology and Craft Specialization in Bronze Age Denmark, *Archaeomaterials* 5, 55-74.

Levy, J.E., 1999, Metals, symbols, and society in Bronze Age Denmark. In: J.E. Robb *(ed.)*, *Material Symbols. Culture and Economy in Prehistory,* Carbondale, 205-223

Liversage, D. & J.P. Northover, 1998, Prehistoric trade monopolies and bronze supply in northern Europe. In: C. Mordant & M. Pernot & V. Rychner *(eds.)*, *L'Atelier du bronzier en Europe du XXe au VIIe siècle avant notre ère. Actes du colloque international "Bronze '96" Neuchâtel et Dijon, 1996. Les analyses de composition du métal: leur apport à l'archéologie de l'âge du Bronze,* Paris, 137 - 151.

Louwe Kooijmans, L.P. & P.W.v.d. Broeke & H. Fokkens & A.L.v. Gijn *(eds.)*, 2005, *The Prehistory of the Netherlands*, Amsterdam.

Lynn, C.J., 1977, Trial excavations at the King's Stables, Tray Twonland, County Armargh, *Ulster Journal of Archaeology* 40, 42-62.

Maggi, R. & M. Pearce, 2005, Mid fourth-millenium copper mining in Liguria, north-west Italy: the earliest known copper mines in Western Europe, *Antiquity* 79, 66-77.

Mariën, M.E., 1952, *Oud België. Van eerste landbouwers tot de komst van van Ceasar,* Antwerpen.

Marschall, W., 1968, Metallurgie und frühe besiedlungsgeschichte Indonesiens, *Ethnologica* 14,

Meijlink, B.H.F.M. & P. Kranendonk, 2002, *Archeologie in de Betuweroute: Boeren, erven, graven. De Boerengemeenschap van De Bogen bij Meteren (2450-1250 v. Chr.),* Amersfoort (Rapportage Archeologische Monumentenzorg 87).

Meller, H., 2002, Die Himmelsscheibe von Nebra - Ein frühbronzezeitlicher Fund von aussergewöhnlicher Bedeutung, *Archäologie in Sachsen-Anhalt* 1, 7-20.

Meller, H., 2004, Die Himmelsscheibe von Nebra. In: H. Meller *(ed.)*, *Der geschmiedete Himmel. Die weite Welt im herzen Europas vor 3600 Jahren,* Stuttgart, 22-33.

Metz, W.H. & B.L.v. Beek & H. Steegstra *(eds.)*, 2001, *Patina. Essays presented to Jay Jordan Butler on the occasion of his 80th birthday*, Groningen / Amsterdam).

Meurkens, L., 2004, *A matter of Elites, Specialists and Ritual? Social and symbolic dimension of metalworking in the North-west European Bronze Age*, Leiden (Unpublished Master Thesis).

Miller, H.M.-L., 2007, *Archaeological Approaches to Technology,* Amsterdam.

Milliken, S. & M. Vidale *(eds.)*, 1998, *Papers from the EAA Third Annual meeting at Ravenna 1997 / European Association of Archaeologists. Vol. IV:Craft specialization: operational sequences and beyond*, Oxford).

Moosleitner, F., 1988, Vier Spangenbarrendepots aus bereching, Land Salzburg, *Germania* 66, (1), 29-67.

Moyler, S., 2008, Doing away with Dichotemies? Comparative Use-Wear Analysis of Early Bronze Age Axes from Scotland. In: C. Hamon & B. Quilliec *(eds.)*, *Hoards from the Neolithic to the Metal Ages. Technical and codified practices. Session of the XIth Annual Meeting of the European Association of Archaeologist,* Oxford (BAR International Series 1758), 79-90.

Muckelroy, K., 1981, Middle Bronze Age trade between Britain and Europe: a maritime perspective,( posthumously published by Sean McGrail), *Proceedings of the Prehistoric Society* 47, 275-297.

Muhly, J.D., 1973, *Copper and tin: The distribution of mineral resources and the nature of the metals trade in the Bronze Age,* New Haven.

Needham, S.P., 1980, An assemblage of Late Bronze Age metalworking debris from Dainton, Devon, *Proceedings of the Prehistoric Society* 46, 177-215.

Needham, S.P., 1993, A Bronze Age goldworking anvil from Litchfield, Staffordshire, *Antiquaries Journal* 73, 125-160.

Needham, S.P., 1998, Modelling the flow of metal in the Bronze Age. In: C. Mordant & M. Pernot & V. Rychner *(eds.)*, *L'Atelier du bronzier en Europe du XXe au VIIe siècle avant notre ère. Actes du colloque international "Bronze '96" Neuchâtel et Dijon, 1996. Production, circulation et consommation du bronze,* Paris, 285-308.

Needham, S.P. & N. Dean, 1987, La cargaison de Langdon Bay à Douvres (Grande-Bretagne). La signification pour les échanges à traver la Manche. In: J.-C. Blanchet *(ed.)*, *Les relations entre le continent et les Iles Britanniques à l'Age du Bronze, Actes du colloque de Lille dans le cadre du 22ème Congrès Préhistorique de date d'édition, 2–7 September 1984 (Paris, Société Préhistorique Française)*, 119-124.

Northover, J.P., 1982, The Exploration of the Long-distance Movement of Bronze in Bronze and Early Iron Age Europe, *Institute of Archaeology bulletin* 19, 45-72.

Northover, J.P., 1989, Properties and Use of Arsenic-Copper Alloys. In: A. Hauptman & E. Pernicka & G.A. Wagner *(eds.)*, *Archäometallurgie der Atlen Welt,* Bochum (Der Anschnitt Beiheft 7), 111-118.

Northover, J.P. & B.E.P. Staniaszek, 1982, The properties of leaded bronze alloys. In: A. Aspinall *(ed.)*, *Proceedings of the 22nd Symposium on Archaeometry: Held at the University of Bradford, Bradford, U.K., 30th March-3rd April 1982,* Bradford, O' Brien, W., 1990, Prehistoric copper mining in south-west Ireland: the Mount Gabriel-type mines, *Proceedings of the Prehistoric Society* 56, 269-290.

O' Brien, W., 1994, *Mount Gabriel. Bronze Age mining in Ireland,* Galway.

O' Brien, W., 1996, *Bronze Age Copper Mining in Britain and Ireland,* Princes Risborough.

O' Brien, W., 1997, Mount Gabriel and metal sourcing in the Bronze Age, *Journal of Historical Metallurgy* 31, (1), 8-11.

O' Brien, W., 1999, Resource availability and metal supply in the insular Bronze Age. In: A. Hauptman *(ed.)*, *The Beginnings of Metallurgy,* (Der Anschnitt Beiheft 9), 227-235.

O' Brien, W., 2004, *Ross Island. Mining, metal and society in Early Ireland,* Galway (Bronze Age Studies 6).

O' Conner, B., 1980, *Cross-Channel relations in the Later Bronze Age. Relations between Britain, North-eastern France and the Low Countries during the Later Bronze Age and the Early Iron Age, with particular reference to the metalwork,* Oxford (British Archaeological Reports 91).

O' Kelly, M.J. & C.A. Shell, 1979, Stone object and a bronze axe from Newgrange, Co. Meath. In: M. Ryan *(ed.)*, *The origins of metallurgy in Atlantic Europe. Proceedings of the fifth atlantic colloquium,* Dublin, 127 - 144.

Ottaway, B.S., 2002, Towards interpretative Archaeometallurgy. In: M. Bartelheim & E. Pernicka & R. Krause *(eds.)*, *Die Änfange der metallurgie in der alten Welt. The beginnings of metallurgy in the old world,* Rahden, 7-13.

Ottaway, B.S. & S. Seibel, 1997, Dust in the wind: experimental casting of bronze in sand moulds. *Instrumentum. Monographies 5. Paléométallurgie des Cuivres. Actes du colloque de Bourg-en-Bresse et Beaune, 17-18 October 1997*,

Ottaway, B.S. & E.C. Wager *(eds.)*, 2002, *Metals and society : papers from a session held at the European Association of Archaeologists sixth Annual meeting in Lisbon 2000* Oxford (BAR International series 1061).

Ottoway, B.S., 2001, Innovation, production and specialisation in early prehistoric copper metallurgy, *European Journal of Archaeology* 4, (1), 87-112.

Pare, C.F.E., 2000, Bronze and the Bronze Age. In: C.F.E. Pare *(ed.)*, *Metals make the world go round. The supply and circulation of metals in Bronze Age Europe,* Exeter, 1-38.

Pearson, M.P., 2005 [1991], *Bronze Age Britain,* London.

Pernot, M., 1998, L'Organisation de l'atelier du bronzier. In: C. Mordant & M. Pernot & V. Rychner *(eds.)*, *L'Atelier du bronzier en Europe du XXe au VIIIe siècle avonat notre ère. Actes du colloque international "Bronze '96" Neuchâtel et Dijon, 1996. Tome II. Du minerai au métal,du métal à l'objet,* Paris, 107-116.

Primas, M., 1986, *Die Sicheln in Mitteleuropa. I: Österreich, Schweiz, Süddeutschland,* (Präehistorische Bronzefunde 18).

Probst, E., 1996, *Deutschland in der Bronzezeit. Bauern, Bronzegiesser und burgherre zwischen Nordsee und Alpen,* München.

Raftery, B., 1976, Rathgall and Irish hillforts problems. In: D.W. Harding *(ed.)*, *Hillforts: Later prehistoric earthworks in Britain and Ireland,* London, 339-357.

Randsborg, K., 1974, Social stratification in Early Bronze Age Denmark: a study in the regulation of cultural systems, *Praehistorische Zeitschrift* 49, 38-61.

Read, C., 1999, *Ballyconneely, Co. Clare.,* (http://www.excavations.ie).

Rees, H., 1993, Later Bronze Age and Early Iron Age settlement in the Lower Test Valley - Evidence from excavations and finds 1981-1989, *Proceedings of the Hampshire Field Club & Archaeological Society* 49, 19-46.

Rehder, J.E., 1994, Blowpipes versus Bellows in Ancient Metallurgy, *Journal of Field Archaeology* 21, (3), 345-350.

Rehder, J.E., 2000, *The mastery and uses of fire in antiquity,* Montreal.

Renfrew, C., 1973, *Before Civilization. The radiocarbon revolution and prehistoric Europe,* London.

Reynolds, P.J., 1999, The Nature of Experiment in Archaeology. In: A.F. Harding *(ed.)*, *Experiment and design: Archaeological studies in honour of John Coles,* Oxford,

Roberts, B., in press, *Creating Traditions and Shaping Technologies: understanding the earliest metal objects and metal production in Western Europe,*

Roberts, B., in press, *Metallurgical Networks and Technological Choice: understanding early metal in Western Europe,*

Roberts, B., in press, *Migration, Craft Expertise and Metallurgy: analysing the 'spread' of metal in Western Europe,*

Roberts, B. & B.S. Ottaway, 2003, The use and significance of socketed axes during the Late Bronze Age, *European Journal of Archaeology* 6, 119-140.

Roe, P.G., 1995, Style, society, myth, and structure. In: C. Carr & J.E. Neitzel *(eds.)*, *Style, society and person: archaeological and ethnological perspectives,* New York,

Rovira, S., 2002, Early slags and smelting by-products of copper metallurgy in Spain. In: M. Bartelheim & E. Pernicka & R. Krause *(eds.)*, *The beginnings of metallurgy in the Old World,* Leidorf, 12-26.

Rowlands, M.J., 1971, The archaeological interpretation of prehistoric metalworking, *World Archaeology* 3, 210-223.

Rowlands, M.J., 1976, *The production and distribution of metalwork in the Middle Bronze Age in Southern Britain,* Oxford (BAR 31).

Rowlands, M.J., 1980, Kinship, Alliance and exchange in the European Bronze Age. In: J.C. Barrett & R. Bradley *(eds.)*, *Settlement and Society in the British later Bronze Age,* Oxford, 15-55.

Ruiz-Gálvez, M., 2000, Weight systems and exchange networks in Bronze Age Europe. In: C.F.E. Pare *(ed.)*, *Metals make the world go round. The supply and circulation of metals in Bronze Age Europe,* Exeter, 267-279.

Ryan, M. *(ed.)* 1978, *The Origins of Metallurgy in Atlantic Europe. Proceedings of the fifth Atlantic Colloquium*, Dublin.

Sackett, J.R., 1982, Approaches to Style in Lithic Archaeology, *Journal of Anthropological Archaeology* 1, 59-112.

Sackett, J.R., 1986, Isochrestism and Style: A Clarification, *Journal of Anthropological Archaeology* 5, 266-277.

Samson, A.V.M., 2006, Offshore finds from the Bronze Age in North-Western Europe: The schipwreck scenario revisited, *Oxford journal of Archaeology* 25, (4), 371–388.

Scarre, C. & F. Healy, 1993, *Trade and exchange in prehistoric Europe: proceedings of a conference held at the University of Bristol, April 1992,* Oxford.

Schoneveld, J. & P. Kranendonk *(eds.)*, 2002, *Drie erven uit de Midden-Bronstijd bij Lienden*, Amersfoort (Rapportage Archeologische Monumentenzorg 89).

Schreurs, J., 1990, Heel: de prehistorie. In: H. Beurskens & P. Derks *(eds.)*, *Rond de Toren. Uit de geschiedenis van Heel, van Catualium,* Heythuysen, 30-51.

Shennan, S., 1993, Commodities, transactions, and growth in the central European Early Bronze Age, *Journal of European Archaeology* 1.2, 59-71.

Shennan, S., 1995, *Bronze Age copper producers of the Eastern Alps. Excavations at St. Veit-Klinglberg,* Bonn (Universitätsforschungen zur prähistorischen Archäologie 27).

Shennan, S., 1999, Cost, benefit and value in the organization of early European copper production, *Antiquity* 73, 352-363.

Shepperd, R., 1980, *Prehistoric mining and allied industries,* London.

Sherratt, A., 1993, What would a Bronze-Age World System look like? Relations between temperate Europe and the Mediterranean in Later Prehistory, *Journal of European Archaeology* 1(2), 1-57.

Sherratt, S., 2000, Circulation of metals at the end of the Bronze Age in the Eastern Mediterranean. In: C.F.E. Pare *(ed.)*, *Metals make the world go round. The supply and circulation of metals in Bronze Age Europe,* Exeter, 82-98.

Siemons, H.-A.R. & M.M. Sier, 1999, *Aanvullend Archeologisch Onderzoek in het tracé van de Betuweroute, vindplaats 14: Kesteren/Woonwagenkamp,* Amersfoort (Rapportage Archeologische Monumentenzorg 39).

Siguat, F., 2002, Technology. In: T. Ingold *(ed.)*, *Companion Encyclopedia of Anthropology,* London, 420-458.

Sperber, L., 2000, Zum Grab eines spätbronzezeitlichen Metallhandwerkers von Lachen-Speyerdorf, Stadt Neustad a.d. Weinstrasse, *Archäologischen Korrespondenzblatt* 30, 383-402.

Sprater, F., 1929, Neue Funde in der Pfalz. Grabfund der Früh-Hallstat-Zeit von Speyerdorf mit Metallbarren, *Pfälzisches Museum* 46,

Stevens, F., 2008, Elemental interplay: the production, circulation and deposition of Bronze Age metalwork in Britain and Ireland, *World Archaeology* 40, (2), 238-252.

Sundstrom, L., 1965, *The trade of Guinea,* (Studia Ethnologica Upsaliensia XX).

Theunissen, E.M., 1990, Preshitorische bewoning op de Caberg (groeve Klinkers), *Archeologische Kroniek van Limburg over 1988-1989, Publications de la Societé Historique et Archéologique dans le Limbourg* 126, 211.

