

Edited by:

MICHELA SPATARO, MARTIN FURHOLT

Detecting and explaining

TECHNOLOGICAL INNOVATION IN PREHISTORY





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MICHELA SPATARO, MARTIN FURHOLT

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Preface of the editors

With this book series, the Collaborative Research Centre *Scales of Transformation: Human-Environmental Interaction in Prehistoric and Archaic Societies* (CRC 1266) at Kiel University enables the bundled presentation of current research outcomes of the multiple aspects of socio-environmental transformations in ancient societies. As editors of this publication platform, we are pleased to be able to publish monographs with detailed basic data and comprehensive interpretations from different case studies and landscapes as well as the extensive output from numerous scientific meetings and international workshops.

The book series is dedicated to the fundamental research questions of CRC 1266, dealing with transformations on different temporal, spatial and social scales, here defined as processes leading to a substantial and enduring reorganization of socio-environmental interaction patterns. What are the substantial transformations that describe human development from 15,000 years ago to the beginning of the Common Era? How did interactions between the natural environment and human populations change over time? What role did humans play as cognitive actors trying to deal with changing social and environmental conditions? Which factors triggered the transformations that led to substantial societal and economic inequality?

The understanding of human practices within often intertwined social and environmental contexts is one of the most fundamental aspects of archaeological research. Moreover, in current debates, the dynamics and feedback involved in human-environmental relationships have become a major issue, particularly when looking at the detectable and sometimes devastating consequences of human interference with nature. Archaeology, with its long-term perspective on human societies and landscapes, is in the unique position to trace and link comparable phenomena in the past, to study human involvement with the natural environment, to investigate the impact of humans on nature, and to outline the consequences of environmental change on human societies. Modern interdisciplinary research enables us to reach beyond simplistic mono-causal lines of explanation and overcome evolutionary perspectives. Looking at the period from 15,000 to 1 BCE, CRC 1266 takes a diachronic view in order to investigate transformations involved in the development of Late Pleistocene hunter-gatherers, horticulturalists, early agriculturalists, early metallurgists as well as early state societies, thus covering a wide array of societal formations and environmental conditions.

The publication on detecting and explaining technological innovation in prehistory includes interdisciplinary research, with case-studies from Europe, the Indus Valley, Iran, and Mexico. We are very thankful to the editors of the workshop proceedings Michela Spataro and Martin Furholt and to graphic illustrator Carsten

Reckweg for their deep engagement in this publication. We also wish to thank Karsten Wentink, Corné van Woerdekom and Eric van den Bandt from Sidestone Press for their responsive support in realizing this volume and Hermann Gorbahn and Katharina Fuchs for organizing the whole publication process.

Wiebke Kirleis and Johannes Müller

Contents

Preface of the editors	5
Preface	9
Detecting and explaining technological innovation in prehistory – an introduction	11
<i>Michela Spataro, Martin Furholt</i>	
Understanding the acceptance of innovative technical skills across time. Ethnographic and theoretical insights from Latin America	23
<i>Dean E. Arnold</i>	
Innovation or inheritance?	49
Assessing the social mechanisms underlying ceramic technological change in early Neolithic pottery assemblages in Central Europe	
<i>Louise Gomart, Alexandra Anders, Attila Kreiter, Tibor Marton, Krisztián Oross, Pál Raczky</i>	
Changes in the pottery production of the Linear Pottery Culture. Origins and directions of ideas	73
<i>Anna Rauba-Bukowska, Agnieszka Czekaj-Zastawny</i>	
Innovations in ceramic technology in the context of culture change north of the Carpathians at the turn of the 6th and 5th millennia BCE	85
<i>Sławomir Kadrow</i>	
Neolithic pottery innovation in context. A model and case study from the Central and Western Balkans	107
<i>Robert Hofmann</i>	
Technological innovation and social change. Early vs. late Neolithic pottery production of the Central Balkans	135
<i>Jasna Vuković</i>	

Technological changes and innovations in the osseous industries in the early and late Neolithic in the Balkans	151
<i>Selena Vitezović</i>	
Early wheelmade pottery in the Carpathian Basin	177
<i>Szabolcs Czifra, Éva Kovács-Széles, Orsolya Viktorik, Péter Pánczél, Attila Kreiter</i>	
The onset of wheel-throwing in Middle Asia. A Neolithic innovation?	199
<i>Massimo Vidale</i>	
Technological Innovation. Defining terms and examining process through the talc-faience complex in the Indus Civilization	219
<i>Heather Margaret-Louise Miller</i>	
Skill in high-temperature crafts. An artisanal perspective on fire	231
<i>Katarina Botwid</i>	

Skill in high-temperature crafts. An artisanal perspective on fire

Katarina Botwid

Abstract

Within high-temperature crafts there is knowledge that connects different technologies. Can this knowledge be utilized to pinpoint key features of the introduction of new technologies within a crafting community? Is it even possible to distinguish between skilful or lesser skilled high-temperature users? I am going to explain my ideas and theories about how to approach technological innovations in order to explain technological leaps and levels of skill in prehistoric Europe. This paper will address craft questions from an artisanal position, based on craft theories and archaeological experiments. I will provide a scientific artisanal view on the introduction of new innovative techniques and artefacts on metal-crafting in the Late Bronze Age (Sweden). This paper will hopefully contribute to an interesting discussion on how improvement, innovation and collaboration allow for more reliable archaeological interpretations.