Thévenot, J.-P., 1998, Un outillage de bronzier: le dépôt de *la petite laugère*, à génelard (Saone-et-loire, France). In: C. Mordant & M. Pernot & V. Rychner *(eds.)*, *L'Atelier du bronzier en Europe du XXe au VIIIe siècle avonat notre ère. Actes du colloque international "Bronze '96" Neuchâtel et Dijon, 1996. Tome II. Du minerai au métal, du métal à l'objet,* Paris, 123-144.

Timberlake, S., 2001, Mining and prospection for metals in Early Bronze Britain - making claims within the archaeological landscape. In: J. Brück *(ed.)*, *Bronze Age Landscapes. Tradition and Transformation,* Exeter, 179-192

Timberlake, S., 2003, Early metal mining research in the UK: the developments of the last ten years. In: P.T. Craddock & J. Lang *(eds.)*, *Mining and Metal Production through the Ages*, 21-42.

Timberlake, S., in press, *The use of experimental archaeology/archaeo-metallurgy as a tool in the understanding and reconstruction of Early Bronze Age mining and melting technologies, including new evidence for the smelting of chalcopyrite ore - the work of the Early Mines Research Group, UK,*

Tylecote, R., F., 1962, *Metallurgy in Archaeology,* London.

Tylecote, R., F., 1986, *The prehistoric metallurgy of the British Isles,* London.

Tylecote, R., F. , 1987, *The early history of metallurgy in Europe,* London.

Ucko, P.J., 1969, Ethnography and the archaeological interpretation of funerary remains, *World Archaeology* I, (2).

Ufkes, A. & Bloo, S.B.C., 2002, Aardewerk. In: In: B.H.F.M. Meijlink & P. Kranendonk *(eds.)*, *Archeologie in de Betuweroute: Boeren, erven, graven. De Boerengemeenschap van De Bogen bij Meteren (2450-1250 v. Chr.),* Amersfoort (Rapportage Archeologische Monumentenzorg 87), 317-377.

Vandkilde, H., 2005, A biographical perspective on *Ösenringe* from the Early Bronze Age. In: T. Kienlin *(ed.)*, *Die Dinge als Zeichen: Kultureles Wissen und materieller Kultur. Internationale Fachtagung an der Johan Wolfgang Goethe-Universität, Frankfurt am Main 3.-5. April 2003,* Bonn, 263-281.

Vandkilde, H., in press, *Metallurgy, Inequality and Globalisation in the Bronze Age,*

Verhart, L., 1993, *De prehistorie van Nederland,* Leiden.

Verhelst, E.M.P., 2006, Metaal en sintels. In: M. Schurmans *(ed.)*, *Bewoningssporen uit de Bronstijd, IJzertijd en Romeinse Tijd langs de Houtense stroomgordel. Houten VleuGel Tracé van de Betuweroute ACH Vindplaats 19, 20 en 21. Inventariserend Veldonderzoek in de vorm van proefsleuven,* Amsterdam (Zuidnederlandse Archeologische Notities 53), 41-44.

Verlaeckt, K., 1996, *Between river and barrow. A reappraisal of Bronze Age metalwork found in the province of East-Flanders (Belgium),* Oxford (BAR International Series 632).

Waddel, J., 1998, *The prehistoric archaeology of Ireland,* Galway.

Wang, Q. & B.S. Ottaway, 2004, *Casting experiments and Microstructure of Archaeologically Relevant Bronzes,* Oxford (BAR International Series 1331).

Wentink, K., 2006, *Ceci n'est pas une hache. Neolithic Depositions in the Northern Netherlands,* Leiden (Research Master Thesis).

Winghart, S., 1998, Producktion, Verarbeitung und Distribution - Zur rolle spätbronzezeitlichen Eliten im Alpenvorland. In: B. Hänsel *(ed.)*, *Mensch und Umwelt in der Bronzezeit Europas. Man and environment in European Bronze Age,* Kiel, 261-264.

Winghart, S., 2000, Mining, processing and distribution of bronze: reflections on the organisation of the metal supply between the northern Alps and the Danube region. In: C.F.E. Pare *(ed.)*, *Metals make the world go round. The supply and circulation of metals in Bronze Age Europe. Proceedings of a conference held at the University of Birmingham in June 1997,* Oxbow, 279.

Wunderlich, C.-H., 2004, Vom Bronzebarren zum Exponat -Technische anmerkungen zu den funden von Nebra. In: H. Meller *(ed.)*, *Der geschmiedete Himmel. Die weite Welt im herzen Europas vor 3600 Jahren,* Stuttgart, 38-43.

Wyss, R., 1967, *Bronzezeitliche Gußtechnik,* Bern (Aus dem Schweizerischen Landesmuseum 19).

Zich, B., 2004, Vom Dolch zum Schwert. In: H. Meller *(ed.)*, *Der geschmiedete Himmel. Die weite Welt im herzen Europas vor 3600 Jahren,* Stuttgart, 132-133.

# APPENDICES

# Appendix 1: Experiment 1, Archeon

This experiment was performed by Jeroen Zuiderwijk, an experimental bronze caster at Archeon. A small flat axe was cast in a clay mould. Following is a description of the process and the tools used to perform the melt and cast.

The furnace used in the experiment (photograph by J. Zuiderwijk).

*The furnace*

The furnace used during the experiments in Archeon is around 50 centimeters long, 15 wide and 10 deep. The linings are strengthened with clay. The linings are made from a mixture of clay, sand and horse dung. The sand and dung prevent the clay from bursting. Three of these walls are vertical. The fourth, opposite to where the crucible and the tuyere are, is placed at a slightly sloping angle so that removing the crucible from the fire is easier. The clay linings are baked by the fire but only up to a temperature of around 600 - 700 °C depending on their position. The piece of clay lining right below the tuyere, where air is blown straight into the fire, shows traces of vitrification, indicating higher temperatures.

*Bellow*

A system is used where two bellows press air trough one air-pipe. This is possible because of the Y-shape of the wooden air pipe. The leather sacks of the bellows are not sewed together, but are kept tight by slats, making it possible to open and close the bellows. New air is not sucked in through the tuyere but literally 'grasped' by opening up the bellow. In this manner it not only solves the problem of hot air entering the bellow, operating them is also made considerably easier. This operation was performed by the apprentice. Most importantly is keeping a continuous airflow, to superheat the fire and keep it at the same high temperature.

*Airpipe*

The wooden air pipe used in this experiment was based on an actual find of such a Y-shaped pipe in Hjortspring, Denmark. This pipe is dated to the Iron Age (350 B.C; Crumlin-Pedersen & Trakadas 2003). The archaeological example is hollowed out, but to make the production of the pipe easier,

Pouring the liquid bronze in the mould. The stick is used to prevent pieces of charcoal to clog the mould. The mould is held in place with whitties and placed at a slighty sloping angle (photograph by author).

a groove was cut into the Y-shaped wood used for the experiment. Covering it with leather and sewing it close made sure that no air could escape. The tuyere is attached to the end of the pipe.

*Tuyere*

The tuyere used is an elbow tuyere made from the same material as the crucible. Its round shape was made by rolling clay around a stick. Rolling the stick made the tube of clay wider on one side until it came off. Next, the side that is placed above the fire is bent and a small opening with a sharp edge is made. This is done force the air trough a small opening in order to provide a very localized and powerful draught that penetrates the fire deep.

*Crucible*

The crucible in the experiment is made from white-baking pottery clay. Despite its heat-resistance (max 1400 ˚C according to J. Zuiderwijk) this clay is not yet suitable to make a crucible. It is tempered with charmotte, silver sand (40 – 50 %) and horse dung (10%). The sand reduces some of the stresses that act upon the crucible when heated. It also vitrifies during the superheating of the fire, by which cracks that form in the crucible are held together. The dung has a similar function and acts as a binding material. The crucible used in the experiment has an extension at the back with a hole in it. A stick can be inserted in order to lift the crucible from the fire. On average a crucible will last up to 15-20 casts depending on where the cracks occur.

*Mould*

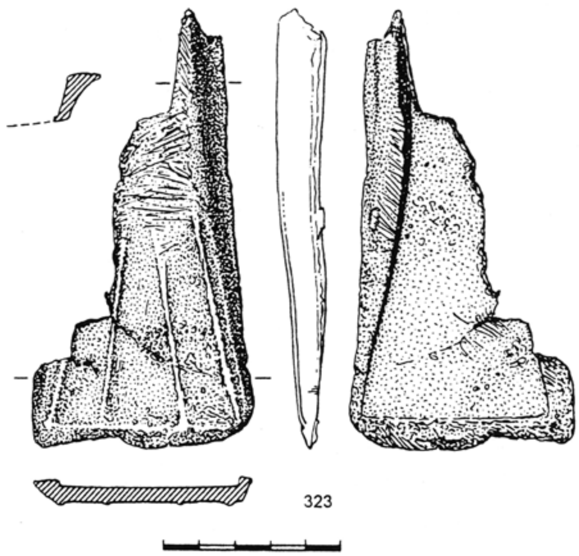
The mould is made from local clay. I do not have information on tempering material. A model of the flat-axe is pressed into the clay and the mould is baked. Before its use it is pre-heated again. This serves two functions: it reduces the thermal shock and it vaporizes any moisture in the clay. If the clay mould contains too much moisture this may result in a bad cast, because the steam will produce small holes in the cast. There is even the possibility that the mould cracks or burst. By placing the mould next to the furnace or into a separate oxidizing fire and heating it for at least 4-5 hours at 700-800 $^{0}$C, the mould is prepared for the cast.

*Melting and casting.*
Melting and casting takes place inside the hut with a thatched roof. In the 8 years of bronze casting taken place here, it not once caught fire. When new coals are put into the fire hot particles do escape from the fire. However, a very peculiar and natural 'solution' for this problem is found. If the hot particles do reach the roof spider webs stop them. This technique seemed to work perfectly. Bronze is put into the crucible and placed in the furnace right under the tuyere, coals are put around and over it. The coals by itself will burn at a temperature of around 900 °C, but to melt the bronze a temperature of around a 1000 °C is needed.[1] The smith himself actually prefers a temperature of 1200 °C, which makes the pouring easier, to ensure a good cast. A couple of hundred grams of bronze take around 20 minutes to become liquid and ready for the cast. The furnace is superheated by the use of bellows. Observing the color of the fire roughly tells the bronze caster the temperature. An orange glow indicates a temperature of around 900 °C; a very fierce white yellowish color indicates a temperature reaching over 1100 °C. During the heating process, the moulds are placed next to the fire. One of the moulds from the experiment, placed to close to the center of the heat source and therefore heated rather fast, split in two before anything was done with it.

When casting, the mould is placed between two sticks (*whitties*) and placed at a slight angle. This makes it possible for the air to escape when metal is poured into the mould. This is necessary, because otherwise air can not escape the mould and will form small air holes in the cast object. When pouring the metal in the mould a stick is held on the crucible to keep pieces of charcoal and debris from flowing out. Pieces of charcoal can disrupt the casting process by blocking the flow of bronze in the mould. Pouring has to be done fast, the liquid bronze will start to coagulate immediately. None of the bronze is wasted. If the cast fails it will be re-melted. Runners and pieces of bronze removed from the cast afterwards, or small droplets of bronze that fell next to the mould, will all be used again. The clay mould is destroyed most of the times. Occasionally it opens up perfectly and can be used again, but this is not intended. A good casting from good bronze (containing around 10 % of tin) will have gold like colour. If there is less tin in the alloy the colour will appear more copper like. A small dagger, with a nice 'gold like' colour was re-melted because the cast failed. It was heated again at a much higher temperature and for a longer period. The axe, cast from it the second time, had a considerable more copper like colour. Clearly, the bronze was heated too long making the tin oxidise and evaporate. Observations like these may also have guided the Bronze Age smith during the practice of melting and casting bronze objects.

1 This, of course, is dependent upon the sort of alloy and the percentages in which the different metals occur in the alloy.

# Appendix 2: Metallurgy related artefacts and debris from the Netherlands




The mould from Buggenum, Limburg (taken from Butler & Steegstra 1997/1998).

## 2.2 Moulds

***Buggenum-Meuse, fragment of bronze half-mould for palstave.***
*Dimensions*
Present length: 12,5 cm
Width: 6,4 cm
Blade width of negative: 5,2 cm

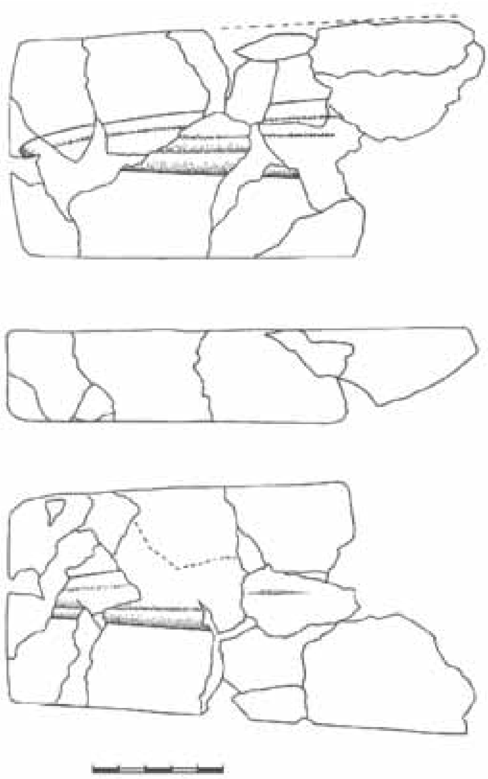
*Dating*
Middle Bronze Age – Late Bronze Age

*The mould*
The mould was supposedly found with a palstave, which, according to Butler, could have come from this mould (Butler 1973, 325). Nonetheless, in the catalogue this axe is not mentioned anymore in association to this mould and the mould is assigned to type AXP:P/\ (palstave with trapeze-shaped blades), but with reverse because it would be modified somewhat by hammering and sharpening (Butler 1997-1998, 227). No examples of this type of axe are known in the Netherlands (*Op. cit*, 271). The mould has a remnant of a lug for slotting into a hole of the missing half of the mould. Four radial thin ribs decorate the outside of the mould half connected by a thin rib at the base.

*Context*
The mould was dredged from the Meuse, near Haelen, *Gemeente* Buggenum, Limburg (197.500/360.500), together with a palstave (Cat No. 394). The fact that it is a river found may indicate that it was deliberately deposited, like many other bronzes (*cf.* Fontijn 2002). It is unknown whether the mould was used locally, broke and was subsequently deposited, or that it represents nothing more than a piece of scrap material.

*References*
Fontijn 2002, 138, appendix 8
Butler & Steegstra 1997-1998, 227-228, 271, fig. 72, Cat. Nos. 323.
Butler 1973, 322, afb. 1.
Brongers & Woltering 1978, p. 96, fig. 53 (but ascribed findspot Roermond)
De Laet 1982, 430-431
Wielockx 1986, Cat. No. Hi2b

### *Cuijk, clay mould fragments*



The mould from Cuijk (taken from Fontijn 2002)

*Dimensions*
Fragmented

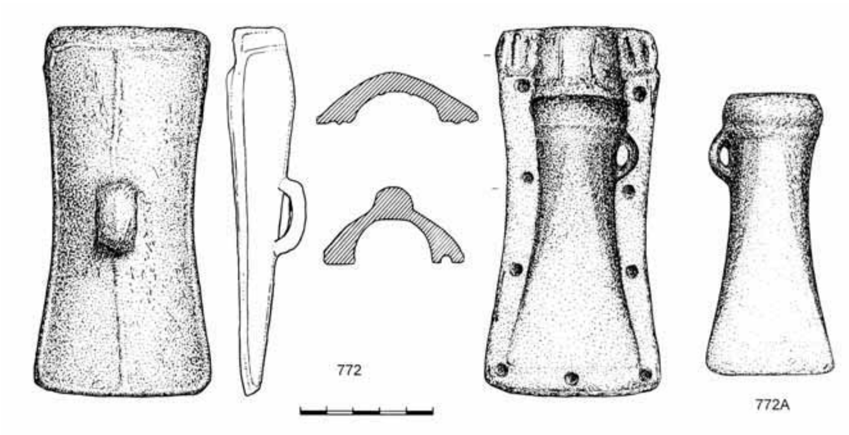
*Dating*
Middle Bronze Age

*The mould*
Information on this mould has not been published properly yet. Merely a small description by Fontijn (2002, 138) is available, who himself was only able to study a plaster of this find. The mould is severely damaged and fragmented, but could be reconstructed, as can be seen in the figure. It is half of a two piece mould. Nonetheless it is hard to say what kind of object could be formed in this mould. Fontijn gives three possibilities; a sword, spear or dagger, of which the latter is the most likely. The mould is tempered with a 'glittering' mineral which might be biotite or muscovite.

*Context*
The fragments were found somewhere around Cuijk (Noord-Brabant) by an amateur (Jo de Wit) and allegedly came from a pit, in which coarse-tempered shards were found as well. These could be dated to the Middle Bronze Age.

*References*
Fontijn 2002, 138, fig 7.16, appendix 8

## *Havelte, half of a bronze mould for socketed axe*




The Havelte mould with a plaster cast (taken from Butler & Steegstra 2005/2006).

*Dimensions*
Length: 14 cm
Width: 6,8 cm

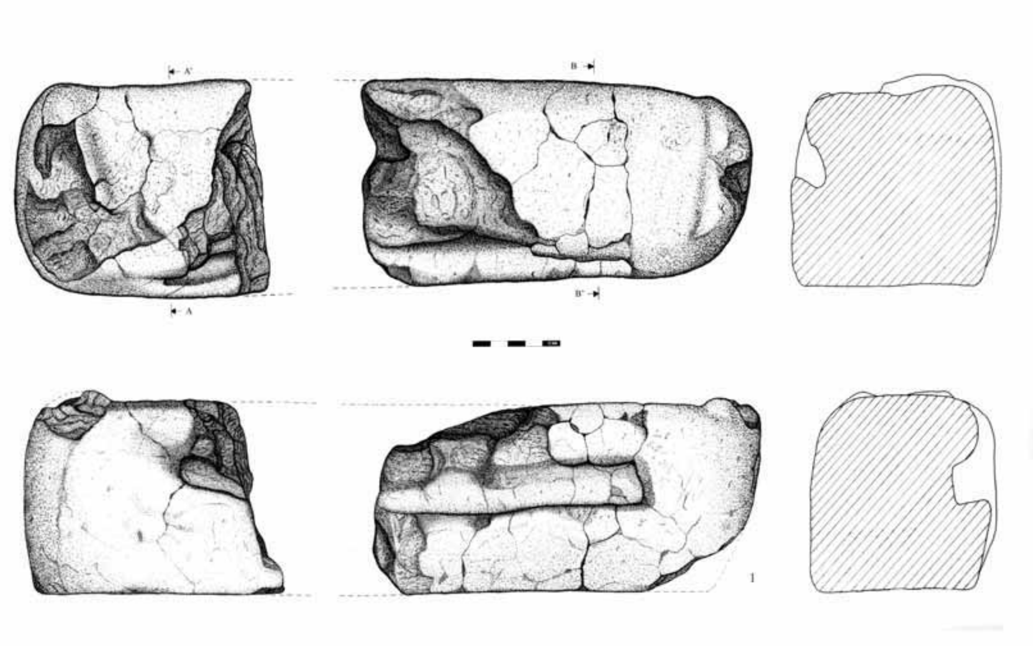
*Dating:*
Late Bronze Age

*The mould*
Half-mould for casting a socketed axe with. It has a cylindrical mouth and the inside is ribbed. There are nine dowel holes for keying in with the other half of the mould. A D-shaped loop can be found on the outside of the mould. A plaster has been taken from this mould.

*Context*
The mould is a stray find from Havelte, Ruiterweg. No other features have been recorded. However, a remarkable other find associated with metalworking has been found in Havelte, het Lok (see appendix 2.2). Here, two socketed axes an Urnfield knife and a casting jet were discovered. Whether this is coincidence or has anything to do with a probable production locus of a Bronze Age smith somewhere in the area is difficult to say.

*References*
Butler & Steegstra 2005/2006, 209, Cat. No. 772, fig. 107.
Verslag 1907, 7, no. 7.
v. Heemskerck-Düker & Felix 1942: pl. 97
Butler 1961, 204, fig. 11 and 12
Butler 1963, pl. XII: 6-8

## *Ittervoort, a possible mould?*



The possible mould from Ittervoort (taken from Drenth 2007).

*Dimensions*
Fragment 1:
Present length: 22 cm
Max. width: 10,5 cm
Thick: 10 cm

Fragment 2:
Present length: 12,5 cm
Width: 10,5 cm
Thick: 11, 5 cm

*Dating*
Late Bronze Age – Early Iron Age.

*Mould or firestand?*
These two fragments most probably make up what is an oblong earthenware object. In one of the long sides of fragment 1 a right angled groove can be found, at least 14,5 cm long, 2,5 deep and approximately 2,5 cm deep. The same groove can be found in fragment 2. Here the groove is somewhat slanting and has a (rest)length of 4 cm, a width of 1,5 and a maximum depth of 2 cm. Both fragments are secondarily burned.

Although I have not been able to study the object first handed I tentatively suggest the possibility of a mould. The original interpretation from the excavation report states that this object is a firestand (Drenth *et al.* 2007, 119-120). Drenth comes to this conclusion on typological grounds (although no parallels are given). He also states that he has no clue as to the function of the groove.

I think that this groove and the minimal height of the object argue against an interpretation as firestand. The groove may actually be a negative of a bronze object, most likely an ingot. A parallel of such a mould may be the mould found in Rotta (see figure).

Mould from Rotta (Wittenberg) with on al four sides a negative for an ingot (taken from Meller 2004).

*Context*

The objects were found in feature 359 during the excavations at Santfort-Ittervoort (Limburg). This feature is dated to the end of the Bronze Age - (Early) Iron Age. It yielded several other intriguing finds, such as a near complete pot with organic tempering and a peculiar decoration that may be an import. The excavators think that this feature and the finds, together with some other features from structure 1 and 2 may be part of a ritual burning of pottery and the destruction of a house (Drenth *et al.* 117-120). Several postholes were completely filled with secondarily burned pottery, after the post was removed.

The possibility that the object in question is a mould may be corroborated by some other finds at this site which indicate that at least metal was present, but metalworking may also have been part of the activities at this site. The bronze needle found in feature 54 and part of a bronze ring from feature 45 indicate that bronze was present at this site. Furthermore a casting jet was found during the excavation (see appendix 2.2), a strong indicator for metalworking activities.[2]

*References*

Drenth, E., H. Heijmans & D. Keijers, 2007.

2 Unfortunatly the excavation is poorly documented. The casting jet was found with a metaldetector, but the exact location within the research area is unknown. The bronze needle disappeared during the excavation.

***Oss-Horzak, fragment of clay mould for multiple objects.***

The Oss mould. On the left is the pin-side, on the right the axe-side (photograph Faculty of Archaeology, Leiden).

*Dimensions*
Present length: 11,5 cm
Width: 11 cm
Thick: 4 cm.

*Dating:*
Middle Bronze Age B

*The mould*
The mould appears to be a fragment of what used to be at least a two piece mould. In both sides of the recovered mould piece objects are carved. I will address the mould by each side, according to the main object that can be cast in it; *i.e.* the axe-side and the pin-side.

The axe-side shows that a small palstave could be cast in this mould. It is carved out of the clay, partly cutting off the negative of an arrowhead. Next to these are two arrowheads in a row with a single barb (see figure). The palstave that could be cast from this negative is of a type that Butler would address as 'regional', belonging to the group of parallel sided palstaves (AXPP/\; Butler & Steegstra 1997-1998; Fontijn 2002, 121). The flanges on its side however, are thought to be a northern rather then a southern feature. The single-barbed arrowheads are in a row, indicating that they were cast in series. The blade is very small though, and would probably need hammering after the cast. Both the surface of the mould as well as the surface of the object negatives is blackened, indicating that it may have been in contact with a fire. This may be the result of pre-heating of the mould before casting, which is needed to ensure that the mould will not crack (Coghlan 1975, 60-61; see section 7.5; appendix 1). The pin-side is not blackened however, which may be the result of a contra-mould covering this part. Another possibility is that the axe-side was covered in charcoal, which prevents the bronze from sticking to the clay when casting (Drescher 1957, 58).

On the pin-side of the mould a negative of a wheel-headed pin can be seen. This gullies of this negative are irregularly shaped and very narrow, making it unlikely that bronze could have flown trough them successfully. It may either be that the other (missing) half of the mould contains a better negative, or that this wheel-headed pin was a failure and never cast (see below). If a pin was cast in it, it would have needed hammering to lengthen the pin to its right length.

The possibility exist that both the axe-side as well as the pin-side had a contra-mould, making it a three piece mould. The piece retrieved from the ground appears to be the uppermost part and is slightly rounded off. The surface in which the negatives are carved is smooth and regular on both sides. The long sides of the mould show horizontal grooves, which may be the result of ropes. These grooves are absent on the short side. On possibility is that these ropes were used to fasten the casting channel, which may have been situated at the short side in a small rounded depression around the opening of the butt of the axe. The mould is entirely oxidized. It consists of very clean clay, tempered with biotite and fired to a temperature of at least 650º C (Fontijn 2002, 138; Fontijn *et al.* 2002, 68). Iron particles are completely lacking. As iron particles can be found in all clay sediments around Oss, we may assume that that the mould was made from non-local clay and may have been an import from afar. The fact that the arrowheads are cut off by the shape of the axe may indicate that it was special clay, which was hard to come by and thus re-used as much as possible.

*Context:*

The mould was found during an excavation of a Roman cemetery in Oss-Horzak. Some Bronze Age features were also discovered at this site. These consisted of some scattered pits which may have belonged to a farmstead, although none was discovered, probably due to the fact that the north part of the site was disturbed by recent building activities and the construction of a sewer. On Friday the 27th of July feature number 19 in trench 63 was cut. An object was taken from the profile just before leaving the field. Rinsing this object, it turned out to be a mould. Because the excavators immediately saw the importance of such a find, the rest of the pit was scrutinized for any other traces of metalworking. A high amount of charcoal, a number of pot shards, stones, and as yet unidentified burnt clay fragments were retrieved. Tabel 1 lists all the finds from feature 63.19. Unfortunately, half of the pit was already destroyed during the constructing of a sewer. No archaeological finds were reported then. Although samples of the pit were sieved through a 2mm sieve, no bronze droplets were discovered.

The pit was dated to the Middle Bronze Age B according to the shards (Fontijn *et al.* 2002). This is now corroborated by a $^{14}$C dating of charcoal found in the pit, which is dated to 3160 +/- 50 BP (GrN-27998).[3] Only one other Bronze Age pit was found in the vicinity of feature 63.19. A cluster of pits that also dates to the Middle Bronze Age B can be found 180 m away. There are no indications that these are associated with each other, besides that they are both dated to the same period.

*Implications:*

This find seems to be directly related to production. It is hard *not* to interpret the high amounts of charcoal and the lumps of loam as related to the casting process, particularly since such finds are entirely missing from the adjacent Bronze Age features. Remarkable is the concentration of very different objects that were apparently produced by the same smith; a regular tool of daily life, rare arrowheads and a wheel-headed pin. It shows that the distinction between specialist and non-specialist cannot easily be made.

The non-native character of the clay and the amount of objects that can be cast in it has been used to discuss the itinerancy of the smith again (Fontijn 2002, 141). However, the mould could have easily be traded or exchanged without a travelling smith accompanying it. The fact that the clay of the mould came from afar does not say anything about the smith who may have used it.

As proposed by Fontijn (2002, 141) it is possible that ornaments such as the wheel-headed pin may have been copied locally. Another possibility is that the mould was imported but the pin-side never used to cast. Rather, this suitable block of clay was used to carve other products in.

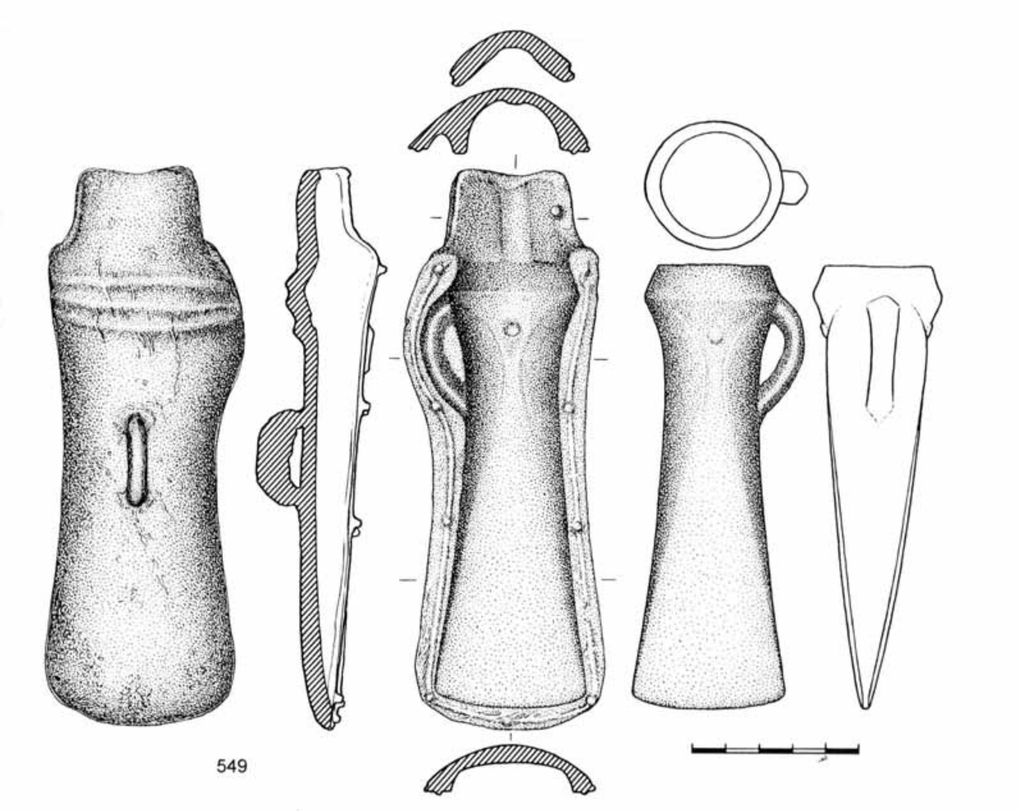
*References:*

Fontijn 2002, 138-140, appendix 8

Fontijn *et al.* 2002

3 Cal. BC 1527 – 1312 with 95 % probability.

***Roermond-Meuse: bronze casting half-mould for Helmeroth axes***




The Roermond mould. On the right a plaster cast taken from it (taken from Butler & Steegstra 2001/2002).

*Dimensions*
Length: 17,1 cm
Width: 5,9 cm at shoulder, 5,7 cm at base

*Dating*
Late Bronze Age

*The mould*
A plaster cast has been taken from this mould (see figure). This type of axe is catalogued by Butler and Steegstra as type Helmeroth (AXT:helm). A projection on the mould would have housed a clay funnel for pouring the molten bronze into the mould. There are three horizontal ribs on the shoulder of the mould. There is a D-loop handle on the external face of the mould. The edges on the inside show nine small lugs for keying with the other half of the mould which has not been recovered.

*Context*
Dredged from the river Meuse near Roermond. Erroneously attributed to Maastricht (Butler 1973, 338), but rectified later by the same author (Butler & Steegstra 2001/2002, 303). As with the

Buggenum mould it was found in a wet context. Whether the mould was actually used is difficult to say. It ended up in the river Meuse and thus it is more informative on depositional practices than bronze production.