Keywords: skill, artisanal perspective, Bronze Age, technological innovation, high-temperature, craft, ceramics, metal, declarative knowledge, silent knowledge

Introduction

Different scientific fields and subjects tend to communicate in certain ways. According to my theoretical standpoint the answer to the question, “Can contemporary craft knowledge be utilized to pinpoint key aspects in the introduction of new technologies within an ancient crafting community?” would be “YES!”

Every researcher starts somewhere and, in my own experience, ceramic art was a way to express myself. In the process of learning to create ceramic art, it was of great importance to me to be a part of an artisanal tradition of ceramists. Later on, this experience-based knowledge was applied to the field of archaeology where I began to express myself in the academic arena. As an educated ceramist and archaeologist, I have an interesting role working as a consulting expert coop-

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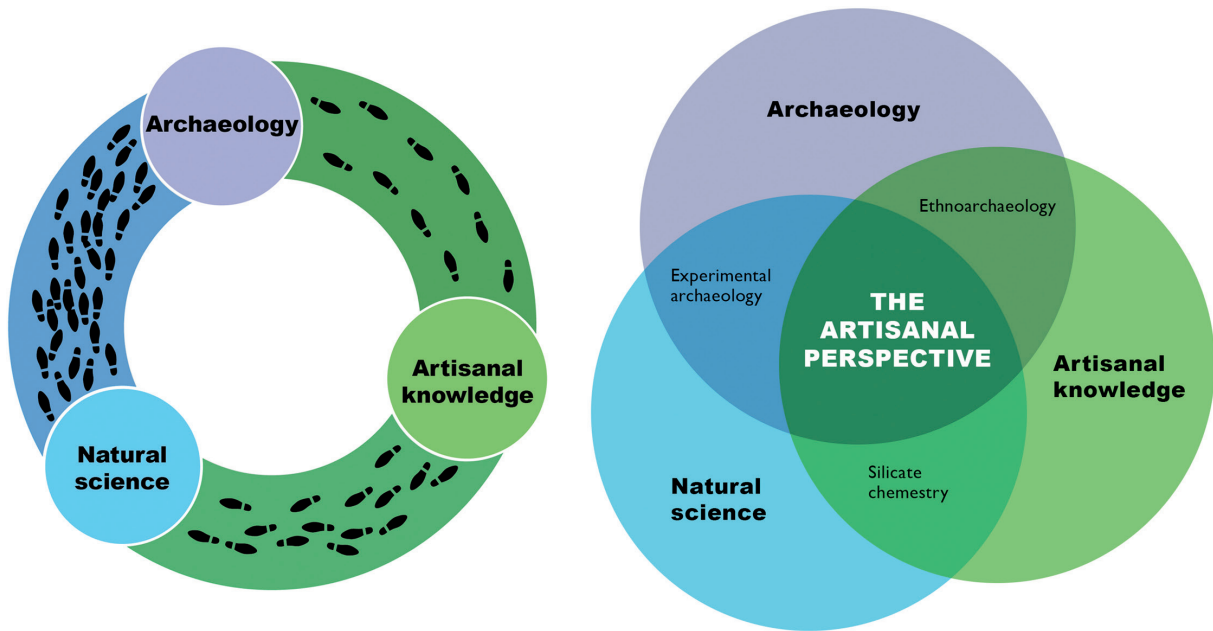
erating in different collaborations and fields. This interdisciplinary position needs a theoretical framework and methods for conducting artisanal interpretations. This article starts by presenting theories and methods. After this, a brief research background will be given and questions concerning high-temperature skill will be addressed. The results of one experiment concerning high-temperature use and the traces this technology has left behind or shed light upon will be put forward from an artisanal skill perspective, and in conclusion, some of the traces of new technology in a specific prehistoric context will be explained and highlighted.

Theories and framework

Harry Collins and Robin Evans (UK), researchers in social sciences, point out that there are ways to achieve a specific understanding of a practitioner's contribution to science (Collins and Evans 2002; 2007; 2014). The silent (practitioner's) knowledge must be accepted as knowledge in its own right. To be able to assure that the communication between practitioners and scientists is open-minded and respectful, new ways of understanding are needed. In this work it is necessary to clear or untangle communication between scientific fields. The aim is to visualise how often we (archaeologists and artisans) reach out to other fields for qualified analysis or verify our interpretations. There are some similarities: artisans often turn to natural science, as do archaeologists (Fig. 1, left).

Artisans and archaeologists do not meet regularly, perhaps because of the lack of a natural arena to do so, or because of the differences of social and/or cultural statuses between them and the alienation caused by this. This description is of course, simplified and generalised, but still needs to be taken into account. Why, then, do archaeologists so rarely design experiments and/or workshops together with artisans that carry with them valuable technical and practical knowledge? Archaeology, craft and science would all reap the benefits from trying to reconsider and change this condition. Working with theories about practical knowledge (Botwid 2009a; 2009b; 2014; 2016) and considering how such knowledge could be seamlessly introduced into the theoretical arena is clearly a path that is closed to the “third wave” of social science. *The Third Wave of Science Studies: Studies of Expertise and Experience* published and written by Collins and Evans (2002, 250-59) provoked many researchers in the scientific and academic community. By starting to address questions about how to re-think expertise and introduce concepts such as *interactive* or *contributory expertise* or so-called *uncertified expertise* (Collins and Evans 2000, 254), the authors also called for a new categorisation in, or of, science. The presented kind of experience-based expertise originates from working in generations of practise or being trained in terms of a master-apprentice relationship, where the knowledge is very specialised. Collins and Evans are aware that different languages (verbal/non-verbal) can be a hindrance and therefore call for what they term “translators”. In my roles as archaeologist and skilled practitioner (with expertise in the craft of ceramics), I have addressed that challenge and have therefore been taking on the role between crafting and archaeology (in a contemporary Swedish theoretical discourse “craft science” [Almevik 2017]).