*References*

Fontijn 2002, appendix 8
Butler & Steegstra 2001/2002, 303
Mariën 1952, 226
Butler 1973, 338, fig. 15

## *Someren Waterdael III: clay half mould for an urnfield knife*

The mould from Someren (photograph by H. Hiddink, ACVU-HBS, Amsterdam.

*Dimensions:*
Length: 12 cm
Width: 5,6 cm

*The mould*
During the writing of this thesis a new discovery was made at an excavation in Someren, Waterdael III. The object has not been studied in detail yet and the data published here are preliminary observations by Henk Hiddink, who kindly provided me with the data.

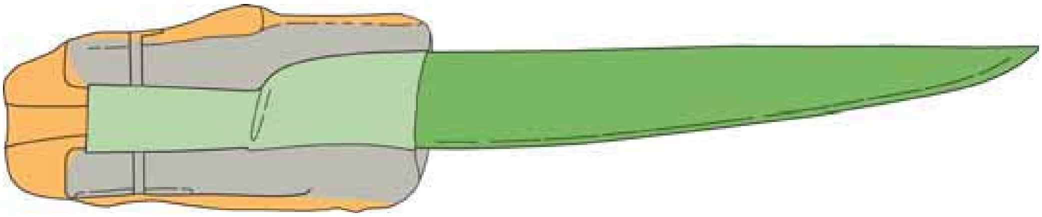
The piece is a large fragment of one half of the mould in which the handle, bridge and part of the blade of an urnfield knife could be cast. The other half of the mould has not been found. It appears to be made from baked loam. Two small air holes can be found on either side of the mould. The slightly orange colored opening at the short side of the mould shows that it was actually used. The break on the short side of the mould is ancient. It is unclear how big the missing part is and this depends on how much of the blade was actually cast and how much was hammered out. It is possible that a large part of the blade was cast, but hammering the blade to its final shape is also a possibility, which would also increase its hardness considerably.

*Context*
The mould was found during large-scale excavations (14.4 ha) of Someren-Waterdael III. Apart from a large cemetery dating to the Late Iron Age / Roman period and c. 150 medieval buildings and well, several prehistoric sites were found. In the centre of the excavation there is a small urnfield of some 40-50 graves (mainly Early Iron Age, some Middle Iron Age). The mould was found in a small pit (feature 286.012, find-number 4), some 100 meters northeast of the urnfield. The oval-shaped pit measured 1.5 by 1 meter and was only 27 centimeters deep. No layers were visible. It is not clear whether the pit was situated in a farm-yard. The area directly to the west

could not be excavated because of ongoing construction work. The trial trenches made earlier produced no features, however. In the area to the north and east several outbuildings, pits and two house-plans were discovered. A prelimenary analysis of these features points to a dating in the Late Bronze Age and Early Iron Age.

*References*

Hiddink, H.A., 2008.
Hiddink, H.A./E. de Boer, in prep.



Impression of the urnfield knive that may have been cast using the mould (drawing by H.Hiddink).

## 2.2: Casting jets

### *Drouwenerveld, Gemeente Drouwen, Drenthe*

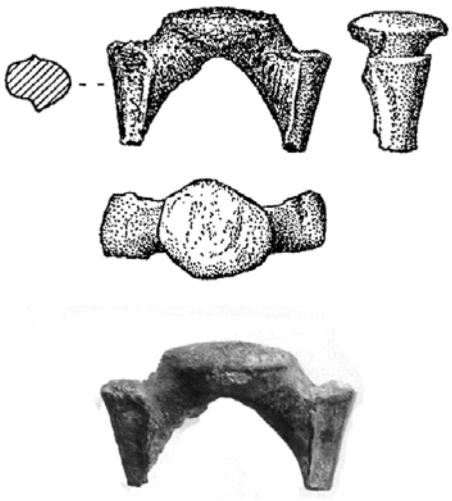

Casting jets from the hoard of Drouwenerveeld (see chapter 4,fig. 4.5 for the rest of the hoard).

Two definite and three possible casting jets can be recognized in the hoard of Drouwenerveld (Butler 1986, 139, fig. 7: 44/1, 44/2, 55, 63, 64). The hoard may have been imported as scrap intended to be re-melted. The first casting jet (No. 24) has tree runners joined arch-wise. Because no 'head' has formed on top of the casting jet (as can be seen in No. 26 or the Havelte casting jet) it is unlikely that a funnel was used to cast the bronze. We can only guess what kind of object was cast that left this kind of casting jet. The second casting jet (No. 25) consist of only one runner, which gets broader at the top. No. 26 also has only one runner which is surmounted by a disc-like head, the second runner seems not to have formed. It is difficult to say whether No. 27 is a casting jet or fragment of a broken object. If it is a casting jet it most probably represents only the top. No. 36 is described as a miscellaneous undetermined fragment both by Butler as well as Van de Broeke. Nonetheless, I think this may be a casting jet too, with one runner and a 'head'.

*Context*
Although a small excavation was undertaken during the recovery of the pot and a second larger excavation a year later, no other features or traces could be found (Kooi 1981).

*References*
Van den Broeke 2007, 604-605, fig. 27.2
Butler & Steegstra 2003-2004, 267-269
Butler 1986, 133-168, figs. 2-5

### ***Havelte, gemeente Havelte, Drenthe***



The casting jet was found inside a socketed axe (taken from Butler 1961 and Bloemers *et al. 1981)*.

In 1872 a small hoard was found in Havelte "het Lok" by a farmer who was ploughing his field. It consisted of two axes, a Central European Urnfield socketed knife and a casting jet.

*The casting jet*
The casting jet was found inside one of the axes. It has two conical runners, each with a vertical seam on each face. These are joined arch-wise and surmounted by a disc-like head. The casting jet has a width of 4,6 cm and a height of 2,85 cm.

*The axes and Urnfield knife*
Both axes are well documented under Cat. No. 663 and 689 in the catalogue on socketed axes (Butler & Steegstra 2003/2004). Therefore, I will limit myself to a basic description. The axe in which the casting jet was found is a socketed axe with face arches, multiple neck ribs and embellished with a saw-tooth motive around the socket (AXT:ANr3+Emb.). The second axe has face arches, 'wings' one neck rib and no embellishment (AXT:AWiNr1). The knife is most probably an imported piece from the Alpine region and has a very distinct 'Urnfield' decoration.

The hoard can be dated between Halstatt B2/3/Montelius V, mostly on the basis of the Urnfield knife.

*Context*
The hoard is a stray find.

*References*
Butler & Steegstra 2003-2004, 267, fig. 91A
Butler 1986, 162, fig. 29
Butler 1969, fig 43
Butler 1961, 207-212

### *Heel, gemeente Beegden, Limburg*

This casting jet has been found in an area southeast of the Heelderpeel. It measures approximately 4,5 cm in length and has 2 runners that are connected arch-wise. The casting jet has no obvious 'head'. Besides it similarity to other casting jets there is no positive evidence to date it to the Bronze Age.

*Context*

There is no detailed information on where or how it was recovered, besides a note by Butler and Steegstra where this casting jet is mentioned as a comparison to the one found in Havelte. Here, it is mentioned that it was found with a metaldetector in scraped ground in a dredge area. Within a circle of 500 meters from the supposed findspot of the casting jet a Middle Bronze Age settlement (Willems 1983) and two Iron Age settlements are located (Schreurs 1990, fig 9).

*Reference*

Schreurs 1990, 45, afb. 14.
Butler & Steegstra 2003/2004, 239

### *Ittervoort, Gemeente Leudal, Limburg*

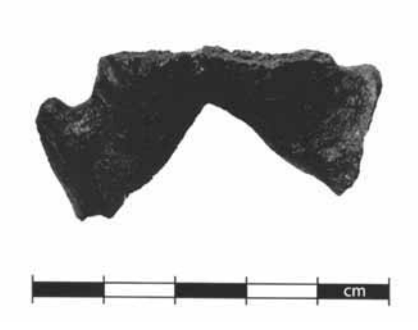
During excavations at Santport, Ittervoort a bronze casting jet was found with the use of a metal detector. The casting jet measures around 5 cm. It can be dated, though with reserve, to the Late Bronze Age or Early Iron Age on the basis of other finds from this site.

*Context*

Unfortunately, the exact find location on the site is unknown.

*Reference*

Drenth, Heijmans & Keijers 2007, 121, afb. 45.




The casting jet from Ittervoort (taken from Drenth 2007)

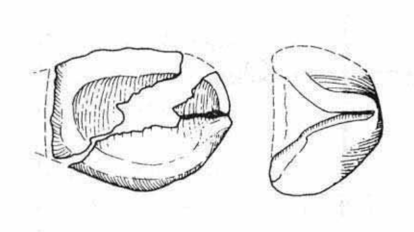
## 2.3: Crucibles

***Kesteren- Woonwagenkamp, Gemeente Neder-Betuwe, Gelderland***

A spoon-like earthenware object was found during a preliminary research at Kesteren, Woonwagenkamp, in advance of the Betuweroute (site 14). It measures 4,6 cm in length and 3,8 in width. On one of the short sides an incision can be found. This might have been cut in order to pour the molten metal. The rather small size of the object seems inconsistent with its possible use as a crucible. Only a very small amount of metal could have been melted. If it is a crucible it is therefore more likely that gold or tin was melted, rather than bronze. No additional research has been done to see whether any particles of metal are left in the ceramics. No information on the color or state of the ceramic is given.

*Context*

Later excavations following the *AAO* uncovered three farmyards dating to the Middle Bronze Age (1600 – 1500 BC), which may be interpreted as a small settlement. Site 14 was probably inhabited for two generations, assuming the house found here lasted for c. 30 years.  It is unlikely that the complete settlement has been excavated. No other traces indicating metal-working were recovered.



*Reference*

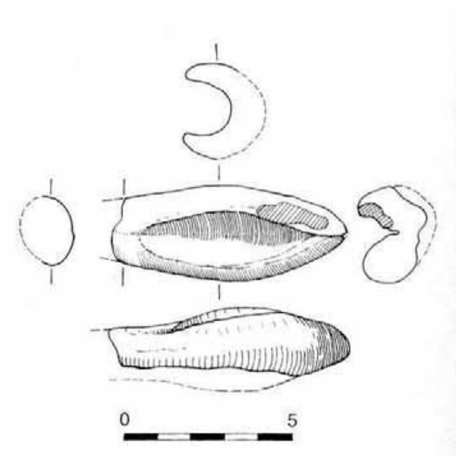
Siemons & Sier 1999, 26-27
Schoneveld & Kranendonk 2002

***Geldermalsen knooppunt B-Voetakker, gemeente Geldermalsen, Gelderland***

Another possible crucible was found in the track of the Betuwe route (site 28), during the *AAO* at Geldermalsen knooppunt B-Voetakker. This spoon-like object made from earthenware measures 7,2 by 3,0 cm. Judging from the size and the form of this object, it would not make the best crucible. No bronze rest material was found, neither any sign of vitrification (Ufkes & Bloo 2002, 376).

*Context*

Knooppunt B/Voetakker is part of a cluster of sites known as the Bogen. The site has been excavated completely. Site 28 has yielded several pieces of metal, most of which are bronze but also a piece of lead has been found. The Bogen represent sites that were occupied from the Late Neolithic to Middle Bronze Age (2450 – 1250 BC). It has yielded a range of artefacts that may have belonged to the metalworker's toolkit and as I have argued in this thesis (chapter 7 & 8). It is not unlikely that metalworking has taken place here.




*References*

Bulten & Smiths 1998, 26
Ufkes & Bloo 2002, 376

## 2.4: Droplets

### *Houten VleuGel Tracé*
Two small bronze droplets were found in the Houten VleuGel Tracé. The first is of an irregular shape the second has a more rounded / oval shape. Both fragments have been in contact with fire and have been molten at some point. In the second layer an egg-shaped, vitrified object was found (114gr. 56 by 45 mm). This might be a sintel. Its distinct reddish brown colour indicates that it might contain cuprite. Chemical analysis might reveal whether this is a copper slag.

*Context:*
All finds were done in a Middle Bronze Age context.

*Reference:*
Verhelst 2006

### *Caberg Maastricht Groeve Klinkers, Gemeente Maastricht, Limburg*
A few fragments of bronze were found in the fill of two pits which also contained Bronze Age earthenware. No further description of the pits is given.

*References*
Theunissen 1990, 211
Fontijn 2002, 373 appendix 8

### *Nijmegen, Kops-Plateau*
During the excavation of a roman cemetery a Middle Bronze Age pot was encountered of which the upper part was already missing. The pot lay in the bottom of a pit at its side. No other objects were found. Inside the pot were some small pieces of melted bronze.

*References*
Fontijn 2002, appendix 8
Fontijn unpublished ROB excavation

### *Meteren-De Bogen site 28-1, 28-2 and 29 (Voetakker)*
At Meteren-De Bogen there are stong indications that metalworking has taken place. Several small bronze fragments have been found, next to a droplet of bronze (Butler & Hielkema 2002, 593ff) indicating that the bronze has been liquid at some time. Amongst the finds are also lead and a piece of tin platae (l. 2,30 cm, w. 1.0 cm, t. 0,20-0,50 cm).

*Reference*
Butler & Hielkema 2002

# Appendix 3: Metallurgy related debris in a secure context from North-West Europe

The following table is made primarily on the basis of the information collected by Lucas Meurkens. (2004). His appendix has been summarized in the table. Some additional sites have been added. The bold typeface sites indicate that a substantial amount of metalworking debris has been found at that specialization has been or may be surmised. The italic typeface sites have been interpreted as places where the 'ritual dimension' of metalworking is evident (either by the original author or Meurkens 2004). While in the publications the amount of debris is often listed I did not use these numbers as it would give a distorted image. Whether 76 pieces of clay mould have been found or 6 may not provide us with anymore information than the level of fragmentation on a site. Hence, the number 1 is used when a site has yielded evidence of that kind listed.

| country | Site | Context | Dating | metalwork debris | | | | | | | | | | | mould artefact types | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | clay mould(s) | stone mould(s) | bronze mould(s) | crucible(s) | furnace(s) | tuyere(s) | slag | anvil | hammer-, whet-, polishing stones | metalworking implemts | bronze(s): scrap, ingots, roughcast etc. | swords / rapiers | axes / palstave | dagger / knife | spears | ornaments | other implements |
| NL | Someren Waterdael III, Brabant | settlement | LBA-EIA | 1 | | | | | | | | | | | | | 1 | | | |
| NL | Oss Horzak, Brabant | settlement | MBA | | 1 | | | | | | | | | | | 1 | | | 1 | 1 |
| BE | Marche-les-Dames, Namur | rock shelter | LBA | 1 | | | | 1 | 1 | 1 | | 1 | | | | | | 1 | | 1 |
| Denmark | Ferslev, Zealand | stone foundation of long house | LBA | 1 | | | 1 | | | | | | | | | | | | | |
| Denmark | Jyderup Skov, Zealand | settlement | LBA | 1 | | | | | | | | | | | | | | 1 | 1 | |
| Denmark | Ganløse, Zealand | large pits | LBA | 1 | | | 1 | | | | | 1 | | 1 | | | | | | |
| Denmark | Gundøgaard, Zealand | settlement | LBA | 1 | | | 1 | | | | | | | | | | | | | |
| Denmark | Skamlebaek, Zealand | settlement | LBA | 1 | | | | | | | | | | 1 | | | | | | |
| Denmark | Fragtrup, N. Jutland | settlement | LBA | 1 | | | | | | | | | | 1 | | | | | | |
| Denmark | Abbetved, Zealand | burned daub ? | LBA | 1 | | | | | | | | | | | | | | | | |
| Denmark | Voldtofte, Funen | extensive daub ? | LBA | 1 | | | 1 | | | | | | | | 1 | | | | | |
| Denmark | Haag, N. Jutland | burned daub ? | LBA | 1 | | | 1 | | | | | | | 1 | 1 | 1 | | 1 | 1 | |
| Denmark | Vindblaes, N. Jutland | stone paved areas, midden debris | LBA | 1 | | | 1 | | | | | | | | | | | 1 | 1 | |
| Denmark | Troldting, N. Jutland | settlement | LBA | 1 | | | 1 | 1 | | | | | | 1 | | | | | | |
| France | **Cannes-Écluse, Seine-et-Marne** | settlement | LBA | | | | | 1 | 1 | | | | | 1 | | | | | | |
| France | Catenoy 'Le Camp César', Oise | promontory | LBA | 1 | | | | 1 | | | | | | 1 | 1 | | | | | |
| France | **Choisy-au-Bac "Le Confluent", Oise** | settlement | LBA-EIA | | | | | 1 | | | | | 1 | 1 | | | | | | |
| France | Cuiry-les-Chaudardes "Le Champ Tortu", Aisne | enclosure | LBA-EIA | | 1 | | | | | | | | | | | | | | | 1 |
| France | Lestiala, Finistère | furnace | LBA | | | 1 | | 1 | | | | | | | | 1 | | | | |
| France | Quiévrecourt "L'Hôpital", Haute-Normandie | enclosure | LBA-EIA | 1 | | | | | | | | | | 1 | 1 | | | | | |
| France | Sainte-Marie-Laumount, Calvados | furnace | LBA | | | 1 | | 1 | | | | | | | | 1 | | | | |
| France | **Sorel-Moussel "Fort-Harrouard", Eure-et-Loire** | promontory | LBA | 1 | 1 | | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| France | Soumont-Saint-Quentin, Manche | hillfort | LBA | 1 | | | | | | | | | | | | | | 1 | | |
| France | Vieux-Moulin "Saint-Pierr en Chastre", Oise | hillfort | LBA | | | 1 | | | | | | 1 | 1 | 1 | 1 | 1 | | | | 1 |
| | Aldermaston Wharf, Berkshire | settlement | LBA | 1 | | | 1 | | 1 | | | | | | | | | | | |
| | Beeston Castle, Cheshire | hillfort | LBA | 1 | | | 1 | | | | | | | 1 | | | | | | |
| | Billown, Isle of Man | settlement | MBA | | | | 1 | 1 | | 1 | | | | | | | | | | 1 |
| | The Breiddin, Powys | hillfort | LBA | 1 | | | 1 | 1 | | | | 1 | 1 | 1 | 1 | | 1 | 1 | | 1 |

| country | Site | Context | Dating | metalwork debris | | | | | | | | | | | mould artefact types | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | clay mould(s) | stone mould(s) | bronze mould(s) | crucible(s) | furnace(s) | tuyere(s) | slag | anvil | hammer-, whet-, polishing stones | metalworking implemts | bronze(s): scrap, ingots, roughcast etc. | swords / rapiers | axes / palstave | dagger / knife | spears | ornaments | other implements |
| United Kingdom | Brighton "Downsview", Sussex | settlement | MBA-LBA | | 1 | | | | | | | 1 | 1 | | | | | | 1 | |
| | Burderop, Down, Wiltshire | settlement | MBA-LBA | | 1 | | | | | | | | | 1 | | 1 | | | | |
| | Carshalton "Queens Mary's Hospital", Surrey | enclosure | LBA | | | | 1 | | | | | | | 1 | | | | | | |
| | *Charlton Kings "Sandy Lane", Gloucestershire* | burnt mound | MBA ? - LBA | 1 | | | | | | | | | | | | | | 1 | | |
| | Chisle "Highstead", Kent | enclosure | LBA | 1 | | | | | | | | | | | | | | | | 1 |
| | Cladh Hallan, South Uist | settlement | LBA | 1 | | | 1 | | 1 | 1 | | | | | 1 | | | 1 | 1 | |
| | *Dainton, Devon* | cairns | LBA | 1 | | | 1 | | | | | | | 1 | 1 | | | 1 | | 1 |
| | Dean Moor, Devon | settlement | MBA-LBA | | | | | | | | | | | | | | | | | |
| | Deal "Mill Hill", Ken | enclosure | LBA | 1 | | | | | | | | | | | | | | | 1 | |
| | Dunagoil, Bute | hillfort | LBA-LIA | 1 | | | | | | | | | | | | 1 | | | | |
| | Egham "Petters Sport Field", Berkshire | settlement | LBA-EIA | | 1 | | | | | | | | | 1 | | 1 | | | | |
| | Egham "Runnymede Bridge", Berkshire | settlement | LBA | 1 | | | 1 | 1 | | | | | | 1 | | | | | | |
| | Fimber, Yorkshire | earthwork | LBA | 1 | | | | | | | | | | | 1 | 1 | | | | |
| | Galmisdale, Isle of Eigg, Highland | lee of large boulder | LBA | 1 | | | 1 | | | | | | | | | 1 | 1 | | | |
| | Grimes Graves, Norfolk | midden group | MBA-LBA | 1 | | | 1 | | | | | | | | | | | 1 | | |
| | Gwithian, Cornwall | settlement | MBA-LBA | 1 | 1 | | | | | | | | | | | 1 | | | | |
| | Hambledon, Dorset | hillfort | LBA-IA | | 1 | | | | | | | | | | | 1 | | | | |
| | Ham Hill, Somerset | hillfort | MBA-LIA | | 1 | | | | | | | | | | | | | | | |
| | *Heathery Burn Cave, Yorkshire (Britton 1968)* | cave | BA | | | 1 | | | | | | | 1 | | | 1 | | | | |
| | *Helsbury, Cornwall* | cave ? | MBA-LBA | | 1 | | | | | | | | | | | 1 | | | | |
| | **Jarlshof, Shetland** | settlement | LBA | 1 | | | | | | | | | | | 1 | 1 | | 1 | 1 | 1 |
| | Kemerton "Huntsman's Quarry", Worcestershire | settlement | LBA | 1 | | | | | | | | | | | 1 | 1 | 1 | 1 | | |
| | Kingston-upon-Thames "Kingston Hill" | settlement | LBA | | 1 | | | | | | | | | 1 | | | | | | 1 |
| | Kynance Gate, Cornwall | settlement | MBA-LBA | 1 | | | | 1 | | | | | | | | | | | | |
| | *Loanhead of Daviot (Scotland)* | stone circle + burial site | BA | | | | | | | | | | | | 1 | | | | | |
| | Melrose "Eildon Hill North" | hillfort | BA? - Roman | | 1 | | | | | | | | | | | | | 1 | | |
| | Mile Oak, Sussex | mounds ? | LBA | | | | 1 | | | | 1 | 1 | | 1 | | | | | | |
| | Mucking "The North Ring", Essex | enclosure | LBA | 1 | | | 1 | | | | | | | 1 | | | | | 1 | 1 |

| country | Site | Context | Dating | metalwork debris: clay mould(s) | stone mould(s) | bronze mould(s) | crucible(s) | furnace(s) | tuyere(s) | slag | anvil | hammer-, whet-, polishing stones | metalworking implemts | bronze(s): scrap, ingots, roughcast etc. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| United Kingdom | Newquay "Trethellan Farm", Cornwall | settlement | MBA | | 1 | | | 1 | | | | 1 | | 1 |
| | *Norton Fitzwarren, Somerset* | hillfort | MBA-IA | 1 | | | | | | | | | | |
| | *Nursling, Hampshire* | isolated pits | LBA | 1 | | | | | | | | | | |
| | Rosskeen, Ross and Cromarty | metalworking site | LBA | | 1 | | | 1 | | 1 | | | | |
| | Sheep Hill, Dunbartonshire | hillfort | LBA | 1 | | | | | | | | | | |
| | *Sigwells, Somerset* | barrows and enclosure | BA-IA | 1 | | | | 1 | | | | | | |
| | Somerford Keynes "Shorncote Quarry" | settlement | LBA | 1 | | | | | | | | | | |
| | South Hornchurch, Essex | enclosure | LBA | 1 | | | | | | | | | | |
| | *Springfield Lyons, Essex* | enclosure | LBA | 1 | | | | | | | | | | |
| | Trevisker, Cornwall | settlement | BA | | | | | | | | | | | 1 |
| | Thwing, Yorkshire | hillfort | LBA | | | | | | | | | | | 1 |
| | Traprain Law, East Lothian | hillfort | LBA-Roman | 1 | | | | | | | | | | 1 |
| | Wadesmill "Moles Farm", Hertfordshire | settlement ? | LBA-EIA | | | | 1 | | | | | | | |
| | *"The King's Stables", Co. Armagh (Northern Ireland)* | ceremonial | LBA | 1 | | | | | | | | | | |
| Ireland | Aran Islands "Dún Aonghasa", Co. Galway | promontory | MBA-LBA | 1 | | | | | | | | | 1 | |
| | *Ballyconneely, Co. Clare* | burials | MBA-LBA | | | | | | | 1 | | | | |
| | Bohovny, Co. Fermanagh | settlement | LBA | 1 | | | | | | | | | | |
| | Corrsdown, Co. Londonderry | settlement | MBA | | 1 | | | | | | | | | |
| | Dalkey Island, Co. Dublin | promontory | BB -BA - EMP | 1 | | | 1 | | | | | | | |
| | Gragan West, Co. Clare | barrow within settlement | MBA ? | | 1 | | | | | | | | | |
| | Killymoon, Co. Tyrone | 'industrial' site | LBA | 1 | | | | | | | | | | |
| | Kilsharvan, Co. Meath | enclosure | LBA | | 1 | | | | | | | 1 | | |
| | Lough Eskragh, Tyrone | metalworking site ? | LBA | 1 | | | 1 | | | | 1 | | | |
| | *Lough Gur, Co. Limerick (wedge tomb)* | burial site | MBA-LBA | | 1 | | 1 | | | | | | | |
| | *Lough Gur, Knockadoon, Co. Limerick* | Isolated metalworking site | MBA-LBA | 1 | 1 | | 1 | 1 | | | | | | 1 |
| | *Newgrange, Co. Meath* | passage tomb + settlement | BB-EBA | | | | | | | | 1 | 1 | | |
| | *Old Connaught, Co. Dublin* | burial and settlement | BA | 1 | | | | | | | | | | |
| | *Raheen, Co. Limerick* | burial site ? | MBA | | 1 | | | | | | | 1 | | |

| Site | mould artefact types: swords / rapiers | axes / palstave | dagger / knife | spears | ornaments | other implements |
|---|---|---|---|---|---|---|
| Newquay "Trethellan Farm", Cornwall | | | | | | |
| *Norton Fitzwarren, Somerset* | 1 | | | | | |
| *Nursling, Hampshire* | | | | | | |
| Rosskeen, Ross and Cromarty | | 1 | | | | |
| Sheep Hill, Dunbartonshire | | 1 | | 1 | | |
| *Sigwells, Somerset* | 1 | 1 | | 1 | | |
| Somerford Keynes "Shorncote Quarry" | | 1 | | | | |
| South Hornchurch, Essex | 1 | | | | | |
| *Springfield Lyons, Essex* | 1 | | | | | |
| Trevisker, Cornwall | | | | | | |
| Thwing, Yorkshire | | | | | | |
| Traprain Law, East Lothian | 1 | 1 | | 1 | | |
| Wadesmill "Moles Farm", Hertfordshire | | | | | | |
| *"The King's Stables", Co. Armagh (Northern Ireland)* | 1 | | | | | |
| Aran Islands "Dún Aonghasa", Co. Galway | | | | 1 | | |
| *Ballyconneely, Co. Clare* | | | | | | |
| Bohovny, Co. Fermanagh | 1 | | | | | |
| Corrsdown, Co. Londonderry | | 1 | | | | |
| Dalkey Island, Co. Dublin | 1 | 1 | 1 | 1 | 1 | 1 |
| Gragan West, Co. Clare | | 1 | | | | |
| Killymoon, Co. Tyrone | | | | 1 | | 1 |
| Kilsharvan, Co. Meath | | | | 1 | | |
| Lough Eskragh, Tyrone | 1 | 1 | | | | |
| *Lough Gur, Co. Limerick (wedge tomb)* | | | | 1 | | |
| *Lough Gur, Knockadoon, Co. Limerick* | | 1 | | 1 | | |
| *Newgrange, Co. Meath* | | | | | | |
| *Old Connaught, Co. Dublin* | 1 | | | | | |
| *Raheen, Co. Limerick* | | 1 | | | | |

# Appendix 4: Axes from the Netherlands labelled local by Butler

List of all the axes labelled 'regional' by Butler and Steegstra in their catalogues. When plotted on a map three concentrations can be seen, especially for the Middle and Late Bronze Age axes (see the maps in this appendix). North-eastern Netherlands (Drenthe), the area around Nijmegen and Middle Limburg have yielded a remarkable amount of regional axes in comparison to other regions. There may be several reasons for this. The concentrations around Roermond (Limburg) and Nijmegen may be the result of high intensity dredging (Fontijn 2002, 48). The concentrations in Drenthe may be the result of large scale research in this area. These areas may nonetheless still form an interesting starting point when looking for the production locus of the smith. All the areas have also yielded interesting metalworking related artefacts.

*Main axe codes:*

AXF = flat axe
AXI = low flanged axe
AXR = high flanged axe
AXS = stopridge axe
AXP = palstave
AXT = socketed axe

| AXE: | TYPE: | Sub-type: | Findspot / Toponiem: | Gemeente: | Provence | X | Y | Cat. No. |
|---|---|---|---|---|---|---|---|---|
| FLAT | EMMEN TYPE | | Valtherspaan | Odoorn | Drenthe | 254950 | 540275 | 42 |
| FLAT | | | Vries, Achterste Holten | Vries | Drenthe | 233100 | 565300 | 43 |
| FLAT | | | Noordveen' | Emmen | Drenthe | ? | ? | 44 |
| FLAT | | | Donkerbroek | Ooststellingwerf | Friesland | 212000 | 559300 | 45 |
| FLAT | | | Suawoude | Tietjerksteradeel | Friesland | 191800 | 576450 | 46 |
| FLAT | | | Near Emmen | Emmen | Drenthe | ? | ? | 47 |
| FLAT | | | Gietem | Gieten | Drenthe | 247 | 558000 | 48 |
| FLAT | | | Gasselterboerveen | Gasselte | Drenthe | 253850 | 558500 | 49 |
| FLAT | | | Eastern Drenthe or Westerwolde | | Drenthe | ? | ? | 50 |
| FLAT | | | Aalten | Aalten | Gelderland | 235650 | 439250 | 51 |
| FLAT | | | | | | | | |
| FLAT | | EMMEN / NEYRUZ TYPE AXES | Vogelenzang | Bloemendaal | Noord-Holland | 100000 | 481000 | 52 |
| FLAT | | | | | | | | |
| FLAT | | SOUTHERN/EASTERN EMMEN AXES | s-Heerenberg | Bergh | Gelderland | 214000 | 432000 | 53 |
| FLAT | | | Leende | Leenderhei | Noord-Brabant | 166000 | 373000 | 54 |
| FLAT | | | | | | | | |
| FLAT | | TRAPEZE-SHAPED LOW-FLANGED AXE REL. TO EMMEN TYPE | Kampershoek | Weert | Limburg | 179000 | 365000 | 55 |
| | | | | | | | | |
| FLANGED | EKEHAAR TYPE | PARALLEL-SIDED HIGH FLANGED AXES, TYPE OLDENDORF, VARIANT EKEHAAR. | | | | | | |
| FLANGED | | | Ekehaar | Rolde | Drenthe | 236000 | 552000 | 123 |
| FLANGED | | | Nieuw-Buinen (near) | Borger | Drenthe | 258000 | 553000 | 124 |
| FLANGED | | | Ees (Eeserveld) | Borger | Drenthe | 245600 | 545800 | 125 |
| FLANGED | | | Ter Wisch/ Ter Haar | Vlagtwedde | Groningen | 269900 | 547700 | 126 |
| FLANGED | | | ? | ? | ? | ? | ? | 127 |
| FLANGED | | | Valthe | Odoorn | Drenthe | 256000 | 54000 | 128 |
| FLANGED | | | ? | ? | ? | ? | ? | 129 |
| FLANGED | | | Nijmegen (at or near), River Waal, | Nijmegen | Gelderland | ? | ? | 130 |
| FLANGED | | | Gramsbergen | Gramsbergen | Overijssel | 242700 | 516300 | 131 |
| FLANGED | | | Krachtighuizen | Putten | Gelderland | 171125 | 472402 | 132 |
| FLANGED | | | Gasselte, North of Kostvlies | Gasselte | Drenthe | 249300 | 55663 | 133 |
| | | | | | | | | |