After considering what can be gained from such an exercise, I describe my own particular vision and view of fields connected in the artisanal perspective (Fig. 1, right) and present a case study concerning high-temperature skill and new technology. The disciplines overlap and cannot always be separated. Collaborations are a possibility in global interactive research more than ever before, and science cannot afford to exclude any kind of knowledge.



Artisanal interpretation

The method *artisanal interpretation* is used to examine artefacts and is developed in my earlier work (Botwid 2009a; 2009b; 2013; 2016). It is based on theories about tacit or silent knowledge. These forms of knowledge are explored within the fields of epistemological philosophy (Molander 1996), practical knowledge (Pye 1968) and in pedagogical research (Gustavsson 2002). Some research refers to this kind of knowledge as embodied knowledge, meaning that it is not possible to learn without practicing it until it gets into an individual's own physical motions, and becomes part of them (Polanyi 1966, 13); they react instinctively and immediately, without thought. This kind of knowledge is, of course, relevant in all practical work. The artisanal interpretations of the skill of ancient artisans, especially concerning ceramics, makes it possible to “read” the artefact when the craft is known and understood (Botwid 2013, 32-34; 2016, 55; 2017, 21-26; Collins 2014, 64; Medbo 2016). A pot could have been made yesterday or five thousand years ago. The impressions are crafted into the artefact, the traces are there, fired to be insoluble, and they represent a level of skill in so-called “frozen moments”. The reading of crafted artefacts is an example of transferring knowledge not only from hand to hand but from time to time. The artisanal exploration is done by tacit, ocular and audial survey together with the experience of the work as an artisan. To be able to distinguish between the different levels of skill, it is valuable that the interpreter has experience of teaching the craft (Botwid 2016, 34).

Figure 1. The author's present view of collaboration within archaeology (left) followed by a diagram of the connecting fields viewed from the contemporary academic arena (right). In the middle of this, the artisanal perspective is striving to communicate with all fields (illustrations © Henning Cedmar Brandstedt 2018).

Different ways of detecting levels of skill in contemporary archaeology

In science theories concerning practice, the division in levels of skill is rough. There are only two levels: the excellent practitioner and then all the others (Molander, 1996, 2002, 33-56; Gustavsson, 2002, 88-90; Pye, 1978, 4-8). In crafting, it is instead proposed that it is possible to use three levels of skill for embodied experience-based knowledge. This makes beginners and untalented artisans clearly visible. It is important to detect learning processes in crafting. Evaluation of skill is a way to divide all kinds of practical or theoretical knowledge. This is very clear in the work of Sandy Budden, a ceramist and archaeologist in the UK who uses three divisions

to evaluate every step of the manufacturing of pots. She uses the categories of *good*, *moderate* and *poor*. Budden uses these three categories for each of the seventeen steps of manufacturing a specific form and before making a statistical conclusion of skill for the material. Her work is an evaluation of every pot connected to the artisanal knowledge of the specific place and timespan in which the pot was made and the result is used to discuss social relations, skill investment in artisanal learning processes and communities (Budden 2008, 1-14; Budden and Sofaer 2009).

Maikel Kuijpers conducted interpretations using categories of level of skill in bronze crafting: amateur, common craftspeople, master crafters and virtuoso. Three of these four levels of skill bear the same signatures as those presented momentarily in this paper (see below), but the additional fourth level includes social status and context which, to my knowledge, makes that level more uncertain or dependent upon timespan or context (Kuijpers 2017, 13-14). I prefer to have Kuijpers' fourth level as a factor in the interpretation, which is grounded in the specific archaeological material and contexts at hand (see also Olausson 2008). It is the *embodied knowledge* of the artisan that places him or her at a certain level of *skill* which is present in his or her crafting traces. These are inherent in an artefact and can be analysed. The visual for identifying the skill level is in a manufactured artefact itself. In this way of evaluating levels of skill, not even timespan nor geographical location matters. Therefore, I stress that it is the technical knowledge – the knowledge and experience of the materials – that gives comparable analysis over time. In discussions or analysis between archaeologists and artisans of all kinds, the level of skill is a starting point and a way of understanding how the craft in focus relates to the ancient maker (ancient technologies). Further, the archaeologist can draw from these discussions some conclusions about society, context and status. The artisanal interpretation is an aspect of technical analysis which is similar to the analysis undertaken in natural science and will be a part of the archaeological interpretation. It is possible to use the evaluation of skill levels in any craft. The three levels that make up the observable evaluation criteria (Botwid 2013, 31-34; Botwid 2016, 32-34) are as follows:

- *Professional artisanal skill: The artisan has extensive experience and a very high level of knowledge. This individual is particularly skilful in her/ his craft and can, in addition, move unhindered within the relevant field of expertise. An artisan who has attained a professional skill level takes risks and is able to completely resolve new problems by using the assembled knowledge she/he possesses.*
- *Good artisanal knowledge: The knowledge that most artisans possess is traditional knowledge. The bearer of tradition is not particularly inclined to take risks even if very skilled at the craft in question. Though not willing to deepen or proceed in knowledge development, such an individual is secure at a lower level of practical knowledge, a knowledge that she/he possesses and refines.*
- *Artisanal knowledge: The lowest level of artisanal-technical knowledge displays craft that is performed by a beginner or by someone who cannot perform on an independent level. This individual can only work step by step on the basis of instructions, or proceed by trial and error without guidance. The execution shows clear technological deficiencies.*

High-temperature skill

Some crafts are dependent on extensive knowledge of firing techniques. Even today, in contemporary craft, high-temperature skill is needed together with a broad knowledge of how to control heat for different purposes. Ceramic craft, metal craft, glass craft and related knowledge for cremation, tar-making or charcoal-production are all dependent on someone knowing how to use fire.