| AXE: | TYPE: | Sub-type: | Findspot / Toponiem: | Gemeente: | Provence | X | Y | Cat. No. |
|---|---|---|---|---|---|---|---|---|
| STOPRIDGE | VLAGTWEDDE TYPE | | ? | ? | ? | ? | ? | 158 |
| STOPRIDGE | | | Eext | Anloo | Drenthe | 245000 | 559000 | 159 |
| STOPRIDGE | | | Boerhaar | Wijhe | Overijssel | 207000 | 538000 | 160 |
| STOPRIDGE | | | Sellingersluis | Vlagtwedde | Groningen | 274500 | 552600 | 161 |
| STOPRIDGE | | | Sellingersluis | Vlagtwedde | Groningen | 274500 | 552600 | 162 |
| STOPRIDGE | | | Wijhe (near) | Wijhe | Overijssel | 205000 | 489000 | 163 |
| STOPRIDGE | | | Hengelo | Hengelo | Overijssel | 252000 | 477000 | 164 |
| STOPRIDGE | | | Epe | Epe | Gelderland | | | 165 |
| STOPRIDGE | | | Weitemanslanden (near Almelo) | Vriezenveen | Overijssel | 243000 | 491000 | 166 |
| STOPRIDGE | | | Berghuizen | Losser | Overijssel | 259000 | 480000 | 167 |
| STOPRIDGE | | | Vrienzenveen, (Weitkant) | Vriezenveen | Overijssel | 243000 | 491000 | 168 |
| STOPRIDGE | | | ? | ? | ? | ? | ? | 169 |
| STOPRIDGE | | | Enschede, (district de Bolhaar) | Enschede | Overijssel | 256000 | 473000 | 170 |
| STOPRIDGE | | | Oeken | Brummen | Gelderland | 206780 | 459230 | 171 |
| STOPRIDGE | | | Lathum, (Lathumse Gat). | Angerloo | Gelderland | 199500 | 444750 | 172 |
| STOPRIDGE | | | Nijbroek | Voorst | Gelderland | 200350 | 476560 | 173 |
| STOPRIDGE | | | Amen | Rolde | Drenthe | 237600 | 550850 | 174 |
| | | | | | | | | |
| | | | | | | | | |
| PALSTAVE | PLAIN PALSTAVES WITH SINUOUS OUTLINE (AXP:PS) | (AXP:PS) | Best | Best | Noord-Brabant | 157500 | 391500 | 244 |
| PALSTAVE | | | Eerselen | Ambt Montfort | Limburg | 194000 | 347800 | 245 |
| PALSTAVE | | | Emmen (near) | Emmen | Drenthe | ? | ? | 246 |
| PALSTAVE | | | Borgerveld | Borger | Drenthe | 247000 | 550000 | 247 |
| PALSTAVE | | | 'Westerveld' | ? | Drenthe | ? | ? | 248 |
| PALSTAVE | | | Someren (near) ? | Someren | Noord-Brabant | 177500 | 377000 | 249 |
| PALSTAVE | | | Wijchen, De Berendonck | Wijchen | Gelderland | 181750 | 424500 | 250 |
| PALSTAVE | | | ? | ? | ? | ? | ? | 251 |
| PALSTAVE | | | Buggenum | Haelen | Limburg | 197000 | 360000 | 252 |
| PALSTAVE | | | Ool | Roermond | Limburg | 194000 | 355500 | 253 |
| PALSTAVE | | | Sellingen, Zuidveld | Vlagtwedde | Groningen | 273300 | 550100 | 254 |
| PALSTAVE | | | Veelerveen | Bellingwedde | Groningen | 273080 | 564170 | 255 |
| PALSTAVE | | | Annermoeras | Zuidlaren | Drenthe | 247000 | 565000 | 256 |
| PALSTAVE | | | Zweeloo (near) | Zweeloo | Drenthe | 246000 | 535000 | 257 |
| PALSTAVE | | | Eindhoven (district Stratum) | Eindhoven | Noord-Brabant | 162300 | 382300 | 258 |
| PALSTAVE | | | Velp | Grave | Noord-Brabant | 177000 | 418500 | 259 |
| PALSTAVE | | | Roswinkel | Emmen | Drenthe | 266000 | 540500 | 260 |
| PALSTAVE | | | Hees (dealer's provenance) | Nijmegen | Gelderland | 185000 | 428000 | 261 |
| PALSTAVE | | | Ees | Borger | Drenthe | 250000 | 544000 | 262 |
| PALSTAVE | | | Woezik | Wijchen | Gelderland | 178550 | 425250 | 263 |
| PALSTAVE | | | Hoogkarpsel | Drechterland | Noord-Holland | 139780 | 522960 | 264 |
| PALSTAVE | | | Lottum ? | Grubbenvorst | Limburg | 209300 | 386500 | 265 |

| AXE: | TYPE: | Sub-type: | Findspot / Toponiem: | Gemeente: | Provence | X | Y | Cat. No. |
|---|---|---|---|---|---|---|---|---|
| | PLAIN PALSTAVES WITH SINUOUS OUTLINE (AXP:PS) | | | | | | | |
| PALSTAVE | | SMALL VARIETY (AXP:PS < | Havelte | Havelte | Drenthe | 212000 | 533000 | 266 |
| PALSTAVE | | | ? | ? | Drenthe | ? | ? | 267 |
| PALSTAVE | | | Aanschot | Eindhoven | Noord-Brabant | 161150 | 389150 | 268 |
| PALSTAVE | | | ? (dealer's provenance) | Enschede | Overijssel | ? | ? | 269 |
| PALSTAVE | | | Gemonde | Sint-Michelsgestel | Noord-Brabant | 153075 | 402625 | 270 |
| PALSTAVE | | | ? | Emmen | Drenthe | | | 271 |
| PALSTAVE | | | Jipsingboertange | Vlagtwedde | Groningen | 270000 | 554500 | 272 |
| | | | | | | | | |
| PALSTAVE | | AND WIDELY EXPANDED BLADE (AXP:PSW) | Zwaag | Zwaag | Noord-Holland | 134760 | 520720 | 273 |
| PALSTAVE | | | Tweede Exlooërmond | Odoorn | Drenthe | 259000 | 548000 | 274 |
| PALSTAVE | | | Tonden | Brummen | Gelderland | 207000 | 461000 | 275 |
| PALSTAVE | | | Eext | Anloo | Drenthe | 244120 | 558650 | 276 |
| PALSTAVE | | | Hardenberg, 't Holt | Hardenberg | Overijssel | 238700 | 511100 | 277 |
| PALSTAVE | | | Augustapolder | Bergen op Zoom | Noord-Brabant | 78000 | 387000 | 278 |
| PALSTAVE | | | Venlo, Hagerhof | Venlo | Limburg | 208000 | 376000 | 279 |
| PALSTAVE | | | Eder Bosch | Ede | Gelderland | 175000 | 453000 | 280 |
| PALSTAVE | | | Hattem | Hattem | Gelderland | 200000 | 498000 | 281 |
| PALSTAVE | | | Heescheveld | Nijmegen | Gelderland | 185000 | 428000 | 282 |
| PALSTAVE | | | Kessel | Kessel | Limburg | 199310 | 367210 | 283 |
| PALSTAVE | | | ? | Kessel | Limburg | ? | ? | 284 |
| PALSTAVE | | | Beek | Ubbergen | Gelderland | 192000 | 427000 | 285 |
| PALSTAVE | | | Buinen | Borger | Drenthe | 252000 | 551000 | 286 |
| PALSTAVE | | | ? | ? | ? | ? | ? | 287 |
| PALSTAVE | | | Rutten | Noord-Oostpolder | Flevoland | 179196 | 534076 | 288 |
| PALSTAVE | | | Near Heesche Poort | Nijmegen | Gelderland | 186000 | 428000 | 289 |
| PALSTAVE | | | Vasserveld | Tubbergen | Overijssel | ? | ? | 290 |
| PALSTAVE | | | Montfort | Ambt Montfort | Limburg | 192000 | 347800 | 291 |

| AXE: | TYPE: | Sub-type: | Findspot / Toponiem: | Gemeente: | Provence | X | Y | Cat. No. |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| PALSTAVE | PLAIN PALSTAVES WITH PARALLEL (H) SIDES (AXP:PH) | SMALL (AXP:PH<) | De Meent | Rhenen | Utrecht | 168000 | 444500 | 292 |
| PALSTAVE | | | Vasse | Tubbergen | Overijssel | 254500 | 493100 | 293 |
| PALSTAVE | | | Sevenum | Sevenum | Limburg | 200000 | 380000 | 294 |
| PALSTAVE | | | Pandijk | Odoorn | Drenthe | 254520 | 537500 | 295 |
| | | | | | | | | |
| PALSTAVE | | BUT ABRUPTLY EXPANDED (J) BLADE TIPS (AXP:PHJ) | Zuidbarge | Emmen | Drenthe | 255500 | 530700 | 296 |
| PALSTAVE | | | Noordbarge, Noordbroekmaden | Emmen | Drenthe | 254480 | 530900 | 297 |
| PALSTAVE | | | Borger, De Vorrels | Borger | Drenthe | 247900 | 549500 | 298 |
| PALSTAVE | | | Gasselternijveen | Gasselte | Drenthe | 252300 | 555300 | 299 |
| PALSTAVE | | | Roderveld | Roden | Drenthe | 223250 | 572750 | 300 |
| PALSTAVE | | | Klazienaveen | Emmen | Drenthe | 263500 | 528300 | 301 |
| PALSTAVE | | | Onstwedderholte | Stadskanaal | Groningen | 265700 | 564000 | 302 |
| PALSTAVE | | | Oudleusen | Dalfsen | Overijssel | 218000 | 505000 | 303 |
| PALSTAVE | | | Berlicum | Berlicum | Noord-Brabant | 156000 | 410000 | 304 |
| | | | | | | | | |
| PALSTAVE | | BUT WITH CRINOLINE-SHAPED BLADE TIPS (AXP:PHC) n=3 | De Peel' | ? | Noord-Brabant | ? | ? | 305 |
| PALSTAVE | | | ? | Echt | Limburg | ? | ? | 306 |
| PALSTAVE | | | ? | ? | | ? | ? | 307 |
| | | | | | | | | |
| PALSTAVE | PLAIN PALSTAVES WITH TRAPEZE, OR WITH PARRALEL-SIDED HAFTING PART AND BLADE PART WITH TRAPEZE OUTLINE (AXP:P/\) n=15 | (AXP:P/\) | Scheveningen | s-Gravenhage | Zuid-Holland | 78500 | 458500 | 308 |
| PALSTAVE | | | Sevenum | Sevenum | Limburg | 20000 | 380000 | 309 |
| PALSTAVE | | | Pepinusbrug | Echt | Limburg | 192600 | 444300 | 310 |
| PALSTAVE | | | Weitemanslanden | Vriezenveen | Overijssel | 243000 | 491000 | 311 |
| PALSTAVE | | | ? | ? | Utrecht | ? | ? | 312 |
| PALSTAVE | | | Leunen, 'op de steeg' | Venray | Limburg | 195300 | 390800 | 313 |
| PALSTAVE | | | Montfort | Ambt Montfort | Limburg | 194000 | 348000 | 314 |
| PALSTAVE | | | From river Rhine or Waal | ? | ? | ? | ? | 315 |
| PALSTAVE | | | ? | Roermond | Limburg | ? | ? | 316 |
| PALSTAVE | | | Batenburg. From the Maas (dealer's prove | Wijchen | Gelderland | 171800 | 425700 | 317 |
| PALSTAVE | | | ? | Kessel | Limburg | 200400 | 368800 | 318 |
| PALSTAVE | | | ? (dealer's provenance) | Nijmegen | Gelderland | ? | ? | 319 |
| PALSTAVE | | | Near Heesche Poort | Nijmegen | Gelderland | 186000 | 428000 | 320 |
| PALSTAVE | | | Wessem | Wessem | Limburg | 189000 | 152000 | 321 |
| PALSTAVE | | | Vilt, Berg en Terblijt | Valkenburg aan de | Limburg | 184000 | 318000 | 322 |

| AXE: | TYPE: | Sub-type: | Findspot / Toponiem: | Gemeente: | Provence | X | Y | Cat. No. |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| PALSTAVE | PLAIN LOOPED PALSTAVES WITH SINUOUS OUTLINE (AXPL:PS) n= | MEDIUM SIZE (AXPL:PS><) | Ter Apel | Vlagtwedde | Groningen | 269870 | 544520 | 325 |
| PALSTAVE | | | ? | Emmen | Drenthe | ? | ? | 326 |
| PALSTAVE | | | Sleen (near) | Sleen | Drenthe | ? | ? | 327 |
| PALSTAVE | | | Noordveen | Emmen | Drenthe | 259000 | 540000 | 328 |
| PALSTAVE | | | Dubbroek/Blerick | Maasbree/Venlo | Limburg | 204000 | 374000 | 329 |
| PALSTAVE | | | St. Oederode | St. Oederode | Noord-Brabant | 159000 | 396000 | 330 |
| PALSTAVE | | | Eindhoven (district Stratum) | Eindhoven | Noord-Brabant | 162000 | 382000 | 331 |
| PALSTAVE | | | Boxmeer | Boxmeer | Noord-Brabant | 193620 | 409020 | 332 |
| | | | | | | | | |
| PALSTAVE | | AND EXTRA-SHORT BLADE SMALL SIZE (AXPL:PS<) | Valthe | Odoorn | Drenthe | ? | ? | 333 |
| PALSTAVE | | | Norgerveen | Norg | Drenthe | 228300 | 558300 | 334 |
| PALSTAVE | | | Drouwen (near) | Borger | Drenthe | 249000 | 552000 | 335 |
| PALSTAVE | | | Ane | Gramsbergen | Overijssel | 242300 | 515700 | 336 |
| PALSTAVE | | | Wijthem, Boschwijk | Zwolle | Overijssel | 206250 | 501650 | 337 |
| PALSTAVE | | | Ter Apel | Vlagtwedde | Groningen | 268770 | 544570 | 338 |
| | | | | | | | | |
| PALSTAVE | (AXP L:PH ) | | Emmen (near) | Emmen | Drenthe | ? | ? | 339 |
| PALSTAVE | | | Belfeld | Belfeld | Limburg | 206100 | 367400 | 340 |
| | | | | | | | | |
| PALSTAVE | PALSTAVES WITH FLANGED BLADE PART AND SINUOUS OUTLINE (AXP:FS...) | NARROW-BLADE (AXP:FSN) | Zuidbarger Es | Emmen | Drenthe | 257500 | 530500 | 341 |
| | | | | | | | | |
| PALSTAVE | | (AXP:FS) | Wieringermeerpolder (section H.21) | ? | Noord-Holland | ? | ? | 342 |
| PALSTAVE | | | De Zilk, Ruigenhoek | Noordwijkerhout | Zuid-Holland | 97000 | 479000 | 343 |
| | | | | | | | | |
| PALSTAVE | | J-TIPS (AXP:FJS) | Holsloot | Sleen | Drenthe | 250070 | 528550 | 344 |
| PALSTAVE | | | Tolbert | Leek | Groningen | 219000 | 577000 | 345 |
| PALSTAVE | | | Hooglanen | Beilen | Drenthe | 233400 | 551100 | 346 |
| PALSTAVE | | | ? | ? | Friesland | ? | ? | 347 |
| PALSTAVE | | | Wildervank | Veendam | Groningen | 254000 | 566000 | 348 |
| PALSTAVE | | | Oene | Epe | Gelderland | 200500 | 483000 | 349 |
| | | | | | | | | |
| PALSTAVE | | WIDE BLADE (AXP:FSW) | Odoorn | Odoorn | Drenthe | 253200 | 540750 | 350 |
| PALSTAVE | | | Eeserveen | Borger | Drenthe | 249000 | 549000 | 351 |
| PALSTAVE | | | ? | Ommen | Overijssel | 226000 | 503000 | 352 |
| PALSTAVE | | | Rectum | Wierden | Overijssel | 236000 | 482300 | 353 |
| PALSTAVE | | | Wijnjewoude | Opsterland | Friesland | 210000 | 564000 | 354 |
| PALSTAVE | | | Achterveld | Leusden | Gelderland | 162000 | 460000 | 355 |
| PALSTAVE | | | Daarlerveen | Hellendoorn | Overijssel | 236000 | 496000 | 356 |
| PALSTAVE | | | Wervershoof | Werwershoof | Noord-Holland | 140200 | 526500 | 357 |
| PALSTAVE | | | ? | Nijmegen | Gelderland | ? | ? | 358 |
| PALSTAVE | | | Sleenerzand | Sleen/Zweeloo | Drenthe | 248300 | 5372500 | 359 |
| | | | | | | | | |