To widen the understanding of ancient practical knowledge, interpretations based on tacit knowledge are relevant. The collaboration of educated professional

artisans and archaeologist is, in my view, one way to reach a clear, more valid interpretation of the craft at hand. In crafts where the archaeologist does not hold the necessary practical knowledge or cannot take on the role of “craft-translator,” it is possible to collaborate with skilled artisans as a form of *uncertified expertise* to extract valuable knowledge that is a good foundation for archaeological synthesis concerning crafting issues. When it comes to high-temperature crafts, I am able to use my own expertise on firing wood up to 1350°C, and can give important information about vitrification in different clay bodies and choices of minerals to mix with the raw clay. Ceramic knowledge was applied in the following case study and proved to be relevant in melting bronze for casting (Botwid 2017, 53).

The aim of this article is to concentrate specifically on high-temperature skill traceable in prehistoric material. This case study focuses on the crafts of firing ceramics and melting bronze through four technological aspects of a certain pipe-formed tuyère, the Pryssgården tuyère (LBA).

Key questions to consider are as follows. In what way was the ceramic craft changing to meet the new requirements for metal craft? Could the decorative elements on tuyères be a technological design? Who made the tuyères – the ceramist or the bronze-smith?

Presentation, background and outline

The site of Pryssgården is situated in South East Sweden and most of its finds are dated to the Late Bronze Age period IV-VI (c. 1100-500 BCE) (Borna Ahlqvist *et al.* 1998). There are traces of communication in ancient artefacts and craft materials which are often interpreted as the result of trading or import. Pryssgården could be described as an important node for new expressions and techniques in the late Bronze Age. In the monograph *Understanding Bronze Age Life: Pryssgården (LBA) in Sweden from an Artisanal Perspective* (2017), I described how travelling artisans and the sharing of their artisanship with new communities can be the reason for moving material or techniques over large geographical distances.

Learning and sharing knowledge develops new links between people. This might be one reason for ancient artisans trying new paths and techniques. In some cases, the traces of trial-and-error are visible in the findings. In other cases, the findings tell of knowledge established at Pryssgården over long periods of time. Ceramics which are well fired show that these artisans knew of, and had mastered high-temperature technology (Botwid 2017, 121-33).

The most famous artefact discovered at Pryssgården (1993-1994) was the so-called Pryssgård figurine (dated 902-807 BCE). It was interpreted as a unique find of a goddess figurine by Ulf Stålbom (1998, 130-32). Later, the artefact was reinterpreted as a possible tuyère by Henrik Thrane (2006) and Joakim Goldhahn (2007, 1). A tuyère is a funnel or pipe-shaped object made of clay which is used to divert the airflow from a bellow or other air source into a kiln or hearth (Thrane 2006, 271; Stilborg 2002, 150; Tylecote 1976, 22, 190; Jantzen 2008, plates 56-57). There are several types of tuyère. In the present interpretation, the term refers to an elbow-shaped ceramic pipe (Tylecote 1976, 22). This find from Pryssgården can be contrasted to others from Late Bronze-Age Cyprus (1600 BCE), where elbow-shaped tuyères were found in the excavations of Politiko Phorades. Here, natural resources and suitable environments made metal craft possible. The find consisted of fifty almost complete tuyères and over 600 fragments made of clay that was composed to meet the requirements for high-temperature crafting.

(Knapp *et al.* 2001, 207-208). At the 2013 conference “Prehistoric pottery across the Baltic” in Lund, I suggested that the Pryssgården figurine should really be reinterpreted as a zoomorphic tuyère, a functional object manufactured with features



Figure 2. Locations of Scandinavian sites with proposed tuyères that indicate bronze melting (illustration © Henning Cedmar Brandstedt 2018).

of a horse (Botwid 2013b). I reconstructed it as a horse with flaring nostrils. The significance of the horse in the Bronze Age and the interaction between man and animal are clearly seen in artefacts and rock carvings (Ling 2013, 33; Skoglund 2006; Kristiansen and Larsson 2005, 324; Jennbert 2010). I suggested that making a tuyère in the shape of a horse had no practical importance – a simple, straightforward pipe-formed ceramic object would have served its technical purpose just as well (Botwid 2017, 42). Although there were no traces of bronze melting reported at the Pryssgården site (Borna Ahlqvist *et al.* 1998) or in the extensive material findings (about 9000 individual finds that I examined between 2013-2016), I suggested that the Pryssgården tuyère is evidence that bronze melting was taking place at the site (Botwid and Eklöv- Pettersson 2016). *Whilst I still support this conclusion, within this article I additionally discuss the interpretation of the meaning of the features of the horse and argue that the imprints around the rim can be of great importance.*

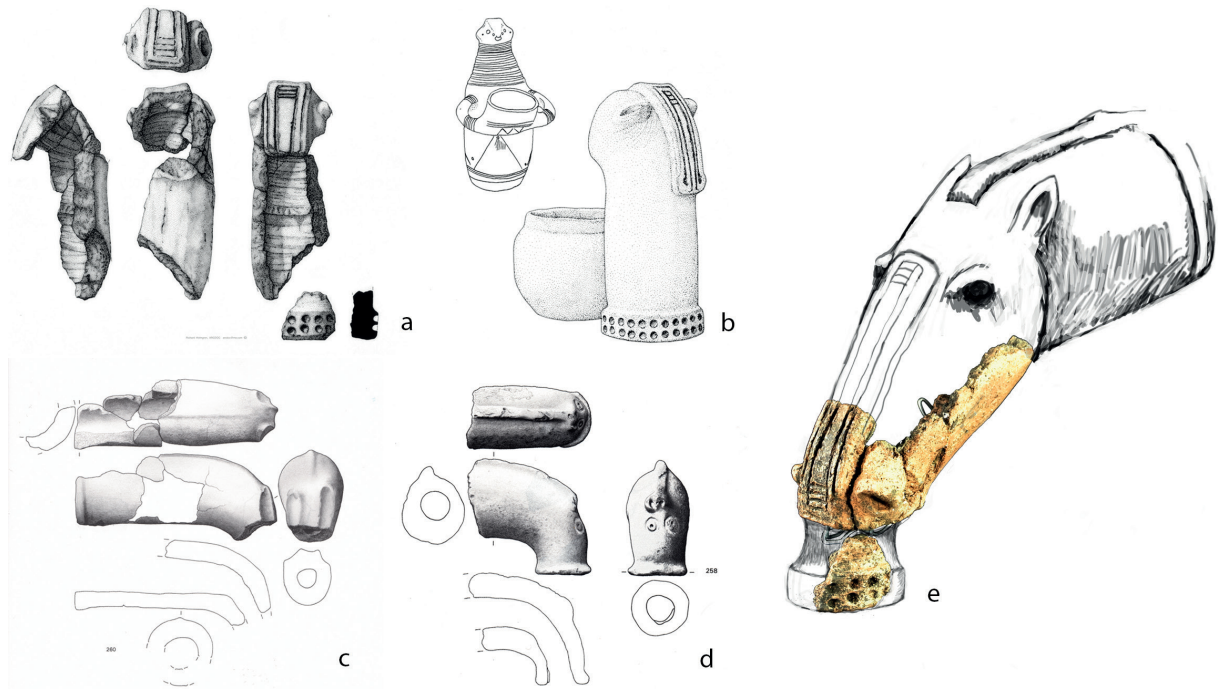


Figure 3. (a) Find 5918, dated to 902-807 BCE (illustration © Ark. Doc.), (b) Stålbom's interpretation (1998) compared to a figurine from Deszczno LBA (illustration © Ark. Doc.), (c) Find from Stora Heddinge och (d) Baldslev (plates 57, 56 in Jantzen 2008) presented by Thrane and published in *Fornvännen* 2008, (e) Botwid's re-interpretation (illustration © Botwid 2013).

Case study: archaeological experiments

In short, the experiment and reconstructions of a Bronze Age smelting occasion were conducted at Lund University and the open-air museum, Vikingatider, in Sweden in May 2014. A hypothetical Bronze Age workshop was designed.¹ Three different tuyères and one crucible (a crucible from Brogården, reconstructed by Eklöv Pettersson) were manufactured out of ordinary brick-clay from south-west Sweden (Horn's brickyard in Skövde municipality). The clay is naturally tempered and is mixed with 10% of added sand. Two of the tuyères and the crucible were biscuit-fired in a controlled firing to 800°C in an electric kiln before use. One of the tuyères was left to dry completely and was not fired before use. The theoretical idea behind the workshop was as follows: the tuyère will direct the airflow from the bellows into the hearth from above, resulting in an airstream of unheated cold air being directed into the fuel, which results in raising temperatures to 1000°C and above, which melts the scrap-metal. The main question of this experiment was to explore how melting metal and using technical ceramics in a Bronze Age workshop could give answers to the question of whether artefacts without residues or sintering could possibly have been used in metalcraft (see Botwid and Eklöv Pettersson 2016).

Alongside the results that we expected would be generated from the experiment, there were several other interesting outcomes. These will form the basis of the present exploration concerning technical innovation in high-temperature craft.

1 I am indebted to Paul Eklöv Pettersson, Andreas Nilsson and Simon Rosborg with whom I conducted the experiment.

Four features of the tuyère in Pryssgården

High-temperature technical signs or innovations can be understood from many different starting points. The conscious use of fire is well known, and is acknowledged as extensive and important in processing materials and transforming them to serve mankind. In the artisanal approach, many crafts are connected through this use of heat. To practice high-temperature craft such as, in this case, ceramics, it is crucial to be able to take on new crafts such as bronze-smithing. To shed light on the relation between these two high-temperature crafts I have chosen to study an artefact existing in this overlap: the tuyère. For the purpose of this article, I am focusing on four of its main features.