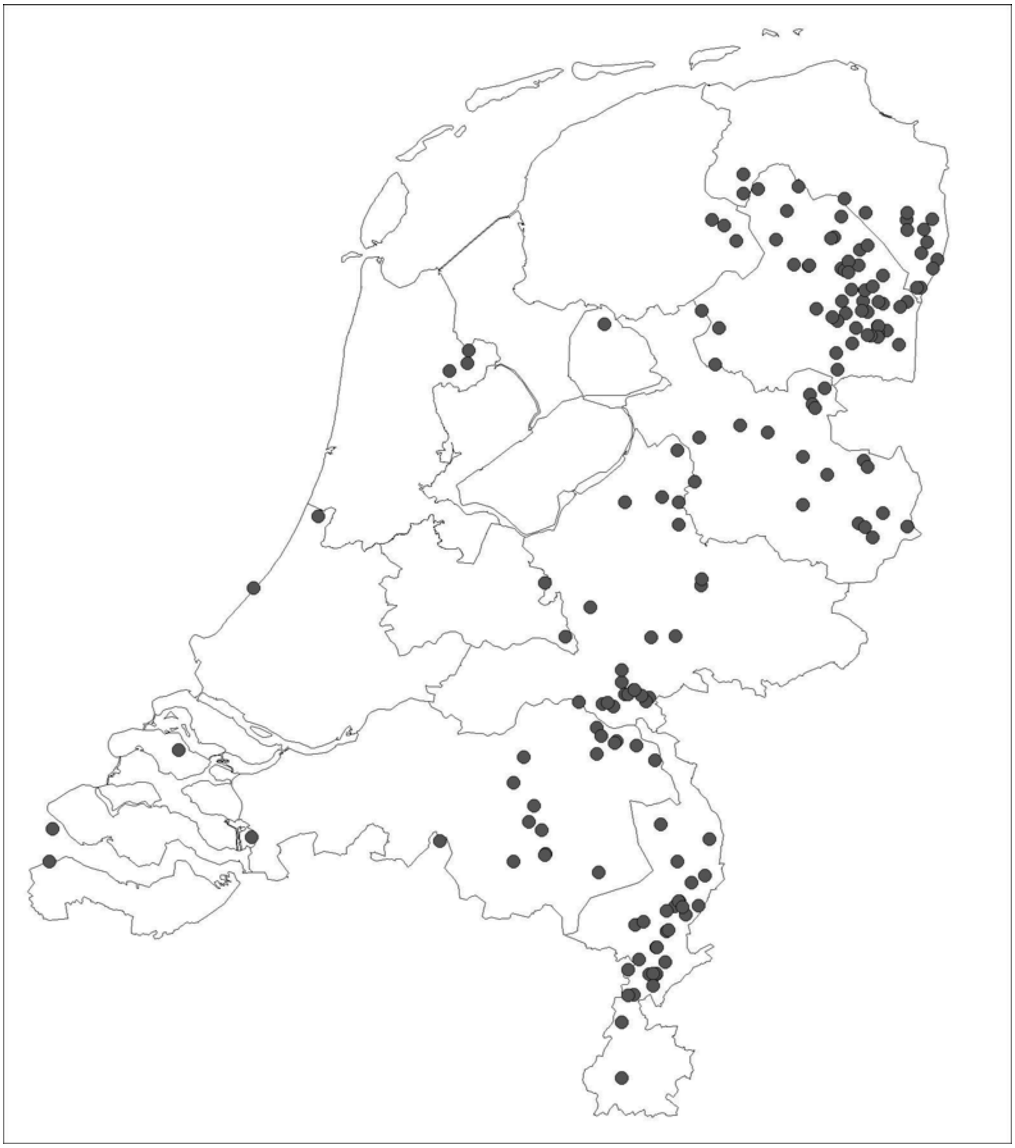
| AXE: | TYPE: | Sub-type: | Findspot / Toponiem: | Gemeente: | Provence | X | Y | Cat. No. |
|---|---|---|---|---|---|---|---|---|
| PALSTAVE | PALSTAVES WITH MIDRIB OR MIDRIDGE AND SINUOUS OUTLINE (AXP:MIS) | NARROW MIDRIB AND DOUBLE-SINUOUS (=CRINOLINE) OUTLINE, LARGE SIZE (AXP:MISC>) | Weurt | Beuningen | Gelderland | 184000 | 431500 | 360 |
| PALSTAVE | | | ? | Heythuisen | Limburg | ? | ? | 361 |
| PALSTAVE | | | Susteren Gebroek | Susteren | Limburg | 186000 | 341700 | 362 |
| PALSTAVE | | | ? | ? | ? | ? | ? | 363 |
| PALSTAVE | | | | | | | | |
| PALSTAVE | | LARGE, NARROW MIDRIB AND SINUOUS OUTLINE, WIDE BLADE (AXP:MIS>) | (River) Maas or Waal (dealer's provenance) | ? | Gelderland | ? | ? | 364 |
| PALSTAVE | | | ? | Kessel | Limburg | 200500 | 368800 | 365 |
| PALSTAVE | | | ? | ? | Overijssel | ? | ? | 366 |
| PALSTAVE | | | | | | | | |
| PALSTAVE | | NARROW MIDRIB AND SINUOUS OUTLINE, MEDIUM BLADE WIDTH (AXP:MIS><) | Bakkeveen | Opsterland | Friesland | 231500 | 566500 | 367 |
| PALSTAVE | | | Hardenberg | Hardenberg | Overijssel | 239500 | 510000 | 368 |
| PALSTAVE | | | Montfort | Ambt Montfort | Limburg | 193000 | 348000 | 369 |
| PALSTAVE | | | ? | Roermond | Limburg | ? | ? | 370 |
| PALSTAVE | | | Gassel | Mill en St. Hubert | Noord-Brabant | 182660 | 414520 | 371 |
| PALSTAVE | | | Eelde | Zuidlaren | Drenthe | 234825 | 573625 | 372 |
| PALSTAVE | | | | | | | | |
| PALSTAVE | | NARROW MIDRIB AND SINUOUS OUTLINE, SMALL VERSION (AXP:MIS<) | Gassel | Mill en St. Hubert | Noord-Brabant | 182000 | 414000 | 373 |
| PALSTAVE | | | Between Helden and Neer | Roggel en Neer | Limburg | 197000 | 366000 | 374 |
| PALSTAVE | | | De Kolck | Broekhuizen | Limburg | 20818 | 389500 | 375 |
| PALSTAVE | | | Vierhouten | Ermelo | Gelderland | 185000 | 483000 | 376 |
| PALSTAVE | | | | | | | | |
| PALSTAVE | | LOOPED PALSTAVE WITH NARROW MIDRIB OR MIDRIDGE AND SINUOUS OUTLINE; SMALL VERSION (AXPL:MIS<) | Dreischor | Brouwershaven | Zeeland | 57000 | 412000 | 377 |
| PALSTAVE | | | Eimeren | Elst | Gelderland | 184000 | 435000 | 378 |
| PALSTAVE | | | Volkel/Zeeland | Uden/Lanterd | Noord-Brabant | 177000 | 411000 | 379 |
| PALSTAVE | | | Gasselternijveen | Gasselte | Drenthe | 254500 | 556700 | 380 |
| PALSTAVE | | | Escharen, De Schans | Grave | Noord-Brabant | 178300 | 416000 | 381 |
| PALSTAVE | | | ? | ? | ? | ? | ? | 382 |
| PALSTAVE | | | Haps | Cuyk | Noord-Brabant | 188360 | 413300 | 383 |
| PALSTAVE | | | Hunerberg | Nijmegen | Gelderland | 189700 | 427700 | 384 |
| PALSTAVE | | | | | | | | |
| PALSTAVE | | NARROW MIDRIB AND SINUOUS OUTLINE, WIDE BLADE (AXP:MISW) | Coevorden | Coevorde | Drenthe | 246000 | 521000 | 385 |
| PALSTAVE | | | ? | Wijchen | Gelderland | ? | ? | 386 |
| PALSTAVE | | | Kessel | Kessel | Limburg | 201500 | 367000 | 387 |
| PALSTAVE | | | Near Stevensweert (R.Maas) | Stevensweert | Limburg | 186000 | 349000 | 388 |
| PALSTAVE | | | | | | | | |
| PALSTAVE | | AS (AXP:MIS) WITH BLADE FLANGES, WIDE BLADE | ? | ? | ? | ? | ? | 389 |
| PALSTAVE | | | (Dealer's provenance) | Nijmegen | Gelderland | ? | ? | 390 |
| PALSTAVE | | | | | | | | |
| PALSTAVE | | AXP:MBFHJ | Engeland | Gramsbergen | Overijssel | 238000 | 513900 | 391 |
| PALSTAVE | | | | | | | | |

| AXE: | TYPE: | Sub-type: | Findspot / Toponiem: | Gemeente: | Provence | X | Y | Cat. No. |
|---|---|---|---|---|---|---|---|---|
| PALSTAVE | AXP:M I/V | | ? | ? | ? | ? | ? | 392 |
| PALSTAVE | | | ? | ? | ? | ? | ? | 393 |
| PALSTAVE | | | Buggenum | Haelen | Limburg | 197500 | 360500 | 394 |
| PALSTAVE | | | | | | | | |
| PALSTAVE | AXP :MT SW | | Leveroij | Weert | Limburg | 188000 | 362000 | 395 |
| PALSTAVE | | | Between Susteren and Dieteren | Susteren | Limburg | 187500 | 342000 | 396 |
| PALSTAVE | | | | | | | | |
| PALSTAVE | AXP:M VSW | | Graetheide | Born | Limburg | 184000 | 334000 | 397 |
| PALSTAVE | | | Oerle | Veldhoven | Noord-Brabant | 153000 | 380000 | 398 |
| PALSTAVE | | | Linne | Ambt Montfort | Limburg | 196560 | 351280 | 399 |
| PALSTAVE | | | | | | | | |
| PALSTAVE | AXP:AH | | Aardappelfabriek | Gasselte | Drenthe | 254500 | 556700 | 400 |
| PALSTAVE | | | | | | | | |
| PALSTAVE | PALSTAVES WITH ARCH-SHAPED ORNAMENT ON THE SIDES, (AXP:AFS) (AXP:AMFS) | BLADE FLANGES AND SINUOUS OUTLINE (AXP:AFS) | ? | ? | ? | ? | ? | 401 |
| PALSTAVE | | | ? | ? | ? | ? | ? | 402 |
| PALSTAVE | | | ? | ? | ? | ? | ? | 403 |
| PALSTAVE | | | ? | Vlagtwedde | Groningen | ? | ? | 404 |
| PALSTAVE | | | Exloo | Odoorn | Drenthe | 253900 | 543900 | 405 |
| PALSTAVE | | | (Near) Exloo | Odoorn | Drenthe | 256000 | 545000 | 406 |
| PALSTAVE | | | Weper, Weperpolder | Ooststellingwerf | Friesland | 217000 | 558000 | 407 |
| PALSTAVE | | | Roswinkelerveen | Emmen | Drenthe | 264000 | 539000 | 408 |
| PALSTAVE | | | Donkerbroek | Ooststellingwerf | Friesland | 213400 | 562400 | 409 |
| PALSTAVE | | | East Groningen | ? | Groningen | ? | ? | 410 |
| PALSTAVE | | | (Near) Kiel-Windeweer (Dealar's provenan | Hoogezand-Sapper | Groningen | 248000 | 570000 | 411 |
| PALSTAVE | | | Canal Buinen/Schoonoord | Borger | Drenthe | ? | ? | 412 |
| PALSTAVE | | | Amen, De Boeskollen | Rolde | Drenthe | 237790 | 550930 | 413 |
| PALSTAVE | | | Wachtum | Dalen | Drenthe | 245630 | 525800 | 414 |
| PALSTAVE | | | Wedde, (near Hoornderveen) | Stadskanaal | Groningen | 266000 | 566000 | 415 |
| PALSTAVE | | | Wezup | Zweeloo | Drenthe | 244430 | 536080 | 416 |
| PALSTAVE | | | Reestdal | Meppel | Drenthe | 210950 | 522450 | 417 |
| PALSTAVE | | | | | | | | |
| PALSTAVE | | MIDRIB, BLADE FLANGES AND SINIOUS OUTLINE (AXP:AMFS) | Driene | Hengelo | Overijssel | 253800 | 4758200 | 418 |
| PALSTAVE | | | Weende, Weenderveld | Vlagtwedde | Groningen | 271580 | 557500 | 419 |
| PALSTAVE | | | | | | | | |
| PALSTAVE | | AND SINUOUS OUTLINE (AXP:AS) | ? | Emmen | Drenthe | ? | ? | 420 |
| PALSTAVE | | | ? | ? | ? | ? | ? | 421 |
| PALSTAVE | | | Westerbork | Westerbork | Drenthe | 23990 | 538400 | 422 |
| PALSTAVE | | | (near) Onstwedde | Stadskanaal | Groningen | 266000 | 561000 | 423 |
| PALSTAVE | | | Losser | Losser | Overijssel | 266000 | 476000 | 424 |
| PALSTAVE | | | Zevenhuizen | Leek | Groningen | 219000 | 571500 | 425 |
| PALSTAVE | | | Odoorner Zijtak | Odoorn | Drenthe | 253000 | 538000 | 426 |
| PALSTAVE | | | | | | | | |
| PALSTAVE | | WIDE BLADE VARIANT (AXP:ASW) | Esbeek, Molenheide | Hilvarenbeek | Noord-Brabant | 132000 | 186000 | 427 |
| PALSTAVE | | | Berg en Dal | Groesbeek/Ubberge | Gelderland | 191000 | 426000 | 428 |
| PALSTAVE | | | | | | | | |
| PALSTAVE | | (AXP:AGSW) | Beesel | Beesel | Limburg | 202500 | 364800 | 429 |