Clay Preparation

The first feature of the tuyère is the clay preparation. A high-quality end result starts with the preparation of a suitable clay body (Arnold 1985, 20-32, 61-65). To locate a good clay resource before weathering (Botwid 2017, 146 I:II) and maturing it (Botwid 2017, 148 I:IV) would have been fundamental skills which were well known to the ceramists at Pryssgården. Prepared clay was divided into suitable lumps and was stored in a sheltered place safe from freezing or drying out (Botwid 2017, 145-48 I-III). A prepared clay can be developed further through the addition of temper. Depending on its type, the temper can either alter the properties of the clay or the properties of the fired ceramic material. The choices in temper are many but narrowed down by natural resources, tradition or competence. Organic material such as straw, seeds or sawdust can offer armouring when building thin or very big pots, helping to ease both the forming and the drying process. As organic tempering burns away during firing, the pot will become more porous than a pot that is tempered with geological material.

Geological materials such as fired crystallized stone, sand or crushed and ground fired clay sherds make good temper for high-temperature purposes. Silica-rich minerals give the clay body a very strong resistance to vitrification. Artisans of high-temperature crafts are aware of the practical sides of silicate chemistry through experience, tradition, or sometimes through education. To make tuyères like those analysed via ocular survey and artisanal interpretations, it is determined that the first feature – knowledge in tempering the clay – is known. Both finds (F5918 and 511) are competently tempered to be sustainable for heat and cracking, and the clay body contains a higher amount of silica. The mineral has been combined with the ordinary mixes for clay suitable for domestic ware. It is obvious through a close ocular survey of the Pryssgården tuyère, in which the broken parts were analysed, that silica-rich stones or pure quarts have been fired to the point of crystallization, then ground to a powder before being added into the clay.

Rolling from the inside

The second feature of the tuyère is a tucking or rolling technique that occurs together with the pipe form.

As can be seen in the drawing and the photo in Figure 4, the Pryssgården tuyère has clear traces of manufacture on its inside. It was not thumbled or drilled, but built around a padded organic core. Studying the imprints, paleo botanist Per Lagerås suggests this organic core was made from straw from a cultivated grain.

The rolling technique allows for a clay tube to be formed without seams. This is desirable as seams are more vulnerable to cracking in the stress that changing temperature exerts on ceramic material. The pressure through repeated rolling

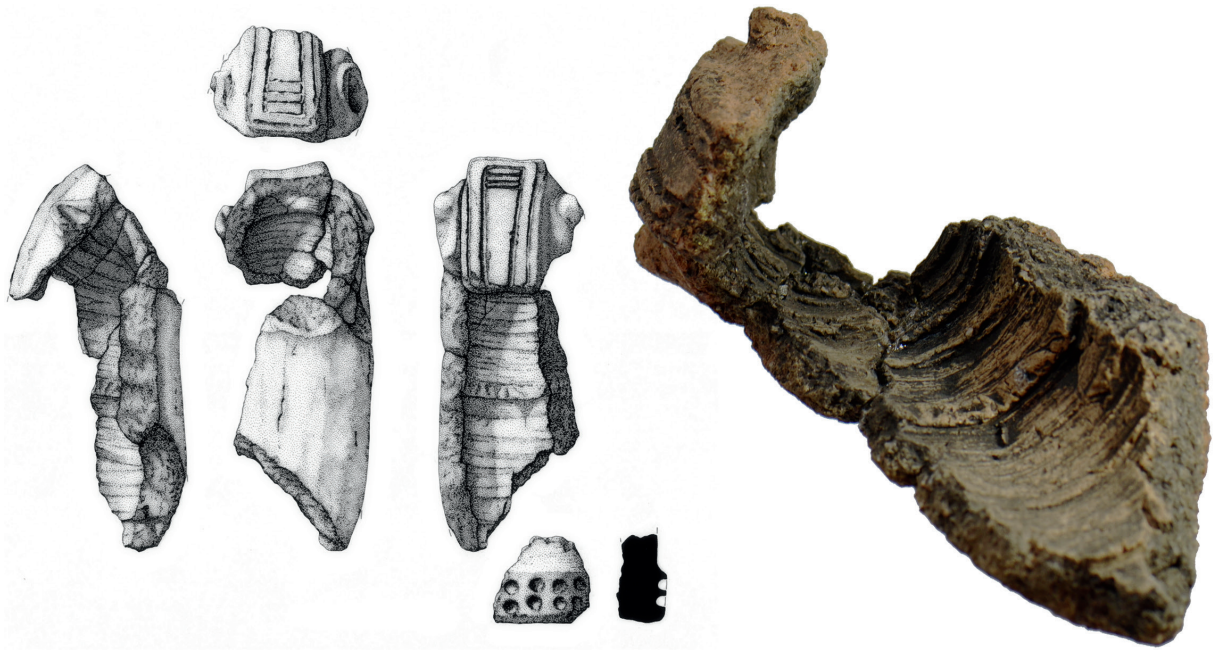


Figure 4. Find 5918 archaeological (illustration ©arc.doc; inside-photo © Katarina Botwid).

during manufacture would also strengthen the ceramic material as the clay particles are pressed firmly together.

To my knowledge, the rolling technique is not described in the ceramic literature but is quite common when rolling pipes. The series of pictures below (Fig. 5) show how the different stages result in a tube. The tube is formed around a wooden stick that is covered or wrapped with bast fibres. Bast fibres were specifically chosen for the experiment because this raw material existed in the Bronze Age and was easily accessible. The rolling technique is based on the clay being rolled from the inside of the tube (Botwid 2017, 43-46).

To the lower right (see Fig. 6) is a reconstruction of a rolled tube with fibre bast and twisted string wrapped around the stick. The bottom left shows the tube-shaped clay object at Malmö Historical Museum (MHM), excavated from the site Fosie IV in 1993, and interpreted as a tuyère (Björnhem and Sävestad 1993, 79). Notice that it was rolled from the inside with a twisted string and straw as padding.

In a newly conducted excavation outside Lund in southern Sweden, another tuyère was found (LUHM 32365:51). It was clearly manufactured using the earlier described rolling technique. It was similar to the Pryssgården tuyère in form and size allowing me to interpret the find as having been manufactured in the Late Bronze Age, even if the main finds in the context were interpreted as deriving from the pre-Roman Iron Age. One of the carbon dating results points to the Late Bronze Age which supports the interpretation of the pipe being dated to 790-540 BCE (CAL 2). The findings at this excavation imply, therefore, bronze casting (Brink and Larsson 2017, 105).

Visual temperature measurement

The third feature of the tuyère stems from observing the tuyère in action during an experiment at Lund University in 2014. When melting the bronze, the pre-fired tuyère was placed with its mouth over the charcoal-covered crucible. A continuous airstream from the bellows heated the burning charcoal for three hours. For the exact temperatures presented below we used a simple digital field pyrometer programmed to stand 1200°C. The temperature rose up to 500°C, presenting a warm, dark red glow before rising further to 900°C and presenting an orange colour. In the final phase, the temperature reached about 1100°C and achieved an almost white glow. When reaching

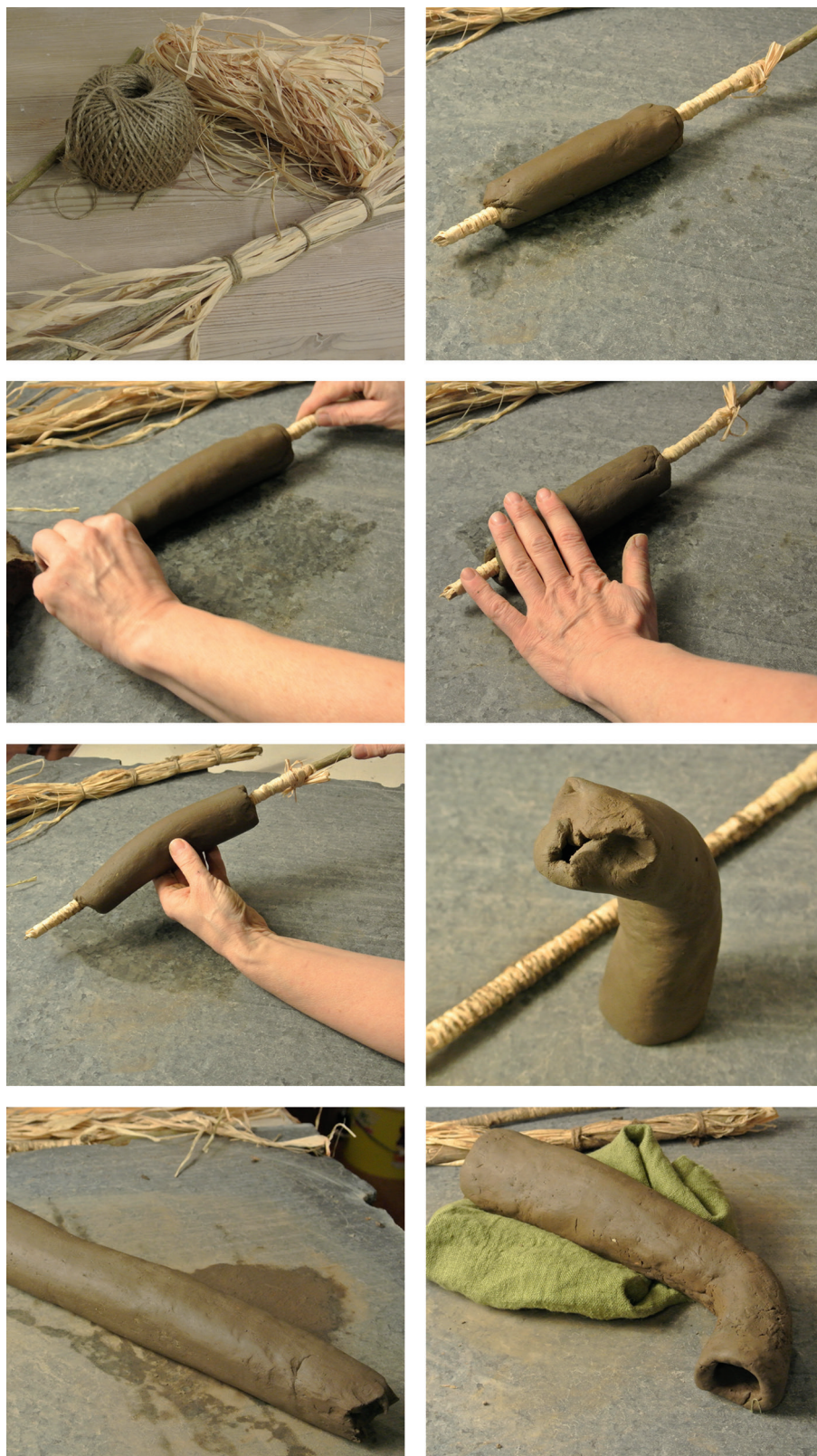


Figure 5. Manufacturing technique for making tubes. This rolling technique is used to form the basic element of a reconstructed tuyère. It is a very convenient and sure technique for making a hollow tube without seams or joints (photo © Paul Eklöv Pettersson).



over 1000°C, the decor started to glow from the inside of the mouth and had a steady bright, pale orange glow in the oxidising atmosphere. One cannot assess the temperature by looking at the crucible or metal as it has to be covered with coal to achieve heavy reduction. Therefore, the colour changes of the mouth of the tuyère can serve as important indicators of temperature. Its pitted design allows the mouth to both show colour and be sturdy enough to withstand the extreme conditions. After the tuyère had cooled down, no coal, reduction or sintering traces were visible; a little soot on the mouth and inside the pipe was the only residue of the usage.