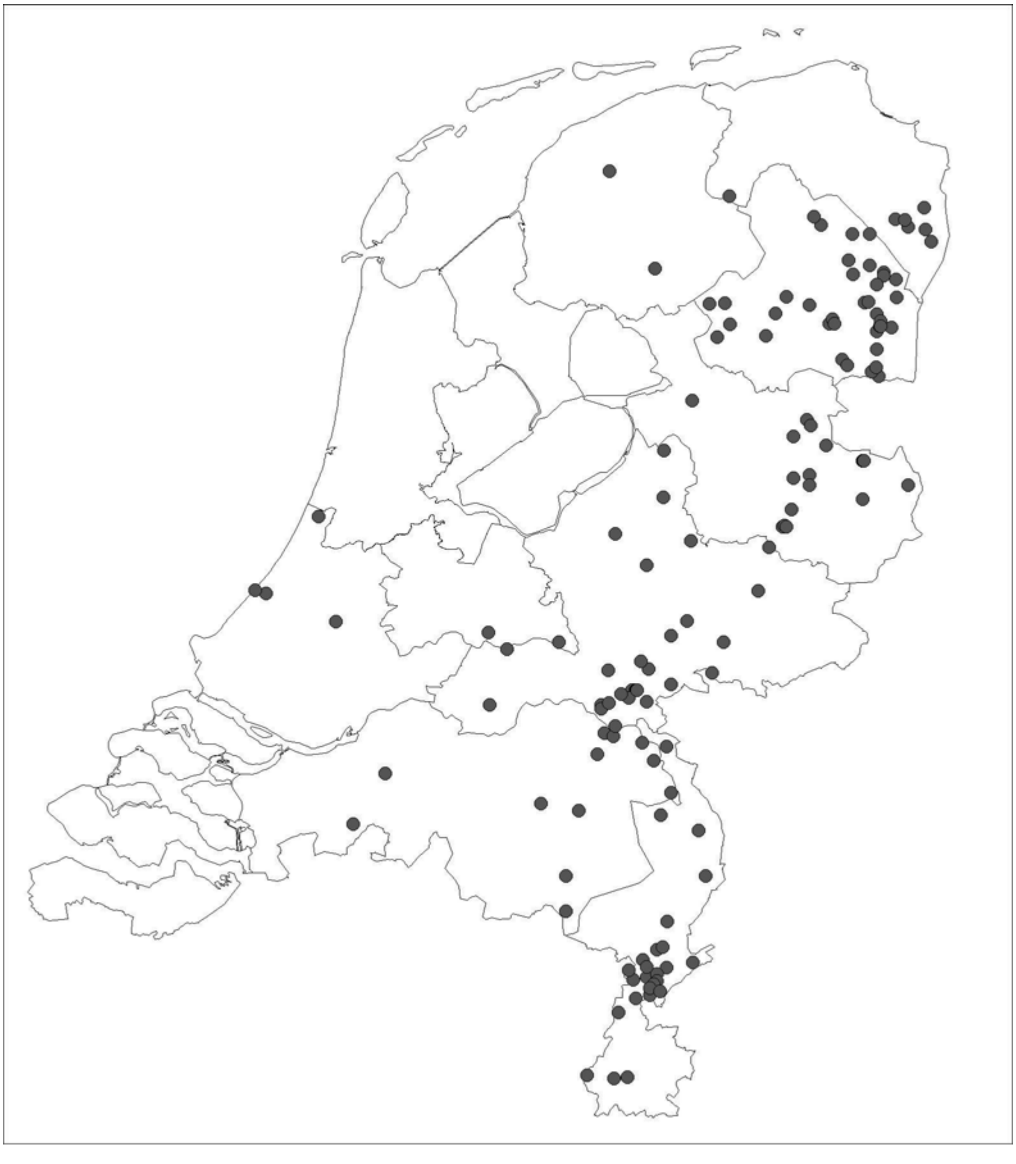
| AXE: | TYPE: | Sub-type: | Findspot / Toponiem: | Gemeente: | Provence | X | Y | Cat. No. |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| SOCKETED | NIEDERMAAS TYPE | PLAIN (AXT:niema.P) | Montfort | Ambt Montfort | Limburg | 194000 | 348000 | 477 |
| SOCKETED | | | Echterbroek | Echt | Limburg | 194000 | 346000 | 478 |
| SOCKETED | | | Donk | Beek en Donk | Noord-Brabant | 171630 | 394770 | 479 |
| SOCKETED | | | Between Grevendicht/Berg | Born | Limburg | 183000 | 337000 | 480 |
| SOCKETED | | | Between Montfort/Odiliënberg | Ambt Montfort | Limburg | ? | ? | 481 |
| SOCKETED | | | | | | | | |
| SOCKETED | | WITH 'WINGS' ALONE (AXT:niema.Wi) | Heeze | Heeze | Noord-Brabant | 168000 | 376000 | 482 |
| SOCKETED | | | Escharen | Grave | Noord-Brabant | 179000 | 417000 | 483 |
| SOCKETED | | | Susteren Heiden, 'Het Eilandje' | Susteren | Limburg | 192000 | 342000 | 484 |
| SOCKETED | | | Ees | Borger | Drenthe | 250200 | 548430 | 485 |
| SOCKETED | | | Batenburg, River Mass (dealer's provenanc | Wijchen | Gelderland | ? | ? | 486 |
| SOCKETED | | | Between Montfort/Odiliënberg | Ambt Montfort | Limburg | ? | ? | 487 |
| SOCKETED | | | Vilt | Valkenburg aan de | Limburg | 185500 | 318500 | 488 |
| SOCKETED | | | Bemelen | Margraten | Limburg | 181620 | 318040 | 489 |
| | | | | | | | | |
| SOCKETED | | WITH 'WINGS' SLIGHTLY INDENTED | Nijmegen (dealer's provenance) | Nijmegen | Gelderland | ? | ? | 490 |
| | | | | | | | | |
| SOCKETED | | WITH 'WINGS' AND FLATTISH, OFSET COLLAR (AXT:niema.Wi._Col) | Volkel/Zeeland | Uden?Lanterd | Noord-Brabant | 177000 | 411000 | 491 |
| SOCKETED | | | Wijchen | Wijchen | Gelderland | 178000 | 425000 | 492 |
| SOCKETED | | | ? | ? | ? | ? | ? | 493 |
| SOCKETED | | | Ottersum | Gennep | Limburg | | | 494 |
| SOCKETED | | | | | | | | |
| SOCKETED | | WITH 'WINGS' AND PELLET (AXT:niema.Wi.pel) | Venray | Venray | Limburg | 195175 | 393500 | 495 |
| SOCKETED | | | St. Joost | Ambt Montfort | Limburg | 191000 | 347000 | 496 |
| | | | | | | | | |
| SOCKETED | | WITH 'WINGS' AND MIDRIB (AXT:niema.Wi.M) | Blerick | Venlo | Limburg | 208000 | 376000 | 497 |
| | | | | | | | | |
| SOCKETED | | WITH 'WINGS', FLAT, OFFSET COLLAR, AND SLIGHT MIDRIDGE (AXT:niema.WI._Col.MI) | Zaltbommel (dealer's provenance) | Geldermalsen | Gelderland | 146000 | 425000 | 498 |
| SOCKETED | | | ? | ? | ? | ? | ? | 499 |
| | | | | | | | | |
| SOCKETED | AXT:helm) | PLAIN (AXT:helm.P) | Winsseling, River Waal | Nijmegen | Gelderland | 186750 | 429250 | 532 |
| SOCKETED | | | Peij, Pepinusbrug | Echt | Limburg | 192000 | 344000 | 533 |
| SOCKETED | | | | | | | | |
| SOCKETED | | WITH PELLET (AXT.helm.Pel) | Wijk bij Duurstede, River Lek (Dealer's pro | Wijk bij Duurstede | Gelderland | 151000 | 441000 | 534 |
| SOCKETED | | | 'Meijerij van 's-Hertogenbosch' | | Noord-Brabant | ? | ? | 535 |
| SOCKETED | | | Maasbracht | Maasbracht | Limburg | 191000 | 350000 | 543 |
| SOCKETED | | | | | | | | |
| SOCKETED | | WITH SINGLE VERTICAL FURROW (AXT:helm.I) | Elsen, Elsenerveen | Markelo | Overijssel | 230000 | 476000 | 536 |
| SOCKETED | | | Stevensweert (dealer's provenance) | Stevensweert | Limburg | 186000 | 349000 | 537 |
| | | | | | | | | |
| SOCKETED | | WITH VERTICAL PARALLEL FURROWS (AXT:helm.II) | Peij, Pepinusbroek | Echt | Limburg | 193000 | 345000 | 538 |
| SOCKETED | | | Peij, Pepinusbrug | Echt | Limburg | 192000 | 344000 | 539 |
| SOCKETED | | | Swolgen | Meerlo | Limburg | 206000 | 389000 | 540 |

| AXE: | TYPE: | Sub-type: | Findspot / Toponiem: | Gemeente: | Provence | X | Y | Cat. No. |
|---|---|---|---|---|---|---|---|---|
| SOCKETED | HELMEROTH TYPE (/ | | Susteren, 'De Mehre' | Susteren | Limburg | 187999 | 341060 | 541 |
| | | | | | | | | |
| SOCKETED | | WITH CONICAL COLLAR (AXT:helm.VCol) | Wessem | Heel | Limburg | 190000 | 352000 | 542 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| SOCKETED | | VAR. BOTTROP (AXT:helm.bott) | Diergaarde | Echt | Limburg | 195000 | 343000 | 544 |
| | | | | | | | | |
| SOCKETED | | WITH PLASTIC 'WINGS' (AXT:helm.Wi) | Oude Maas' | Ohé en Laak | Limburg | 187250 | 346400 | 545 |
| | | | | | | | | |
| SOCKETED | | EXCEPTIONAL PIECES (AXT:helm.X) | ? | ? | ? | ? | ? | 546 |
| SOCKETED | | | ? | ? | ? | ? | ? | 547 |
| SOCKETED | | | Vlodrop | Vlodrop | Limburg | 204270 | 351210 | 548 |
| | | | | | | | | |
| SOCKETED | GEISTINGEN TYPE (AX | | Caberg | Maastricht | Limburg | 174000 | 319000 | 550 |
| SOCKETED | | | Caberg | Maastricht | Limburg | 174000 | 319000 | 551 |
| SOCKETED | | | (Near) Nijmegen | Nijmegen | Gelderland | ? | ? | 552 |
| SOCKETED | | | Berg en Dal | Ubbergen/Groesbee | Gelderland | 191000 | 426000 | 553 |
| SOCKETED | | | Berg en Dal | Ubbergen/Groesbee | Gelderland | 191000 | 426000 | 554 |
| SOCKETED | | | ? | ? | ? | ? | ? | 555 |
| SOCKETED | | | ? | ? | ? | ? | ? | 556 |
| SOCKETED | | | Vierlingsbeek (dealer's provenance) | Vierlingsbeek | Noord-Brabant | 198000 | 400000 | 557 |
| SOCKETED | | | ? | ? | ? | ? | ? | 558 |
| SOCKETED | | | ? | ? | ? | ? | ? | 559 |
| SOCKETED | | | Ool | Roermond | Limburg | 194000 | 355000 | 560 |
| SOCKETED | | | Herten | Roermond | Limburg | 195600 | 355700 | 561 |
| SOCKETED | | | ? | Nijmegen | Gelderland | ? | ? | 562 |

Distribution of Early Bronze Age axes (all AXI and AXF types).



Distribution of Middle Bronze Age axes (all AXP and AXS types).



Distribution of Late Bronze Age axes (all AXT types).

# Appendix 5: Glossary of metallurgical terms

*Beneficiation:*
The process of pulverizing mined ore into small pieces or powder suitable for roasting and/or smelting. Beneficiation allows for the mechanical removal of some of the gangue in the ore.

*Flux:*
Material added to a smelt in order to chemically combine with gangue in an ore to form a slag separate from the desired metal.

*Gangue:*
Inert particles in an ore which must be mechanically and/or chemically separated from the metal in the refining process. The most common gangue materials in copper ores are iron and silica.

*Roasting:*
The process of heating copper sulfide or chalcopyrite ore in an oxidizing atmosphere. This process of combustion combines sulfur impurities in the ore with oxygen in the air to produce sulfur dioxide gas, which is released into the air and therefore removed from the ore.

*Slag:*
The waste product of a smelting process, consisting of a combination of gangue, fluxes, and other material (charcoal fragments, furnace lining, etc.).

*Smelting:*
The process of refining a metal ore into pure metal through heating in a furnace and chemically separating gangue from metal.

*Melting:*
The process of heating a piece of (ingot) bronze to a temperature where it melts and becomes liquid. Subsequently, an object can be cast from it.

# Acknowledgements

First and foremost I would like to thank my parents for their endless patience and support in every way possible. Mom, dad, I have kept you waiting for quite some time, but finally, it is done! Without saying, the same goes for Annelies. Thank you so much for putting up with the stressful moments, for the *mier en de eekhoorn* and for your unsurpassed perseverance in making sure I ate enough fruits.

I am grateful to Stijn Arnoldussen, who found the time to read and comment on my thesis, although he himself was in the finishing stages of his PhD thesis (for all your remaining questions on the Bronze Age, see "A living landscape"). His critical comments – on almost everything – were extremely useful and gave me a change to re-think and re-write earlier versions of my thesis. I owe him a red pen!

I would also like to thank Lucas Meurkens for letting me use all of his carefully collected information. Although I do not agree with his ideas on the social position of the smith and have criticized some of his findings, I would not have been able to write this thesis without his elaborate appendix.

Thanks to Harry Fokkens and David Fontijn for helping me out writing this thesis. I know it took too long, but Ithaka has made me rich.

My thanks also to several others who have helped me during the writing of this thesis. Henk Hiddink (ACVU) for providing me with information on the unpublished mould from Someren. Ben Roberts (British Museum), Martin Bartelheim (Queens University Belfast), Simon Timberlake (University of Cambridge), William O'Brien (University College Cork), Peter Northover (Oxford University) and Jose Schreurs (RACM), who all provided me with data, unpublished work and the answers to many of my questions. William O'Brien is also thanked for his guidance during the visit of Mount Gabriel and Ross Island.

Without the help of bronze caster Jeroen Zuiderwijk and, not to forget, his apprentice Tim, chapters 7 & 8 would have been far less complete. His interest in and knowledge of melting, moulding, casting and finishing bronze artefacts has given me some valuable insides in the artistry of the early metallurgists. I have rejoiced spending the whole day in Archeon in the bronze smithy's hut, next to a comfortable fire of over a 1000 °C and so fierce my camera was almost not able to make decent pictures. I hope more discussions on the art of bronze casting will follow in times ahead. Please visit his site www.1501bc.com to get a very nice impression of his work.

Herman and Baukje, thanks for your interest and help wherever possible. Nicole, Corné, Dennis, Pepijn, Karsten, Hanneke and Els: thanks!

Last but not least I would like to thank my good friends Frank Stevens and Willem Gijtenbeek. I really needed the occasional beer, good music and a game of chess. Thanks for helping me out with a multitude of things and good discussions. Frank, I really enjoyed the road-trips and talks on the topic of my thesis, as well as any other topic ranging from fireflies to neutrons and protons; "*ik ben overal, maar waar jij me ziet ben ik het meest*"!

## Bronze Age metalworking in the Netherlands

Almost fifty years ago J.J. Butler started his research to trace the possible remains of a Bronze Age metalworkers workshop in the Netherlands. Yet, while metalworking has been deduced on the ground of the existence regional types of axes and some scarce finds related to metalworking, the production locus of the smith has remained elusive. In this Research Master Thesis I have tried to tackle this problem. I have considered both the social as well as the technological aspects of metalworking to be able to determine conclusively whether metalworking took place in the Netherlands or not.

The first part of the thesis revolves around the social position of the smith and the social organization of metalworking. My approach entailed a re-evaluation of the current theories on metalworking, which I believe to be unfounded and one-sided. They tend to disregard production of everyday objects of which the most prominent example is the axe.

The second part deals with the technological aspects of metalworking and how these processes are manifested in the archaeological record. Based on evidence from archaeological sites elsewhere in Europe and with the aid of experimental archaeology a metalworking toolkit is constructed. Finally, a method is presented which might help archaeologists recognize the production locus of a Bronze Age smith.

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