Figure 6. (a) Find 5918 (photo © Katarina Botwid), (b) F511 (photo © Katarina Botwid), and (c) Fosie IV (courtesy of MHM ©) together with (d) an example of the rolling technique. (Photo © Paul Eklöv Pettersson).

Audial temperature measurement

The fourth feature of the tuyère concerns a surprising relation between its horse-like features and the sound of the air pushed from the bellows. The sound of the air meeting the blazing coal bed changes with increasing temperature and could well serve as another indicator of temperature to the experienced artisan. In the final stages of the firing process, the sound bears a striking resemblance to the heaving breaths of a horse exhausted from running.²

Conclusion, interpretation and discussion

The prehistoric metal craft was not possible without knowledge about firing, and ceramists have had a long tradition of high-temperature skill. At Pryssgården, the artisanal-interpreted ceramic vessels indicate a high level of skill or categorised in my own terms, *good artisanal knowledge* (Botwid 2017, 32). Without venturing into how the bronze craft first came to the area, it was met, to a certain extent, by a craft community equipped to understand the high-temperature craft of another field. Prepared clay was at hand and tuyères and crucibles had much the same needs of tempering as cooking pots, which were made to last for a long time. Any specific requirements were easily met. The rolled tubes with the padded core, the

² Sound reference: © Katarina Botwid 2015 <https://vimeo.com/137694259>.



Figure 7. Tuyère II in different stages of the firing process. Notice the bright orange glow appearing in the imprints in the last stage of firing (photo © Katarina Botwid).

utilizing of the glowing imprints at the mouth of the tuyère, and the sound as an indicator of temperature all ought to have been something new at Pryssgårdén.

The rolling technique appears to be connected to the bronze craft. To my knowledge, it occurs at three different places in Sweden, all during the Late Bronze Age. Changes in the ceramic craft technique would be possible to trace and the fact that this technique seems to be linked to the bronze craft might help in detecting it in more places. As it is possible that the rolling technique is even linked to the introduction of bronze craft, it certainly deserves more attention.

Visual measurements of heat were formalized in modern days through the Munsell scale (<http://munsell.com/about-munsell-color/>) but were something which would have been well-known to artisans experienced in high-temperature crafts at the time. If the interpretation of the decor as a temperature indicator is valid, it hints at a developed knowledge of handling high temperatures that is specific to the bronze craft.

The sound of the tuyère is another indicator of temperature. We can only speculate about the reasons why the horse-like sounds are combined with the horse features of the tuyère. It is interesting, however, that this is seen in other tuyères in Europe. I suggest a double function based in the practical pedagogic transfer of knowledge. Metaphors are often used in the training of an artisan, and narratives can be helpful for sharing and remembering new knowledge. Perhaps audial input was crucial to the crafting process as the metal itself was hidden from view. Further study can explore whether the Pryssgårdén tuyère represents two traditions of controlling temperature: an audial and a visual.

When the “horse” is exhausted by the person at the bellows, the bronze is ready. A strong narrative can be part of the transferring of declarative knowledge. Therefore, the narrative can also be part of a strong artistic identity or can be a way of ‘making special’ or artifying (see Dissanayaki 2013, 90-95). Knowledge and craft performances can amaze people who are new to meeting and understanding a new technique, particularly if performed together with colourful fire experiences, the smell of metal, and the choreography of artisans moving and working together in the different stages of the process. The conclusions drawn from the four features of the tuyère help us to better understand the high-temperature skill present at Pryssgårdén. The clay body was performed with a good grasp of the technology and it is therefore clear that high-temperature skill was at least at the level of *good artisanal knowledge* and was already in place. In light of the experimental finds and results, I propose that pipe-formed objects indicate the introduction of metal craft and new ceramic techniques which could easily be adopted by a ceramist at Pryssgårdén. Both the ceramist and the bronze smith could have had the skills necessary to make such pipes. In this case, with the elegant work with the horse features, I propose that the artisan had at least *good artisanal knowledge* in the making which does not exclude a bronze smith who was trained in ceramics *and* metal craft.

Declarative knowledge is proposed to be transferred through a visual, audial and experienced occasion that gives strong impressions and creates memories of handling a new technique. Being a part of this narrative can apply to those with different levels of understanding. What an individual comprehends depends on three things: whether they are part of the artisan group, whether they have a specific understanding that is developed each time they perform the craft, and whether they belong to a group that, as spectators, develops an understanding of the course of events over time (Botwid in press). Events like this can open up an interest for learning or an eagerness to talk about this unusual experience and thus spread the word. The narrative helps to consolidate the knowledge.



Figure 8. Artisans' and spectators' interpretation of the event of bronze casting in Pryssgården LBA. (Illustration © Henning Cedmar Brandstedt 2015).

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With her Master of Arts degree in Ceramics as a vantage point she has both revitalised the ceramic sherd as a source of knowledge of our past as well as developed more scientific ways to include contemporary craftspeople in the process of analysis of archaeological finds.

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